PROJECT MANUAL

SWIFT CREEK ELEMENTARY SCHOOL
RALEIGH, NORTH CAROLINA
WAKE COUNTY PUBLIC SCHOOL SYSTEM

BID SET
APRIL 10, 2024

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LS3P COMMISSION NUMBER 8201-207411

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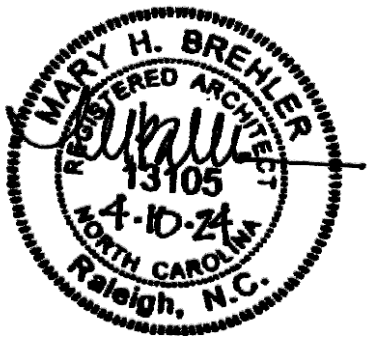
ARCHITECT 434 Fayetteville Street, Suite 1700, Raleigh, NC 27601 919.829.2700	Mary H Brehler License #13105	
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SECTION 210500 – COMMON WORK RESULTS FOR FIRE SUPPRESSION

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

1.2 SCOPE

A. The Advertisement for Bid, Instructions to Bidders, Bidding Requirements, General, Special and Supplementary Conditions, and all other Contract Documents shall apply to the Contractor's work as well as to each of their Sub-Contractor's work.

B. All manufacturers, suppliers, fabricators, contractors, etc. submitting proposals for any part of the work, services, materials, or equipment to be used on or applied to this project are hereby directed to familiarize themselves with the Contract Documents. In case of conflict between these General Provisions and the General and/or Special Conditions, the Contractor shall contact the Engineer for clarification and final determination prior to the Bid.

C. The work included in this Division consists of the furnishing of all labor, equipment, transportation, excavation, backfill, supplies, material, appurtenances, and services necessary for the satisfactory installation of the complete and operating Fire Suppression Systems indicated or specified in the Contract Documents.

D. Any materials, labor, equipment, or services not mentioned specifically herein which may be necessary to complete any part of the Fire Suppression Systems in a substantial manner, in compliance with the requirements stated, implied, or intended in the Plans and/or Specifications, shall be included in the Bid as part of this Contract.

E. It is not the intent of this Section of the Specifications to make any Contractor, other than the Prime Contractor responsible to the Owner. All transactions such as submittal of shop drawings, claims for extra costs, requests for equipment or materials substitution, shall be routed through the General Contractor to the Architect, then to the Engineer. Also, this Section of the Specifications shall not be construed as an attempt to arbitrarily assign responsibility of work, material, equipment or services to a particular trade or Contractor. Unless stated otherwise, the subdivision and assignment of work under the various sections shall be optional.

F. The Architect and Engineer do not define the scope of individual trades, subcontractors, material suppliers and vendors. Any sheet numbering system or specification numbering system used which identifies disciplines is solely for the Architect and Engineer’s convenience and is not intended to define a subcontractor’s scope of work. Information regarding individual trades, subcontractors, material suppliers and vendors may be detailed, described, and indicated at different locations throughout the Contract Documents. No consideration will be given to requests for change orders for failure to obtain and review the complete set of Contract Documents when preparing Bids, prices, and quotations. Unless stated otherwise, the subdivision and assignment of work under the various sections shall be the responsibility of the Contractor holding the prime contract.

G. It is the intent of the Contract Documents to deliver to the Owner a new, complete, and operational project once the work is complete. Although Plans and Specifications are complete to the extent possible, it shall be the responsibility of the Contractors involved to remove and/or relocate or re-attach any existing or new systems which interfere with new equipment or materials required for the complete installation without additional cost to the Owner.

H. In general, all work shall be accomplished without interruption of existing facilities operations. The Contractor shall advise the Owner at least seven (7) days prior to the interruption of any services (gas, domestic water, heating, etc.). The Owner shall be advised of the exact time that interruption will occur and the length of time the interruption will last. Failure to comply with this requirement may result in complete work stoppage for the Contractors involved until a complete schedule of interruptions can be developed.

I. Whenever utilities are interrupted, either deliberately or accidentally, the Contractor shall work continuously to restore said service. The Contractor shall provide tools, materials, skilled journeymen of Bidder/Proposer's own and other trades as necessary, premium time as needed and coordination with all applicable utilities, including payment of utility company charges (if any), all without requests for extra compensation from the Owner.

J. Each Bidder/Proposer shall also be governed by any unit prices and Addenda insofar as they may affect part of their work or services.

1.3 DEFINITIONS AND ABBREVIATIONS:

A. Contractor - Any Contractor whether bidding, proposing, or working independently or under the supervision of a General Contractor, Prime Contractor, Construction Manager and who installs any type of Mechanical Work as specified in the Contract Documents or, the General Contractor.
B. Engineer - The Consulting Mechanical-Electrical Engineer either consulting to the Owner, Architect, or Other, etc. In this case: CMTA, Inc., Consulting Engineers.
C. Architect - The Architect of Record for the project.
D. Contract Documents - All documents pertinent to the quality and quantity of work to be performed on this project. Includes, but not limited to: Plans, Specifications, Instructions to Bidders, General and Special Conditions, Addenda, Alternates, Lists of Materials, Lists of Sub-Contractors, Unit Prices, Shop Drawings, Field Orders, Change Orders, Cost Breakdowns, Schedules of Value, Periodical Payment Requests, Construction Contract with Owner, etc.
E. Bidder/Proposer - Any person, agency or entity submitting a proposal to any person, agency, or entity for any part of the work required under this contract.
F. The Project - All of the work required under this Contract.
G. Furnish - Deliver to the site in good condition and turn over to the Contractor who is to install.
H. Provide - Furnish and install complete, tested, and ready for operation.
I. Install - Receive and place in satisfactory operation.
J. Indicated - Listed in the Specifications, shown on the Plans or Addenda thereto.
K. Typical or Typ.- Where indicated repeat this work, method or means each time the same or similar condition occurs whether indicated or not.
L. ADA - Americans with Disabilities Act.
M. ANSI - American National Standards Institute.
N. ASME - American Society of Mechanical Engineers.
O. IBC - International Building Code.
P. NEC - National Electrical Code.
Q. NEMA - National Electrical Manufacturers Association.
R. NFPA - National Fire Protection Association.
S. OHSA - Office of Safety and Health Administration.
T. UL - Underwriters Laboratories.

1.4 INTENT AND INTERPRETATION:

A. It is the intention of the Contract Documents to call for a complete and operational system, including all components, accessories, finish work, etc as necessary for trouble free operation, tested and ready for operation. Anything that may be required, implied, or inferred by the Contract Documents shall be provided and included as part of the Bid.

B. All Contractors and Vendors providing a bid for this project shall review the Plans and Specifications and determine any modifications and/or adjustments necessary relative to the proposed equipment and materials with specific manufacturer's installation requirements. Include in the bid any necessary installation methods, features, options, accessories, etc. necessary to install the proposed equipment and materials, regardless of whether used as basis of design or being offered as a substitution in accordance with the specific manufacturer's installation requirements whether specifically detailed or not within the Plans and Specifications.

C. Details not usually shown or specified, but necessary for the proper installation and operation of systems, equipment, materials, etc., shall be included in the work, the same as if herein specified or indicated.

D. The Bidder/Proposer shall completely review the Contract Documents. Any interpretation as to design intent or scope shall be provided by the Engineer / Architect. Should an interpretation be required, the Bidder/Proposer shall request a clarification not less than ten (10) days prior to the submission of the proposal so that the condition may be clarified by Addendum. In the event of any conflict, discrepancy, or inconsistency develops; the interpretation of the Engineer shall be final.

E. The Contractor shall give written notice of any materials or apparatus believed inadequate or unsuitable; in violation of laws, ordinances, rules, or regulations of authorities having jurisdiction; and any necessary items of work omitted a minimum of ten (10) days prior to bid. In the absence of such written notice and by the act of submitting a bid, it shall be understood that the Contractor has included the cost of all required items in the bid, and that will be responsible for the approved satisfactory functioning of the entire system without extra compensations.

1.5 INDEMNIFICATION:

A. The Contractor shall hold harmless and indemnify the Engineer, employees, officers, agents and consultants from all claims, loss, damage, actions, causes of actions, expense and/or liability resulting from, brought for, or on account of any personal injury or property damage received or sustained by any person, persons, (including third parties), or any property growing out of, occurring, or attributable to any work performed under or related to this contract, resulting in whole or in part from the negligence of the Contractor, any subcontractor, any employee, agent or representative.

1.6 PLANS AND SPECIFICATIONS:

A. The Plans are diagrammatic only and indicate the general arrangement of the systems and are to be followed. If deviations from the layouts are necessitated by field conditions, detailed layouts of the proposed departures shall be submitted to the Engineer for approval before proceeding with the work. The Plans are not intended to show every item which may be necessary to complete the systems. All Bidder/Proposers shall anticipate that additional items may be required and submit their Bid accordingly.

B. The Plans and Specifications are intended to supplement each other. No Bidder/Proposer shall take advantage of conflict between them, or between parts of either. Should this condition exist, the Bidder/Proposer shall request a clarification not less than ten (10) days prior to the submission of the proposal so that the condition may be clarified by Addendum. In the event that such a condition arises after work is started, the interpretation of the Engineer shall be final.

C. The Plans and Specifications shall be considered to be cooperative and anything appearing in the Specifications which may not be indicated on the Plans or conversely, shall be considered as part of the Contract and must be executed the same as though indicated by both.

D. Contractor shall make all of their own measurements in the field and shall be responsible for correct fitting. The work shall be coordinated with all other branches of work in such a manner as to cause a minimum of conflict or delay.

E. The Engineer shall reserve the right to make adjustments in location of piping, ductwork, equipment, etc. where such adjustments are in the interest of improving the project.

F. Should conflict, overlap or duplication of work between the various trades become evident, this shall be called to the attention of the Engineer. In such event neither trade shall assume to be relieved of the work which is specified under their branch until instructions in writing are received from the Engineer.

G. Unless dimensioned, the Plans only indicate approximate locations of equipment, piping, etc. Dimensions given in figures on the Plans shall take precedence over scaled dimensions and all dimensions, whether given in figures or scaled, shall be verified in the field to insure no conflict with other work.

H. Each Bidder/Proposer shall review all Plans in the Contract Documents to ensure that the work they intend to provide does not create a conflict with or affect the work of others in any way. Where such effect does occur, it shall be the Bidder/Proposer's responsibility to satisfactorily eliminate any such conflict or effect prior to the submission of their proposal. Each Bidder/Proposer shall in particular ensure that there is adequate space to install their equipment and materials. Failure to do so shall result in the correction of such encroachment conflict or effect of any work awarded the Bidder/Proposer and shall be accomplished fully without expense to others and that they are reasonably accessible for maintenance. Check closely all mechanical and electrical closets, chases, ceiling voids, wall voids, crawl spaces, etc., to insure adequate spaces.

I. Where on the Plans a portion of the work is drawn out and the remainder is indicated in outline, or not indicated at all, the parts drawn out shall apply to all other like portions of the work. Where ornamentation or other detail is indicated by starting only, such detail shall be continued throughout the courses or parts in which it occurs and shall also apply to all other similar parts of the work, unless otherwise indicated.

J. Details not usually shown or specified, but necessary for the proper installation and operation of systems, equipment, materials, etc., shall be included in the work, the same as if herein specified or indicated.

K. Where within the Contract Documents the word “typical” or “typ.” is used, it shall mean that the work method or means indicated as typical shall be repeated in and each time it occurs whether indicated or not.

L. Each Contractor shall evaluate ceiling heights specified on Architectural Plans. Where the location of equipment or systems may interfere with ceiling heights or maintenance and access of equipment or systems, the Contractor shall call this to the attention of the Engineer in writing prior to making the installation. Do not install equipment or systems in the affected area until the conflict is resolved. Any such changes shall be anticipated and requested sufficiently in advance so as to not cause extra work or cost incurred on the part of the Contractor or unduly delay the work.

M. The Contractor shall provide a layout confirmation of equipment rooms to verify that all of the equipment submitted and approved will in fact fit into the proposed space and have adequate clearance for service. See COORDINATION DRAWINGS SECTION.

1.7 EQUIPMENT AND MATERIALS SUBSTITUTIONS OR DEVIATIONS:

A. When any Contractor requests approval of materials and/or equipment of different physical size, weight, capacity, function, color, access, that the design allows for it shall be understood that such substitution, if approved, will be made without additional cost to anyone other than the Contractor requesting the change regardless of changes in connections, space requirements, electrical characteristics, etc. from that indicated, electrical service, etc. In all cases where substitutions affect other trades, the Contractor requesting such substitutions shall advise all such Contractors of the change and shall compensate them for all necessary changes in their work. Any Plans, Specifications, Diagrams, etc., required to describe and coordinate such substitutions or deviations shall be professionally prepared at the responsible Contractor's expense. Review of Shop Drawings by the Engineer does not in any way absolve the Contractor of this responsibility.

B. Notwithstanding any reference in the Specifications to any article, device, product, material, fixture, form, or type of construction by name, make or catalog number, such reference shall be interpreted as establishing a standard of quality and shall not be construed as limiting competition; any devices, products, materials, fixtures, forms, or types of construction which, in the judgment of the Engineer, are equivalent to those specified are acceptable, provided the provisions of this Part are met. Requested substitutions shall be submitted to the Engineer a minimum of ten (10) days prior to Bid. If this procedure is not followed, the substitution will be rejected. If prevailing laws of cities, towns, states, or countries are more stringent than these specifications regarding such substitutions, then those laws shall prevail over these requirements.

C. Wherever any equipment and material is specified exclusively only such items shall be used unless substitution is accepted in writing by the Engineer.

D. Each Bidder/Proposer shall furnish along with their proposal a list of specified equipment and materials which is to be provided. Where several makes are mentioned in the Specifications and the Contractor fails to state which, they propose to furnish, the Engineer shall choose any of the makes mentioned without change in price. Inclusion in this list shall not ensure that the Engineer will approve shop drawings unless the equipment, materials, etc., submitted in shop drawings are satisfactorily comparable to the items specified and/or indicated.

1.8 QUALIFICATIONS OF CONTRACTOR/WORKERS:

A. All Contractors and their subcontractors bidding this project must have been a licensed company for a minimum of three (3) years to qualify to Bid this project. Individual employee experience does not supersede this requirement.

B. All fire suppression subcontractors bidding the fire suppression scope of work must have completed one project of 70% this subcontract cost size and two projects of 50% this subcontract cost size.

C. All fire suppression work shall be accomplished by qualified workers competent in the area of work for which they are responsible. Untrained and incompetent workers, as evidenced by their workmanship, shall be summarily relieved of their responsibilities in areas of incompetency. The Engineer shall reserve the right to determine the quality of workmanship of any workers and unqualified or incompetent workers shall refrain from work in areas not deemed satisfactory. Requests for relief of workers shall be made through the normal channels of Architect, Contractor, etc.

D. The Contractor shall hold all required licenses in the State which the work is to be performed.

E. All special systems (Automatic Sprinkler Equipment, etc.) shall be installed only by workers normally engaged in such services. Exception to this specification may only be made in writing by the Engineer.

F. All electrical work shall be accomplished by Licensed Journeymen electricians under the direct supervision of a licensed Electrician. All applicable codes, utility company regulations, laws and permitting authority of the locality shall be fully complied with by the Contractor.

1.9 HAZARDOUS MATERIALS:

A. The Contractor is hereby advised that it is possible that asbestos and/or other hazardous materials are or were present in this building or site.

B. Any worker, occupant, visitor, inspector, etc., who encounters any material of whose content they are not certain shall promptly report the existence and location of that material to the Contractor and/or Owner. The Contractor shall, as a part of their work, ensure that their workers are aware of this potential and what they are to do in the event of suspicion. The Contractor shall also keep uninformed persons from the premises during construction. Furthermore, the Contractor shall insure that no one comes near to or in contact with any such material or fumes therefrom until its content can be ascertained to be non-hazardous.

C. CMTA, Inc., Consulting Engineers, have no expertise in the determination of the presence of hazardous materials. Therefore, no attempt has been made by them to identify the existence or location of any such material. Furthermore, CMTA nor any affiliate thereof will neither offer nor make any recommendations relative to the removal, handling, or disposal of such material.

D. If the work interfaces, connects or relates in any way with or to existing components which contain or bear any hazardous material, asbestos being one, then, it shall be the Contractor's sole responsibility to contact the Owner and so advise them immediately.

E. The Contractor by execution of the contract for any work and/or by the accomplishment of any work thereby agrees to bring no claim relative to hazardous materials for negligence, breach of contract, indemnity, or any other such item against CMTA, its principals, employees, agents, or consultants. Also, the Contractor further agrees to defend, indemnify, and hold CMTA, its principals, employees, agents, and consultants, harmless from any such related claims which may be brought by any subcontractors, suppliers or any other third parties.

F. No asbestos or mercury containing materials shall be installed in this project.

G. It is the policy of the University that no asbestos - containing materials are to be purchased by the University, supplied by any person supplying to the University or installed in or on University property by any person performing work for the University. Furthermore, all products marked “May contain Mineral Fiber” will be assumed to contain asbestos unless the manufacturer provides written certification that no asbestos fibers are present in the product and identifies the fibers for which the product is marked. An exception to this rule can be made where a faculty or staff member certifies that the use of asbestos is essential to an ongoing research or production project and works with Environmental Health and Safety Department to ensure that the material is used, stored, and disposed of in safe and legal manner.

PART 2 – PRODUCTS (NOT APPLICABLE)

PART 3 – EXECUTION

3.1 EXAMINATION OF SITE AND CONDITIONS:

A. Each Bidder/Proposer shall inform themselves of all of the conditions under which the work is to be performed, the site of the work, the structure of the ground, above and below grade, the obstacles that may be encountered, the availability and location of necessary facilities and all relevant matters concerning the work.

B. Each Bidder/Proposer shall also fully acquaint themselves with all existing conditions as to ingress and egress, distance of haul from supply points, routes for transportation of materials, facilities and services, availability of utilities, etc. A proposal shall cover all expenses or disbursements in connection with such matters and conditions. No allowance will be made for lack of knowledge concerning such conditions after Bids are accepted.

3.2 CODES, RULES, PERMITS, FEES, INSPECTIONS, REGULATIONS, ETC.:

A. The Contractor shall give all necessary notices, obtain, and pay for all permits, government sales taxes, fees, inspections, and other costs, including all utility connections, meters, meter settings, taps, tap fees, extensions, etc. in connection with their work. They shall also file all necessary plans, prepare all documents, and obtain all necessary approvals of all governmental departments and/or the appropriate municipality or utility company having jurisdiction, whether indicated or specified or not. They shall also obtain all required certificates of inspection for their work and deliver same to the Engineer before request for acceptance and final payment for the work.

B. Ignorance of Codes, Rules, regulations, utility company requirements, laws, etc., shall not diminish or absolve Contractor's responsibilities to provide and complete all work in compliance with such.

C. The Contractor shall include in their work, without extra cost, any labor, materials, services, apparatus, and Plans in order to comply with all applicable laws, ordinances, rules, and regulations, whether or not indicated or specified.

D. All materials furnished and all work installed shall comply with the National Fire Codes of the National Fire Protection Association, with the requirements of local utility companies, or municipalities and with the requirements of all governmental agencies having jurisdiction.

E. All materials and equipment so indicated and all equipment and materials for the electrical portion of the mechanical systems shall bear the approval label of or shall be listed by the Underwriters' Laboratories (UL), Incorporated. Each packaged assembly shall be approved as a package. Approval of components of a package shall not be acceptable.

F. The Contractor shall furnish three (3) copies of all Final Inspection Certificates obtained to the Engineer when work is complete. Final payment for work will be contingent upon compliance with this requirement.

G. Where minimum code requirements are exceeded in the Design, the Design shall govern.

H. The Contractor shall insure that their work is accomplished in accord with the OHSA Standards and that they conduct their work and the work of their personnel in accord with same.

I. Work in elevators, elevator shafts and elevator equipment rooms shall comply with the Elevator Code enforced by the Authority Having Jurisdiction.

J. Discharge of any toxic, odorous, or otherwise noxious materials into the atmosphere or any system shall be subject to regulations of the Environmental Protection Agency (EPA) and/or the air pollution control commission. If in doubt, contact the State Department for Environmental Protection.

K. Where conflict arises between any code and the Plans and/or Specifications, the code shall apply except in the instance where the Plans and Specifications exceed the requirements of the code. Any changes required as a result of these conflicts shall be brought to the attention of the Engineer at least ten (10) days prior to bid date, otherwise the Contractor shall make the required changes at their own expense.

3.3 SUPERVISION OF WORK:

A. The Contractor shall personally supervise the work for which they are responsible or have a competent superintendent, approved by the Engineer, on the work at all times during progress with full authority to act on behalf of the Contractor.

3.4 CONDUCT OF WORKERS:

A. The Contractor shall be responsible for the conduct of all workers under their supervision. Misconduct on the part of any worker to the extent of creating a safety hazard, or endangering the lives and property of others, shall result in the prompt removal of that worker. The consumption of alcoholic beverages or other intoxicants, narcotics, barbiturates, hallucinogens or dehabilitating drugs on the job site is strictly forbidden.

3.5 COOPERATION AND COORDINATION WITH OTHER TRADES:

A. The Contractor shall give full cooperation to all other trades and shall furnish in writing with copies to the Engineer, any information necessary to permit the work of other trades to be installed satisfactorily and with the least possible interference or delay.

B. Where any work is to be installed in close proximity to, or will interfere with work of other trades, each shall cooperate in working out space conditions to make a satisfactory adjustment. If so, directed by the

Engineer, the Contractor shall prepare composite working drawings and sections at a suitable scale not less than ¼" = 1'-0", clearly indicating how their work is to be installed in relation to the work of other trades, or so as not to cause any interference with work of other trades. Make the necessary changes in the work to correct the condition without extra charge.

C. The Contractor shall furnish to other trades, as required, all necessary templates, patterns, setting plans, and shop details for the proper installation of work and for the purpose of coordinating adjacent work.

3.6 GUARANTEES AND WARRANTIES:

A. The Contractor shall guarantee all equipment, apparatus, materials, and workmanship entering into their Contract to the best of its respective kind and shall replace all parts at their own expense, which are proven defective within the time frame outlined in the General Conditions of the Contract. The effective date of completion of the work shall be the date of the Project's Statement of Substantial Completion. Items of equipment which have longer guarantees, as called for in these Specifications, shall have warranties and guarantees completed in order, and shall be in effect at the time of final acceptance of the work by the Engineer. The Contractor shall present the Engineer with such warranties and guarantees at the time of final acceptance of the work. The Engineer shall then submit these warranties, etc. to the Owner. The Owner reserves the right to use equipment installed by the Contractor prior to date of final acceptance. Such use of equipment shall not invalidate the guarantee except that the Owner shall be liable for any damage to equipment during this period, due to negligence of their operator or other employees. Refer to other sections for any special or extra warranty requirements.

B. Provide all warranty certificates to Owner. All warranties begin starting at the substantial completion date, submit warranty certificates accordingly.

3.7 COST BREAKDOWNS (SCHEDULE OF VALUES):

A. Within thirty (30) days after acceptance of the Contract, the Contractor shall furnish to the Engineer, one copy of a detailed cost breakdown on each respective area of work. These cost breakdowns shall be made in a format approved by the Engineer. Payments will not be made until satisfactory cost breakdowns are submitted.

B. The breakdown shall be minimally as follows. Material and labor shall be listed separately. Pay special attention to required withholding percentages for startup, testing, documentation, acceptance, owner training, etc.:
1. Shop Drawings
2. Motor Load Coordination with Other Subcontractors
3. Record Drawings & Acceptance
4. Owner Training & Acceptance
5. Identification Materials & Labor
6. Piping Materials & Labor
7. Piping Materials & Labor
8. Fire Protection Shop Drawings
9. Fire Protection Materials & Labor
10. Fire Protection Record Drawings & Acceptance
11. Other Equipment and Labor
12. Other Equipment Startup, Testing, Documentation, Training, Acceptance, etc.

3.8 CHANGES IN MECHANICAL WORK:

A. REFER TO GENERAL AND SPECIAL CONDITIONS.

3.9 CLAIMS FOR EXTRA COST:

A. REFER TO GENERAL AND SPECIAL CONDITIONS.

3.10 MATEIALS AND WORKMANSHIP:

A. All equipment, materials and articles incorporated in the work shall be new and of comparable quality to that specified. Each Bidder/Proposer shall determine that the materials and/or equipment they propose to furnish can be brought into the building(s) and installed within the space available. In certain cases, it may be necessary to remove and replace walls, floors and/or ceilings and/or disassemble/reassemble the materials and equipment and this work shall be the responsibility of the Contractor, whether specifically initiated or not.

B. All equipment shall be installed so that all parts are readily accessible for inspection, maintenance, replacement of fans, motors, coils, filters, etc. Extra compensation will not be allowed for relocation of equipment for accessibility or for dismantling equipment to obtain entrance into the building(s). Insure, through coordination that no other Contractor seals off access to space required for equipment materials, etc.

C. Materials and equipment shall bear Underwriters' Laboratories label where such a standard has been established, where applicable.

D. Each length of pipe, fitting, trap, fixture, and device used in the plumbing or drainage systems shall be stamped or indelibly marked with the weight or quality thereof and with the manufacturer's mark or name.

3.11 TEMPORARY SERVICES:

A. The Contractor shall arrange any temporary water, electrical and other services which may be required to accomplish the work. Refer also to General and Special Conditions.

B. All temporary services shall be removed by Contractor prior to completion of work.

3.12 SURVEY, MEASUREMENTS AND GRADE:

A. The Contractor shall lay out their work and be responsible for all necessary lines, levels, inverts, elevations, and measurements. The Contractor must verify the figures shown on the Plans before laying out the work and will be held responsible for any error resulting from failure to do so.

B. The Contractor shall base all measurements, both horizontal and vertical from established bench marks. All work shall agree with these established lines and levels. Verify all measurements at the site and check the correctness of same as related to the work.

C. Should the Contractor discover any discrepancy between actual measurements and those indicated which prevents following good practice or the intent of the contract documents, the Contractor shall promptly notify the Engineer and shall not proceed with this work until the Contractor has received instructions from the Engineer on the disposition of the work.

3.13 PROTECTION OF EQUIPMENT:

A. The Contractor shall be entirely responsible for all material and equipment they furnish in connection with their work and special care shall be taken to properly protect all parts thereof from damage during the construction period. Such protection shall be by a means acceptable to the Engineer. All piping, etc., shall be properly plugged or capped during construction in a manner approved by the Engineer. Equipment damaged, stolen, or vandalized while stored on site, either before or after installation, shall be repaired or replaced by the Contractor at their expense.

3.14 REQUIRED CLEARANCES FOR ELECTRICAL EQUIPMENT:

A. The NEC has specific required clearances above, in front, and around electrical gear, panels etc. The Contractor shall not install any piping, equipment, etc., in the required clearance. If any appurtenance is located in the NEC required clearance, it shall be relocated at no additional cost. Coordinate with the Electrical Contractor prior to any work.

3.15 EQUIPMENT SUPPORT:

A. Each piece of equipment, apparatus, piping, or conduit suspended from the ceiling or mounted above the floor level shall be provided with suitable structural support, pipe stand, platform, or carrier in accordance with the best recognized practice. Such supporting or mounting means shall be provided by the Contractor for all equipment and piping. Exercise extreme care that structural members of building are not overloaded by such equipment. Provide any required additional bracing, cross members, angles, support, etc. Do not support items from roof/floor deck or bridging.

3.16 PIPE MOUNTING HEIGHTS:

A. All exposed or concealed equipment, piping, etc., shall be held as high as possible unless otherwise noted and coordinated with all other trades. Exposed piping shall, insofar as possible, run perpendicular or parallel to the building structure. Refer to Plans for minimum heights of ducts and piping. Minimum height above ceilings shall be 6” clear including insulation, unless otherwise noted.

3.17 BROKEN LINES AND PROTECTION AGAINST FREEZING:

A. No conduits, piping, etc. carrying water or any other fluid subject to freezing shall be installed in any part of the building where danger of freezing may exist without adequate protection being given by the Contractor whether or not insulation is specified or indicated on the particular piping. All damages resulting from broken and/or leaking lines shall be replaced or repaired at the Contractor's own expense. Do not install piping across or near openings to the outside whether or not they are carrying static or moving fluids. Insulation on piping does not necessarily ensure that freezing will not occur. If in doubt, contact the Engineer.

3.18 WEATHERPROOFING:

A. Where any work pierces waterproofing including waterproof concrete, the method of installation shall be as specified and approved by the Architect and Engineer before work is performed. The Contractor shall furnish all necessary sleeves, caulking and flashing required to make openings permanently watertight.

B. Wherever work penetrates roofing, it shall be done in a manner that will not diminish or void the roofing guarantee or warranty in any way. Coordinate all such work with the roofing installer.

3.19 ACCESSIBILITY:

A. The Contractor shall be responsible for the sufficiency of the size of shafts and chases, the adequate clearance in double partitions and ceilings for the proper installation of their work. They shall cooperate with all others whose work is in the same space. Such spaces and clearances shall, however, be kept to the minimum size required.

B. The Contractor shall locate and install all equipment so that it may be serviced and maintained as recommended by the manufacturer. Allow ready access and removal of the entire unit and/or parts such as valves, filters, fan belts, motors, prime shafts, controls, coils, etc.

C. Whether shown on the Plans or not, the Contractor shall provide in the Bid access panels for each concealed shut-off valve, motorized control damper, manual air damper or other device requiring service as

shown on Engineer's Plans or as required. Locations of these panels shall be identified in sufficient time to be installed in the normal course of work. Change orders for access panels will not be accepted.

3.20 SCAFFOLDING, RIGGING AND HOISTING:

A. The Contractor shall furnish all scaffolding, rigging, hoisting and services necessary for erection and delivery onto the premises of any equipment and apparatus furnished. All such temporary appurtenances shall be set up in strict accord with OHSA Standards and Requirements. Remove same from premises when no longer required.

3.21 CONCRETE WORK:

A. The Contractor shall be responsible for the provisions of all concrete work required for the installation of any of their systems or equipment. The Contractor may, at their option, arrange with the others to provide the work. This option, however, will not relieve the Contractor of their responsibilities relative to dimensions, quality of workmanship, locations, etc.

B. In the absence of other concrete Specifications, all concrete related to Mechanical work shall be 3500 psi minimum compression strength at 28 days curing, slump: 4” ± 1”, air entrainment 4.5% water to cement ratio 0.5 and shall conform to the standards of the American Concrete Institute Publication AC1-318. Heavy equipment shall not be installed on pads for at least seven (7) days after pour. Insert 6-inch steel dowel rods into new and existing floors to anchor pads.

C. All concrete pads shall be complete with all pipe sleeves, anchor bolts, reinforcing steel, concrete, etc. as required. Pads larger than 18" in width shall be reinforced with ½" deformed round bars on 6" centers both ways. Bars shall be approximately 2" above the bottom of the pad. All parts of pads and foundations shall be properly rodded or vibrated. If exposed parts of the pads and foundations are rough or show honeycomb after removing forms, all surfaces shall be rubbed to a smooth surface. Chamfer all vertical edges ¾” and tool horizontal edges with ¾” radius.

D. In general, unless otherwise noted, concrete pads for equipment and piping penetrations shall be a minimum of 4” thick, extend six (6) inches beyond the equipment's base dimensions. Where necessary, show work on plans, extend pads 30 inches beyond base or overall dimensions to allow walking and servicing space.

3.22 RESTORATION OF NEW OR EXISTING LANDSCAPING, PAVING, SURFACES, ETC.:

A. The Contractor shall at their expense restore to their original conditions all paving, curbing, surfaces, drainage ditches, structures, fences, landscaping, existing or new building surfaces and appurtenances, and any other items damaged or removed by their operations. Replacement and repairs shall be in accordance with good construction practice; by qualified tradesman and shall match materials employed in the original construction of the item and shall be to the satisfaction of the Owner and/or Engineer.

3.23 MAINTENANCE OF EXISTING UTILITIES AND LINES:

A. The locations of all piping, conduits, cables, utilities, and manholes existing, or otherwise, that comes within the contract construction site, shall be subject to continuous uninterrupted service with no other exception than the Owner of the utilities permission to interrupt same temporarily. Provide a seven (7) day written notice to Engineer, Architect and Owner prior to interrupting any utility service or line.

B. Known utilities and lines as available to the Engineer are shown on the Plans. However, it is additionally required that, prior to any excavation being performed, each Contractor ascertain and mark all utilities or lines that would be endangered by the excavation. Hand dig if required to locate. Contractor shall bear costs of repairing damaged utilities.

C. If utilities or lines occur in the earth within the construction site, the Contractor shall probe and locate the lines prior to machine excavation in the respective area. Hand dig if required to locate.

D. Cutting into existing utilities and services shall be performed in coordination with and as designated by the Owner of the utility. The Contractor shall work continuously to restore service(s) upon deliberate or accidental interruption, providing premium time and materials as needed without extra claim to the Owner.

E. The Contractor shall repair to the satisfaction of the Owner and Engineer, any surfaces or subsurface improvements damaged during the course of the work, unless such improvement is shown to be abandoned or removed.

F. Machine excavation shall not be permitted with ten feet of gas lines, fuel lines, electrical lines or lines carrying combustible and/or explosive materials. Hand excavate only in accord with utility company, agency or other applicable laws, standards or regulations.

G. Protect all new or existing lines from damage by traffic, etc. during construction. Repairs or replacement of such damage shall be at the sole expense of the party responsible.

H. Protect existing trees, indicated to remain with fencing or other approved method. Hold all new subsurface lines outside the drip line of trees, offsetting as necessary to protect root structures. Refer to planting or landscaping plans, or in their absence, consult with the Architect.

3.24 CLEANING:

A. The Contractor shall, at all times, keep the area of their work presentable to the public and clear from rubbish and debris caused by their operations; and at the completion of the work, they shall remove all rubbish, debris, all of their tools, equipment, temporary work, and surplus materials from and about the premises, and shall leave the area clean and ready for use. If the Contractor does not attend to such cleaning upon request, the Engineer may cause cleaning to be done by others and charge the cost of same to the Contractor. The Contractor shall be responsible for all damage from fire which originates in, or is propagated by, accumulations of their rubbish or debris.

B. After completion of all work and before final acceptance of the work, the Contractor shall thoroughly clean all equipment and materials and shall remove all foreign matter such as grease, dirt, plaster, labels, stickers, etc., from the exterior of piping, equipment, fixtures and all other associated or adjacent fabrication.

C. Piping shall be kept clean at all times. Piping stored on the job site shall be placed a minimum of 4” above the floor and shall be completely covered in plastic. Do not install the piping or insulation if the building is not “dried-in”. If this is required, the entire lengths of duct shall be covered in plastic to protect. The Owner/Engineer may periodically inspect that these procedures are followed.

3.25 NOISE, VIBRATION OR OSCILLATION:

A. All work shall operate under all conditions of load without any sound or vibration which is objectionable in the opinion of the Engineer. In case of moving machinery, sound, or vibration noticeable outside of room in which it is installed, or annoyingly noticeable inside its own room, will be considered objectionable. Sound or vibration conditions considered objectionable by the Engineer shall be corrected in an approved manner by the Contractor at their expense.

B. The Contractor shall provide supports for all equipment they furnish. Supports shall be liberally sized and adequate to carry the load of the equipment and the loads of attached equipment, piping, etc. All equipment shall be securely fastened to the structure either directly or indirectly through supporting members by means of bolts or equally effective means. If strength of supporting structural members is questionable, contact Engineer.

3.26 EQUIPMENT/CONTROLS STARTUP & VERIFICATION:

A. The Contractor and their Subcontractors shall include in the bid to provide equipment and startup and verification for ALL Systems specified for this project.

B. Specific line-items shall be included on the schedule of values by each Trade for “equipment and startup”.

C. Specific startup/verification specifications are included throughout the Project Specifications. In general, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians, not third party contractors, and shall complete and submit start-up reports/checklists. The Contractor shall have appropriate trades on site to correct all deficiencies noted by the factory representative. For each deficiency noted, documentation of corrective action (including date and time) shall be submitted to the Engineer and Owner. Where factory start-up is not specified for a particular piece of equipment or system, the Contractor shall be responsible to perform start-up. All information shall be completed by the Contractor and submitted to the Owner/Engineer prior to acceptance of the equipment.

D. The manufacturer’s recommended startup procedures and checklists will be acceptable for use in the project. All startup/verification process shall be thoroughly documented by the Contractor and shall include the time and date when performed.

3.27 INSPECTION, APPROVALS AND TESTS:

A. Before requesting a final review of the installation from the Architect and/or Engineer, each Contractor shall thoroughly inspect their installations to assure that the work is complete in every detail and that all requirements of the Contract Documents have been fulfilled. Failure to accomplish this may result in charges from the Architect and/or Engineer for unnecessary and undue work on their part.

B. The Contractor shall provide as a part of this Contract any required Agency inspection, licensed, and qualified to provide such services. All costs incidental to the provisions of inspections shall be borne by the Contractor.

C. The Contractor shall advise each Inspecting Agency in writing, with an informational copy of the correspondence to the Architect and/or Engineer, when they anticipate commencing the work. Inspections shall be scheduled for rough-in as well as finished work. The rough-in inspections shall be divided into as many inspections as may be necessary to cover all rough-in without fail. Failure of the Inspecting Agency to inspect the work in a timely manner and submit the related reports may result in the Contractor having to expose concealed work not so inspected. Such exposure will be at the expense of the responsible Contractor.

D. Approval by an Agency Inspector does not relieve the Contractor from the responsibilities of furnishing equipment having a quality of performance equivalent to the requirements set forth in these Plans and Specifications. All work under this contract is subject to the review of the Architect and/or Engineer, whose decision is binding.

E. Before final acceptance, the Contractor shall furnish the original and three (3) copies of the certificates of final approval by the Agency Inspector to the Engineer with one copy of each to the appropriate government agencies, as applicable. Final payment for the work shall be contingent upon completion of this requirement.

3.28 ABOVE-CEILING AND FINAL PUNCH LISTS:

A. The Contractor shall review each area and prepare and complete their own punch list for each of the subcontractors as required for the Project Schedule.

B. Seven (7) days notice shall be given to the Engineer for review of above ceiling work that will be concealed by tile or other materials. Seven (7) days notice shall be given to the Engineer for review of below ceiling work and final inspection.

C. When all work from the Contractor's punch list is complete at each of the major Project Stages and prior to completing ceiling installations (or at the final punch list stage), the Contractor shall request that the Engineer develop a punch list. This request is to be made in writing seven (7) days prior to the proposed date. After all corrections have been made from the Engineer's punch list, the Contractor shall review and initial off on each item. This signed-off punch list shall be submitted to the Engineer. The Engineer shall return to the site once to review each punch list and all work prior to the ceilings being installed and at the final punch list review. The Contractor's representative may be requested at the inspections.

D. If additional visits are required by the Engineer to review work not completed by this review, the Engineer shall be reimbursed directly by the Contractor by check or money order (due net 10 days from date of each additional visit) at a rate of $125.00 per hour plus travel expense for extra trips required to complete either of the above ceiling, below ceiling or final punch lists.

3.29 OPERATING INSTRUCTIONS:

A. Upon completion of all work and all tests, each Contractor shall furnish the necessary skilled labor and helpers for operating the systems and equipment for a period of one (1) day of eight (8) hours. During this period, instruct the Owner or their representatives fully in the operations, adjustment, and maintenance of all equipment furnished. Give at least seven (7) days written notice to the Owner, Architect and Engineer in advance of this training period. The Engineer may attend any such training sessions or operational demonstrations. The Contractor shall certify in writing to the Engineer that such demonstrations have taken place, noting the date, time and names of the Owner's representatives that were present.

B. Each Contractor shall furnish three complete bound sets for approval to the Engineer instructions for operating and maintaining all systems and equipment included in this contract. All instructions shall be submitted in draft form, for approval, prior to final issue. Manufacturer's advertising literature or catalogs will not be acceptable for operating and maintenance instructions. Refer to Specification Section SHOP DRAWINGS for additional detail.

C. Each Contractor, in the above mentioned instructions, shall include the maintenance schedule for the principal items of equipment furnished under this contract and a detailed, easy to read parts list and the name and address of the nearest source of supply.

3.30 RECORD DRAWINGS:

A. The Contractor shall insure that any deviations from the Design are as they occur recorded in red, erasable pencil on record drawings kept at the jobsite. The Engineer shall review the record documents from time to time to ensure compliance with this specification. Compliance shall be a contingency of final payment. Pay particular attention to the location of water lines, shut-off valves, and other appurtenances important to the maintenance and operation of Fire Protection Systems. Also, pay particular attention to Deviations in all exterior utilities. Keep information in a set of drawings set aside at the job site especially for this purpose and deliver to the Engineer upon completion of the work.

END OF SECTION 210500

SECTION 210501 - SCOPE OF THE FIRE SUPPRESSION WORK

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR FIRE SUPPRESSION and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

1.2 SCOPE

A. The Fire Suppression work for this Contract shall include all labor, materials, equipment, fixtures, excavation, backfill and related items required to completely install, test, place in service and deliver to the Owner the complete mechanical systems in accordance with the accompanying plans and all provisions of these specifications. This work shall primarily include but is not necessarily limited to the following paragraphs.

B. Installation of all equipment per the manufacturer’s instruction, whether specifically detailed or not.

C. Thorough instruction of the Owner’s maintenance personnel in the operation and maintenance of all mechanical equipment.

D. Thorough coordination of the installation of all piping, equipment, and any other material with other trades to insure no conflict in installation.

E. Approved supervision of the scope.

F. Procurement of all required inspections, including fees for all inspection services and submission of final certificates of inspection to the Engineers.

G. Start-up, verification, and documentation as specified.

H. Record drawings, final inspection certificates, test results, O & M documentation, warranty certification, and other specified closeout documentation.

I. Required schedule of values breakdown.

J. Pipe and equipment identifications.

K. Preinstallation meetings and equipment mockups.

L. 100% automatic sprinkler systems.

M. Drainage systems.

N. All required pressure testing, flushing, purging, pressure and flow testing requirements.

O. Final coordination and connection of all equipment furnished.

P. All required controls, including self-checkout.

END OF SECTION 210501

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SECTION 210502 – SHOP DRAWINGS, MAINTENANCE MANUALS AND PARTS LISTS

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR FIRE SUPPRESSION and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

1.2 SCOPE

A. The Contractor shall prepare and submit to the Engineer, through the Prime Contractor and the Architect within thirty (30) days after the date of the Contract, required copies of all shop drawings, certified equipment drawings, installation, operating and maintenance instructions, samples, wiring diagrams, etc. on all items of equipment specified hereinafter. Refer to Division 1 requirements for shop drawing submittal requirements.

B. The Engineer’s review of shop drawings, schedules or other required submittal data shall not relieve the Contractor from responsibility for adaptability of the item to the project; compliance with applicable codes, rules, regulations, and information that pertains to fabrication and installation; dimensions. weight and quantities; electrical characteristics; and coordination of the work with all other trades involved in this project.

PART 2 – PRODUCTS

2.1 Shop Drawings, descriptive literature, technical data and required schedules shall be submitted on the following:

Access Doors
Test Reports
Fire Protection Sprinkler System (2.2.A, 2.2.C)
Firestopping (2.2.C)
Controls & Components (2.2.B)
Valves

(Refer to the corresponding Special Notes.)

2.2 SPECIAL NOTES:

A. For all items above, upon substantial completion of the project, the Contractor shall deliver to the Engineer (in addition to the required Shop Drawings) three (3) complete copies of operation and maintenance instructions and parts lists for each item above. Where available, documents shall include at least:
1. Detailed operating instructions
2. Detailed maintenance instructions including preventive maintenance schedules.
3. Addresses and phone numbers indicating where parts may be purchased.
4. Expanded parts drawings, parts lists, service manuals, schematics, wiring diagrams.
5. Start-up reports, service records and test reports.

B. Shop drawings for the Fire Suppression Systems shall include detailed, scaled plans and schematic diagrams indicating the function and operation of the system.

C. Shop drawings for the Building Fire Protection System shall be prepared and stamped by a Certified Contractor and shall meet the criteria of the authority having jurisdiction and submitted to the Engineer.

After the Engineer's review, they shall be submitted by the Contractor to the proper state authorities along with the required agency review fee. Refer to Specification Section – FIRE PROTECTION for additional requirements.

D. The Contractor shall submit project specific UL listed firestopping installation drawings to the authority having jurisdiction where required for their approval as required.

2.3 The Contractor shall prepare and submit to the Engineer, shop drawings including design calculations, detailed catalog cutsheets and layout drawings indicating the proposed automatic sprinkler system. All layouts and drawings shall be closely coordinated by the Contractor with the work of ALL other trades. The shop drawings shall indicate the following items:

A. Name and address of Owner, Architect and Engineer.
B. Sprinkler heads including temperature rating.
C. Fire department connection.
D. Post indicator valve.
E. Detector check valves.
F. Wet pipe alarm valves and wet system specialties.
G. Flanged gate and check valves.
H. Pipe hangers.
I. Supervised O.S & Y valve.
J. Fire valve cabinets..
K. The pressure sensing switch.
L. The post indicator supervisory switch (coordinated with the Fire Alarm Contractor).
M. The main gate valve supervisory switch (coordinated with the Fire Alarm Contractor).
N. The flow switch (coordinated with the Fire Alarm Contractor).

2.4 On a set of drawings to the same scale as the drawings accompanying these specifications, indicate:

A. Each head location coordinated with lights, diffusers and other ceiling mounted device.
B. Location of all risers, mains, runout lines, etc.
C. Size of all risers, mains, runout lines, etc.
D. Location and type of pipe hangers.
E. All other information required by the Authority Having Jurisdiction providing approval.

2.5 The Contractor shall submit these shop drawings to the Engineer through the General Contractor and Architect for their review and approval. The Contractor shall submit the reviewed drawings to the Authority Having Jurisdiction for their review and approval. The Contractor shall incorporate all review comments from the Engineer and the Authority Having Jurisdiction. No work shall be performed onsite until all review processes are complete and updated drawings are on the job site.

PART 3 – EXECUTION

3.1 Provide all shops in electronic/PDF format. The Engineer’s comments will be returned in electronic format.

3.2 Each shop drawing and/or manufacturers descriptive literature shall have the proper notation indicated on it selecting equipment, accessories and features and shall be clearly referenced to the specifications, schedules, fixture numbers, etc., so that the Engineer may readily determine what the Contractor proposes to furnish. All data and information schedules indicated or specified shall be noted on each copy of each submittal.

3.3 Submittal data shall include specification data including metal gauges, finishes, accessories, etc. Also, the submittal data shall include certified performance data, wiring diagrams, dimensional data, and a spare parts list. Submittal data shall be reviewed by the Engineer before any equipment or materials is ordered or any work is begun in the area requiring the equipment.

3.4 All submittal data shall have the stamp of approval of the Contractor submitting the data as well as the Prime Contractor and the Architect to show that the drawings have been reviewed by the Contractor. Any drawings submitted without these stamps of approval may not be considered and will be returned for proper resubmission.

3.5 The Contractor shall make any corrections or changes required by the Engineer and shall re-submit for final review as outlined above.

3.6 It shall be noted that review of shop drawings by the Engineer applies only to conformance with the design concept of the project and general compliance with the information given in the Contract Documents. In all cases, the Contractor alone shall be responsible for furnishing the proper quantity of equipment and/or materials required, for seeing that all equipment fits the available space in a satisfactory manner and that piping, electrical and all other connections are suitably located. The Contractor shall also coordinate piping side connections.

3.7 Prior to ordering any materials or rough-in of any kind, the Contractor shall be responsible for final coordination of all electrical requirements (i.e., voltage, phase, circuit breaker, wire sizing, etc.) with the Electrical Contractor. There will be no change in the Contract Amount for any discrepancies. A final coordination meeting shall be held with the Architect, Owner, Engineer, Prime Contractor, Mechanical Contractor, Electrical Contractor, and their sub-contractors.

3.8 Equipment shall not be ordered and no final rough-in connections, etc., shall be accomplished until reviewed equipment shop drawings are in the hands of the Contractor. It shall be the Contractor's responsibility to obtain reviewed shop drawings and to make all connections, etc. in the neatest and most workmanlike manner possible. The Contractor shall coordinate with all the other trades having any connections, roughing-in, etc. to the equipment.

3.9 If the Contractor fails to comply with the requirements set forth above, the Engineer shall have the option of selecting any or all items listed in the Specifications or on the Drawings; and the Contractor shall be required to furnish all materials in accordance with this list.

3.10 Colors for equipment in other than mechanical spaces shall be selected from the Manufacturer's standard and factory optional colors unless noted otherwise on the Plans. Color samples shall be furnished with the shop drawing submission for such equipment.

3.11 All submittals for equipment shall include all information specified and scheduled. This shall include water pressure drops, RPM, noise data, horsepower, voltage motor type, steel or aluminum construction, and all accessories clearly marked.

3.12 All items listed in the schedules shall be submitted for review in a tabular form similar to the equipment schedule. All items submitted shall be designated with the same identifying tag as specified on each sheet.

3.13 Any submittals received in an unorganized manner without options to be provided specifically noted and with incomplete data will be returned for resubmittal.

END OF SECTION 210502

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SECTION 210515 - SLEEVING, CUTTING, PATCHING, REPAIRING AND FIRESTOPPING

1.1 GENERAL:

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR FIRE SUPPRESSION and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

1.2 SCOPE

A. The Contractor shall be responsible for all openings, sleeves, trenches, etc., that may be required in floors, roofs, ceilings, walls, etc., and shall coordinate all such work with the General Contractor and all other trades. Coordinate with the General Contractor, any openings which they are to provide before submitting a bid proposal in order to avoid conflict and disagreement during construction. Improperly located openings shall be reworked at the expense of the Contractor.

B. The Contractor shall plan their work ahead and shall place sleeves, frames or forms through all walls, floors and ceilings during the initial construction, where it is necessary for piping, ductwork, conduit, etc., to route through; however, when this is not coordinated, the Contractor shall then do all cutting and patching required for the installation of their work, or pay other trades for doing this work when so directed by the Engineer. Any damage caused to the building by this Contractor shall be corrected or rectified at their expense.

C. The Contractor shall notify other trades in due time where they will require openings or chases in new concrete, masonry, etc. Set all concrete inserts and sleeves for their work. Failing to coordinate, Contractor shall cut openings for the work and patch same as required at their expense with qualified tradesman.

D. The Contractor shall be responsible for properly shoring, bracing, supporting, etc., any existing and/or new construction to guard against cracking, settling, collapsing, displacing, or weakening while openings are being made. Any damage occurring to the existing and/or new structures, due to failure to exercise proper precautions or due to action of the elements shall be promptly and properly corrected to the satisfaction of the Engineer.

E. All work improperly performed or not performed as required in this section, shall be corrected by the General Contractor at the responsible Contractor’s expense.

PART 2 – PRODUCTS

2.1 SLEEVES:

A. Cast iron or Schedule 40 steel sleeves shall be installed through all walls where pipe enters the building below grade. Sleeves shall be flush with each face of the wall and shall be sufficiently larger than the entering pipe to permit thorough caulking between pipe and sleeve for water proofing. Horizontal sleeves passing through exterior walls or where there is a possibility of water leakage and damage shall be caulked watertight. Utilize “Link-Seal” at these locations.

B. In all cases, sleeves shall be at least two pipe sizes larger than nominal pipe diameter plus insulation. Sleeves through walls and floors shall be cut off flush with inside surface unless otherwise indicated.

C. Vertical sleeves in roofs shall be flashed and counterflashed with lead (4 lb.) or 16 oz. copper and welded or soldered to piping, lapped over sleeve and properly weather sealed. Where sleeves pass through roof construction, sleeves shall extend minimum of 12" above the roof.

2.2 FIRE STOPPING

A. Firestopping materials include (but are not limited to) wraps, strips, caulks, moldable putties, restricting collars with steel hose clamps, damming materials, composite sheets, fire dam caulks, steel sleeves, etc.

B. The following indicates the 3M penetration details for uninsulated pipe penetration of various wall and floor construction types (the list is not inclusive):
   1. One, two or three hour fire rated concrete floor - 3M #5300-MPC8.
   2. One, two or three hour fire rated solid or block concrete wall - 3M #5300-MPC16 or 3M #5300-MPC26.
   3. One hour fire rated gypsum wallboard - 3M #5300-MPC7.
   4. Two hour fire rated gypsum wallboard - 3M #5300-MPC7.

C. The following indicates the 3M penetration details for insulated pipe penetrations of various wall and floor construction types (the list is not inclusive):
   1. One, two and three hour fire rated concrete floor - 3M #5300-IMP2.
   2. One, two and three hour concrete block wall - 3M #5300-IMP2.
   3. One hour fire rated gypsum wallboard - 3M #5300-IMP4.
   4. Two hour fire rated gypsum wallboard - 3M #IMP7.

PART 3 – EXECUTION

3.1 The Contractor shall plan their work ahead and shall place sleeves, frames or forms through all walls, floors and ceilings during the initial construction, where it is necessary for piping, conduit, etc., to route through; however, when this is not coordinated, the Contractor shall then do all cutting and patching required for the installation of their work, or pay other trades for doing this work when so directed by the Engineer. Any damage caused to the building by this Contractor shall be corrected or rectified at their expense.

3.2 The Contractor shall notify other trades in due time where they will require openings or chases in new concrete, masonry, etc. Set all concrete inserts and sleeves for their work. Failing to coordinate, Contractor shall cut openings for the work and patch same as required at their expense with qualified tradesman.

3.3 The Contractor shall be responsible for properly shoring, bracing, supporting, etc., any existing and/or new construction to guard against cracking, settling, collapsing, displacing, or weakening while openings are being made. Any damage occurring to the existing and/or new structures, due to failure to exercise proper precautions or due to action of the elements shall be promptly and properly corrected to the satisfaction of the Engineer.

3.4 CUTTING:

A. All openings in plaster, gypsum board or similar materials, shall be framed by means of plaster frames, casing beads, or angle members as required. The intent of this requirement is to provide smooth, even termination of wall, floor, and ceiling finishes as well as to provide a fastening means for devices, etc.

B. The Contractor shall coordinate all openings in masonry walls with the General Contractor; and, unless otherwise indicated in the Contract Documents, shall provide lintels for all openings required for the mechanical work such as louvers, exhaust fans, etc. Prime paint all lintels. Lintels shall be sized as follows:

   1. New Openings under 48" in width: Provide one 3½"x3½"x3/8" steel angle for each 4" of masonry width. Lintel shall have 8" bearing on each end.
   2. New Openings over 48" in width: Consult with Structural Engineer.

C. No cutting shall be performed at location that will weaken the structure and unnecessary cutting must be avoided. If in doubt, contact the Engineer.

D. Pipe openings in slabs and walls shall be cut with core drill. Hammer devices will not be permitted. Edges of trenches and large openings shall be scribe-cut with a masonry saw.

3.2 PATCHING, REPAIRING AND FINISHING:

A. Patching and repairing made necessary by work performed under this Division shall be included as a part of the work and shall be done by skilled workers of the trade. The work shall be performed in strict accordance with the provisions herein before specified to match adjacent surfaces and in a manner acceptable to the Engineer.

B. Where portions of existing sites, lawns, shrubs, paving, etc. are disturbed for installation of work of this Division, such items shall be repaired and/or replaced back to original or better condition to the satisfaction of the Engineer.

C. Piping and passing through floors, ceilings and walls in finished areas shall be fitted with chrome plated brass escutcheon trim pieces of sufficient outside diameter to amply cover the sleeved openings and an inside diameter to closely fit the pipe/duct around which it is installed.

D. Flanged metal collars shall be provided around all pipes at all wall penetrations, both sides. Penetrations through any wall will require the installation of flanged collars. Openings shall not be any larger than 2” in any direction than the piping/duct passing through the wall. Openings larger than this requirement shall also be infilled to match adjacent construction. Fill void with insulation for sound reduction.

3.3 FIRESTOPPING:

A. Provide shop drawings indicating penetration detail for each type of wall and floor construction. Shop drawings must be specific for each individual type of penetration (one hour fire rated gypsum wall board with insulated metal pipe penetration, etc.) Provide copies to the authority having jurisdiction if required.

B. All pipes penetrating fire rated floors and walls shall be firestopped by this Contractor. All firestopping products and assemblies installed shall be UL listed.

C. Where the installation of conduit, ducts, piping, etc. requires the penetration of fire or smoke rated walls, ceilings or floors, the space around such conduit, duct, pipe, etc., shall be tightly filled with an approved non-combustible fire insulating material and properly sealed to maintain the rating integrity of the wall, floor or ceilings affected.

D. The manufacturer of the firestopping materials shall provide on site training for the installing Contractor. The training session shall demonstrate to the Contractor the proper installation techniques for all the firestopping materials.

E. Firestopping materials include (but are not limited to) wraps, strips, caulks, moldable putties, restricting collars with steel hose clamps, damming materials, composite sheets, fire dam caulks, steel sleeves, etc.

F. The following indicates the 3M penetration details for uninsulated pipe penetration of various wall and floor construction types (the list is not inclusive):
   1. One, two or three hour fire rated concrete floor - 3M #5300-MPC8.
   2. One, two or three hour fire rated solid or block concrete wall - 3M #5300-MPC16 or 3M #5300-MPC26.
   3. One hour fire rated gypsum wallboard - 3M #5300-MPC7.
   4. Two hour fire rated gypsum wallboard - 3M #5300-MPC7.

G. Multiple pipes penetrating fire rated floors and walls may be firestopped as a group. Submit details for specific applications if this method of firestopping is chosen.

END OF SECTION 210515

SECTION 210553 - IDENTIFICATIONS, TAGS, CHARTS, ETC.

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR FIRE SUPPRESSION and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

PART 2 – PRODUCTS:

2.1 TAGS AND CHARTS

A. Provide and install on each valve 1” in size or greater for all mechanical systems a 1.5" diameter circular bronze or baked phenolic tag fitted to each valve so that it cannot be removed. Each tag shall be embossed consecutively with sequential number identifiers. Number identifiers shall be determined by the Contractor sequentially.

B. Provide typewritten valve charts indicating each valve identifier, the valves service, normal position, and its location. Also furnish one electronic copy on CD in “*.xls” format. One (1) copy of this chart shall be mounted in suitable frame(s) with clear plastic covers in a conspicuous location in each of the major mechanical rooms. Repeat only main valves which are to be operated in conjunction with operations of more than single mechanical room.

C. All emergency shutoff valves shall be identified with a permanent engraved tag hung from the valve with 1-inch high lettering. Emergency shutoff valves shall be identified.

D. Label all control panels and disconnect switches with service and equipment served.

2.2 PIPING IDENTIFICATION:

A. All piping and ductwork installed shall be identified according to the charts hereinafter specified. Provide stenciled markers and arrows indicating direction of flow on all piping and ductwork installed under this contract. Markers and arrows shall be painted on the piping and ductwork using machine cut stencils. All letters shall be sprayed using fast drying lacquer paint. All markers and arrows shall be properly oriented so that descriptive name may be easily read from the floor. Piping and ductwork shall be identified on twelve (12) foot centers. All piping and ductwork shall be minimally identified once above all room ceilings and where it passes thru walls or floors. At the Contractor's option, Setmark or equivalent manufactured marking system may be substituted for field marking.

B. The following table describes the size of the color field and size of the identification letters which shall be used for pipes of different outside pipe diameters.

Outside Diameter	Label Length	Letter Size
¾” – 1 ¼”	8”	½”
1 ½” – 2”	8”	¾”
2 ½” – 6”	12”	1 ¼”
8” – 10” 24”		2 ½”

C. The following chart describes the pipe service and label identification which shall be used for various pipes.

PIPE	ABBREVIATION
Fire Protection	SPRINKLER

PART 3 - EXECUTION

3.1 EQUIPMENT IDENTIFICATION:

A. Unless otherwise specified, all equipment shall be identified. The titles shall be short and concise, and abbreviations may be used as long as the meaning is clear. In finished rooms and mechanical rooms, equipment shall be identified neatly and conspicuously with engraved black lamacoid plates (or equivalent) with 1" high white letters on the front of each piece of equipment.

B. All equipment and associated starters/disconnects shall have the electrical panel number and circuit number identified on a lamacoid plate. Coordinate with the Electrical Contractor.

3.2 ACCESS THROUGH LAY-IN CEILINGS:

A. Mark each lay-in ceiling panel which is nearest access to equipment, valves, dampers, filters, duct heaters, etc., with colored tape labels located on the ceiling grid.

END OF SECTION 210553

SECTION 211000 - FIRE PROTECTION SYSTEM

PART 1 - GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR FIRE SUPPRESSION and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. Each Contractor’s attention is also directed to Specification Section SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS LISTS FOR FIRE SUPPRESSION.

1.2 SCOPE

A. No Contractor, other than those regularly engaged in the installation of approved and franchised automatic sprinkler systems will be considered or approved for the work under this Specification Section. The Contractor shall have not less than five (5) years experience in the fabrication and erection of fire protection systems as specified. The Contractor shall have completed five (5) installations similar and equivalent in scope to the systems specified.

B. Before submitting bid, examine the Contract Documents, visit the site (if necessary) and become acquainted with all conditions that may, in any way whatsoever, affect the execution of this work. The Contractor shall take their own measurements and be responsible for exact size and location of all openings required for installation of this work. Figured dimensions where indicated are reasonably accurate and should govern in setting out work. Detailed method of installation is not indicated. Where variations exist between described work and approved practice, the Engineer shall be consulted for directive.

C. It is the intent of the Plans and Specifications to provide a general layout only and locate major equipment, components, piping, etc. Variations in head locations, pipe routing, etc., shall be anticipated by the Contractor and shall be coordinated with all other trades and indicated on the drawings and descriptive literature called for hereinafter. It shall be the express responsibility of the Contractor to provide all required design, materials and equipment and perform all work required to install a complete and approved installation.

D. All materials and methods shall be in accordance with applicable codes, regulations and/or ordinances and meet approval of local inspection authority and the State Fire Marshal. Also, all work shall comply with the latest editions of the National Board of Fire Underwriters, National Fire Protection Association, OHSA Regulations, the International Building Code, the Life Safety Code, International Mechanical Code and governing building codes. All materials and equipment installed as a part of this work shall be listed by the Underwriters Laboratories, Inc. as approved for fire protection installations.

E. Where flow and pressure data are available, they are indicated on the project drawings. The Contractor shall independently verify all such information and notify the Engineer of any discrepancies discovered prior to beginning the work. Where no flow information is indicated on the project drawings, the Contractor shall obtain the data and indicate it on the shop drawing submittal. All flow information obtained shall be less than six (6) months old. Piping systems shall be hydraulically sized based on the most conservative flow information obtained. No adjustments in the contract amount will be allowed for failure of the Contractor to obtain adequate flow information.

F. The Owner’s local insuring agency may review plans prepared and submitted by the Contractor but shall have no authority to make changes once work has begun. Coordinate with the Owner prior to construction.

G. All work performed under this section shall be accomplished in close harmony with all other trades. All work not so coordinated shall be removed and reinstalled at the expense of the Contractor.

PART 2 – PRODUCTS:

2.1 The Contractor shall contact the servicing water company and ascertain their policy pertaining to the bypass water meter. If not furnished by water company, the Contractor shall furnish and install the bypass meter and trimming as detailed on the drawings.

2.2 FIRE DEPARTMENT CONNECTION: Furnish and install a fire department connections with threads as approved by the local fire department; cast brass polished and chromium plated; with connection sizes and lettering as directed by the local authority having jurisdiction; Viking, Automatic Sprinkler Corporation, or approved equivalent.

2.3 WET ALARM VALVES: All alarm valves must be UL and FM approved. Alarm valve shall have a grooved seat design with retarding chamber. Valve shall be rated for 175 PSI working pressure. Valve shall be provided with external bypass line and drain valve. Reliable, Gem, Grinnell, Star, Viking or approved equal.

2.4 TAMPER SWITCHES FOR WATER SHUT-OFF VALVES: Furnish and install tamper switches where required by NFPA 13. All tamper switches shall be UL approved. Coordinate with Fire Alarm System supplier/installer. All tamper switches located in fire protection pits shall be waterproof, capable of operating beneath water and be NFPA approved.

2.5 GATE VALVES: 2½" and over; listed and approved by UL and FM; marked SV-FM; 175# working pressure; 1 BBM; OS&Y; flanged; cast iron discs; bronze seat rings; four point wedging mechanism; equivalent to Mueller, Scott or Lunkenheimer. 2" and under; 150# working pressure; bronze; rising stem; screwed; bronze discs; bronze seat rings; two point wedging mechanism; equivalent to Jenkins, Scott or Lunkenheimer.

2.6 CHECK VALVES: 2½" and over; listed and approved by UL and FM; marked SV-FM; 175# working pressure; 1 BBM; flanged; equivalent to Mueller, Scott, or Lunkenheimer. 2" and under; 150# working pressure; bronze; screwed; equivalent to Jenkins, Scott, or Lunkenheimer.

2.7 INTERIOR PIPE & FITTINGS: Up to 2" Schedule 40 ASTM A-53 black steel; 125# cast iron screwed fittings. 2½" and larger. Schedule 40 black steel with flanged, welded or victaulic (or similar) type approved fittings.

2.8 SPRINKLER HEADS: Gem, Grinnell, Star, Viking, Reliable: All sprinkler heads shall be fed in a reverse bend arrangement. Sprinkler head degree ratings shall be determined by the area serviced in accord with current Codes and Standard Practices. Types of sprinkler heads shall be as follows:

A. Semi-Recessed, Quick Response – Reliable (or equal) Model F1FR-300 semi-recessed automatic sprinkler head. Escutcheon and head shall be white.
B. Upright, Quick Response – Reliable (or equal) Model F1FR Vertical Upright automatic sprinkler head.
C. Sidewall, Quick Response – Reliable (or equal) Model GFR, horizontal sidewall automatic sprinkler head.
D. Concealed, Quick Response – Reliable (or equal) Model G4A Concealed automatic sprinkler head. Cover shall be white. Concealed heads shall be installed where ceilings are 9’ high or less.
E. Caged, Pendent, Quick Response – Reliable (or equal) Model F1FR Vertical Upright automatic sprinkler head with D1 cage, per NFPA requirements. Provide caged sprinkler heads in gym and multipurpose rooms and in rooms where the ceilings are 7’-6’’ or lower.
F. High Temperature Heads: Viking Micromatic 286 degrees F rated blue bulb heads.

G. At the Contractor's option, extended coverage sprinkler heads may be used where appropriate and allowed by code.

H. At the Contractor's option, code approved flexible sprinkler heads may be used where appropriate and in compliance with the installation requirements of these specifications. Flexible hose must accommodate a bend radius of 2" and up to 5 bends on a 36" SS braided hose and include options/accessories for low-profile install variations.

I. When working in existing facilities, sprinkler heads style and color shall match existing.

2.9 CLAMPS AND ANCHORS: Furnish and install approved clamps, as required, at all (45 degree) l/8 bends, (90 degree) ¼ bends and flange and spigot pieces to the straight pipe to insure permanent anchorage of all fire lines. Fittings, clamps, clamp rods, nuts, washers, and glands shall be factory zinc coated.

2.10 HANGERS: All piping shall be adequately and permanently supported in an approved manner on approved hangers. Minimally support piping on 8 foot intervals for pipe 3" and smaller; 10 foot intervals for larger piping. Also support within 24" of changes in direction and end of runs.

2.11 SLEEVES AND ESCUTCHEON PLATES: Furnish and install sleeves for pipes where piping penetrates masonry walls; exterior wall sleeves to be watertight. Fire and smoke stop all penetrations through fire and smoke walls and coordinate with General Contractor for locations. Furnish and install cast brass chrome plated split ring type escutcheons where piping penetrates walls, ceilings, and floors, whether in finished areas or not.

2.12 INSPECTION TEST CONNECTIONS & PRESSURE GAUGES: A 1" inspection test connection as required by the Building Code. Discharge shall run to open air. Control valve for test connection shall be installed not over 7' above the floor. A pressure gauge at the inspection. Test connection at each location indicated on the Plans. Pressure gauges shall be 2½" diameter and readable from the floor.

2.13 SIGNS: Appropriate code approved and required signs shall be installed on all control valves, drains, inspector's test, etc., indicating the function, installation, etc. Signs shall be neatly affixed with rust inhibitive screws, rivets or where hung from piping; with stainless steel No. 14 AWG wire.

2.14 SPRINKLER HEAD CABINET: Furnish and install a cabinet, clearly labeled, with four (4) sprinklers of each type complete with required wrenches. Locate as directed by Engineer. Label "Sprinkler Heads".

2.15 FIRE VALVE CABINETS: The products specified hereunder shall be Croker or equivalent by Larsen's Mfg. Co., J.L. Industries, Kidde, or approved equal. Valve cabinets for recessed installation at all locations where shown shall be similar to Croker Model No. 2700 with flat trim and clear glazed full glass door. Provide 18 ga. steel tub, 20 gauge steel door, 16 gauge steel frame and white enamel finish interior with all exposed exterior portions painted with color selected by Architect. Each cabinet shall be equipped with one 2½" Fire Department valve with cap and chain. All connections and threads shall be as required by the local authority.

PART 3 – EXECUTION:

3.1 Furnish all material, labor, tools, equipment, and supervision required for installation of a complete and new fire protection system as indicated on the project drawings and within these specifications. Include all necessary piping, sprinkler heads, test connections, valves, drains, etc.

3.2 The Contractor shall provide flushing and sterilization of all water lines in accordance with current Codes, Rules and Regulations and shall make connection to domestic water mains in accord with current rules and regulations of the State Department of Sanitary Engineering and Division of Water.

3.3 The Contractor shall obtain and pay for all necessary state, municipal, county, city and other permits and fees and pay all State taxes which are applicable.

3.4 All workmanship, equipment and material shall be guaranteed in writing against defects from any cause, other than misuse, for a period of one year from substantial completion.

3.5 Upon completion, the Contractor shall submit to the Engineer, a properly completed "Sprinkler Contractor's Certificate Covering Materials and Tests" form.

3.6 Upon completion of this work all debris, material, and equipment shall be removed from the building and premises; all piping shall be cleaned ready for finish painting. Do not remove rust inhibitive primer specified hereinafter.

3.7 Do not route sprinkler piping (including drops) directly above any light fixtures. Do not route sprinkler piping near ceiling; hold tight to structure. Where large volumes occur above ceiling route pipe at least 36" above ceiling. Do not route piping within 10' from electrical switchboards and panel boards. The Sprinkler Contractor shall coordinate during design of sprinkler systems to ensure these requirements are met.

3.8 Where sprinkler heads are installed in a tile ceiling, they shall be installed in the middle of the tiles, at half or quarter points along the length of the tiles.

3.9 Coordinate sprinkler head locations in kitchen freezer/cooler units with light fixtures and other ceiling mounted devices to ensure proper coverage is maintained. Provide these heads with cages. Seal freezer/cooler panels where pipe penetrations occur.

3.10 SYSTEM DRAINAGE:

A. The entire System except that part which is below grade and will not freeze shall be installed so as to allow 100% drainage.

B. All sprinkler branch piping shall be installed so as to drain back to the main riser.

C. Approved 2" drawoff piping shall be provided on sprinkler risers with discharge piping running to nearest floor drain or open air.

D. Where sprinkler piping is trapped, an approved auxiliary draw-off shall be provided and neatly installed.

E. All draw-offs shall have a metal tag labeled "Sprinkler Drain".

3.11 INSPECTIONS AND TESTS:

A. Furnish all labor, equipment and conduct all required tests in the presence of the Owner and Engineer or designated representative if requested. Coordinate with Owner and Engineer prior to testing.

B. All interior and exterior piping and devices comprising the fire protection system shall be tested under hydrostatic pressure of not less than 200 PSI and maintained for not less than two (2) hours. Any leaks or cracks developing as a result of these tests shall be repaired to the satisfaction of the Owner.

C. Upon completion of their work, the Contractor shall submit a written and signed certificate to the Engineer indicating that they performed the above prescribed tests and rectified all malfunctions arising therefrom.

3.12 ABOVE CEILING PIPING RELOCATION

A. Include in this project, the relocation of the following piping systems:
   1. Offset (__), 1" fire protection pipes, with (4) elbows and 20 feet total length.
   2. Offset (__), 1-1/4" fire protection pipes, with (4) elbows and 20 feet total length.

B. During Construction, the Contract Sum shall be increased OR decreased based on Contract unit prices for each of the above.

END OF SECTION 211000

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SECTION 220500 – COMMON WORK RESULTS FOR PLUMBING

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Advertisement for Bid, Instructions to Bidders, Bidding Requirements, General, Special and Supplementary Conditions, and all other Contract Documents shall apply to the Contractor's work as well as to each of their Sub-Contractor's work.

1.2 DESIGN CRITERIA

A. All manufacturers, suppliers, fabricators, contractors, etc. submitting proposals for any part of the work, services, materials, or equipment to be used on or applied to this project are hereby directed to familiarize themselves with the Contract Documents. In case of conflict between these General Provisions and the General and/or Special Conditions, the Contractor shall contact the Engineer for clarification and final determination prior to the Bid.

B. The work included in this Division consists of the furnishing of all labor, equipment, transportation, excavation, backfill, supplies, material, appurtenances, and services necessary for the satisfactory installation of the complete and operating Plumbing Systems indicated or specified in the Contract Documents.

C. Any materials, labor, equipment, or services not mentioned specifically herein which may be necessary to complete any part of the Plumbing Systems in a substantial manner, in compliance with the requirements stated, implied, or intended in the Plans and/or Specifications, shall be included in the Bid as part of this Contract.

D. It is not the intent of this Section of the Specifications to make any Contractor, other than the Prime Contractor, responsible to the Owner. All transactions such as submittal of shop drawings, claims for extra costs, requests for equipment or materials substitution, shall be routed through the Prime Contractor to the Architect, then to the Engineer. Also, this Section of the Specifications shall not be construed as an attempt to arbitrarily assign responsibility of work, material, equipment or services to a particular trade or Contractor. Unless stated otherwise, the subdivision and assignment of work under the various sections shall be optional.

E. The Architect and Engineer do not define the scope of individual trades, subcontractors, material suppliers and vendors. Any sheet numbering system or specification numbering system used which identifies disciplines is solely for the Architect and Engineer’s convenience and is not intended to define a subcontractor’s scope of work. Information regarding individual trades, subcontractors, material suppliers and vendors may be detailed, described, and indicated at different locations throughout the Contract Documents. No consideration will be given to requests for change orders for failure to obtain and review the complete set of Contract Documents when preparing Bids, prices, and quotations. Unless stated otherwise, the subdivision and assignment of work under the various sections shall be the responsibility of the Contractor holding the prime contract.

F. It is the intent of the Contract Documents to deliver to the Owner a new, complete, and operational project once the work is complete. Although Plans and Specifications are complete to the extent possible, it shall be the responsibility of the Contractors involved to remove and/or relocate or re-attach any existing or new systems which interfere with new equipment or materials required for the complete installation without additional cost to the Owner.

G. In general, all work shall be accomplished without interruption of existing facilities operations. The Contractor shall advise the Owner at least seven (7) days prior to the interruption of any services (gas, domestic water, heating, etc.). The Owner shall be advised of the exact time that interruption will occur and the length of time the interruption will last. Failure to comply with this requirement may result in

complete work stoppage for the Contractors involved until a complete schedule of interruptions can be developed.

H. Whenever utilities are interrupted, either deliberately or accidentally, the Contractor shall work continuously to restore said service. The Contractor shall provide tools, materials, skilled journeymen of Bidder/Proposer's own and other trades as necessary, premium time as needed and coordination with all applicable utilities, including payment of utility company charges (if any), all without requests for extra compensation from the Owner.

I. Each Bidder/Proposer shall also be governed by any unit prices and Addenda insofar as they may affect part of their work or services.

J. DEFINITIONS AND ABBREVIATIONS:
1. Contractor - Any Contractor whether bidding, proposing, or working independently or under the supervision of a General Contractor, Prime Contractor, Construction Manager and who installs any type of Mechanical Work as specified in the Contract Documents or, the General Contractor.
2. Engineer - The Consulting Mechanical-Electrical Engineer either consulting to the Owner, Architect, or Other, etc. In this case: CMTA, Inc., Consulting Engineers.
3. Architect - The Architect of Record for the project.
4. Contract Documents - All documents pertinent to the quality and quantity of work to be performed on this project. Includes, but not limited to: Plans, Specifications, Instructions to Bidders, General and Special Conditions, Addenda, Alternates, Lists of Materials, Lists of Sub-Contractors, Unit Prices, Shop Drawings, Field Orders, Change Orders, Cost Breakdowns, Schedules of Value, Periodical Payment Requests, Construction Contract with Owner, etc.
5. Bidder/Proposer - Any person, agency or entity submitting a proposal to any person, agency or entity for any part of the work required under this contract.
6. The Project - All of the work required under this Contract.
7. Furnish - Deliver to the site in good condition and turn over to the Contractor who is to install.
8. Provide - Furnish and install complete, tested and ready for operation.
9. Install - Receive and place in satisfactory operation.
10. Indicated - Listed in the Specifications, shown on the Plans or Addenda thereto.
11. Typical or Typ.- Where indicated repeat this work, method or means each time the same or similar condition occurs whether indicated or not.
12. ADA - Americans with Disabilities Act.
13. AGA - American Gas Association.
14. ANSI - American National Standards Institute.
15. ASME - American Society of Mechanical Engineers.
16. IBC - International Building Code.
17. NEC - National Electrical Code.
18. NEMA - National Electrical Manufacturers Association.
19. NFPA - National Fire Protection Association.
20. OHSA - Office of Safety and Health Administration.
21. UL - Underwriters Laboratories.

1.3 INTENT AND INTERPRETATION:

A. It is the intention of the Contract Documents to call for a complete and operational system, including all components, accessories, finish work, etc as necessary for trouble free operation, tested and ready for operation. Anything that may be required, implied, or inferred by the Contract Documents shall be provided and included as part of the Bid.

B. All Contractors and Vendors providing a bid for this project shall review the Plans and Specifications and determine any modifications and/or adjustments necessary relative to the proposed equipment and materials with specific manufacturer's installation requirements. Include in the bid any necessary installation methods, features, options, accessories, etc. necessary to install the proposed equipment and materials, regardless of whether used as basis of design or being offered as a substitution in accordance with the

specific manufacturer's installation requirements whether specifically detailed or not within the Plans and Specifications.

C. Details not usually shown or specified, but necessary for the proper installation and operation of systems, equipment, materials, etc., shall be included in the work, the same as if herein specified or indicated.

D. The Bidder/Proposer shall completely review the Contract Documents. Any interpretation as to design intent or scope shall be provided by the Engineer / Architect. Should an interpretation be required, the Bidder/Proposer shall request a clarification not less than ten (10) days prior to the submission of the proposal so that the condition may be clarified by Addendum. In the event of any conflict, discrepancy, or inconsistency develops; the interpretation of the Engineer shall be final.

E. The Contractor shall give written notice of any materials or apparatus believed inadequate or unsuitable; in violation of laws, ordinances, rules, or regulations of authorities having jurisdiction; and any necessary items of work omitted a minimum of ten (10) days prior to bid. In the absence of such written notice and by the act of submitting a bid, it shall be understood that the Contractor has included the cost of all required items in the bid, and that will be responsible for the approved satisfactory functioning of the entire system without extra compensations.

1.4 INDEMNIFICATION:

A. The Contractor shall hold harmless and indemnify the Engineer, employees, officers, agents and consultants from all claims, loss, damage, actions, causes of actions, expense and/or liability resulting from, brought for, or on account of any personal injury or property damage received or sustained by any person, persons, (including third parties), or any property growing out of, occurring, or attributable to any work performed under or related to this contract, resulting in whole or in part from the negligence of the Contractor, any subcontractor, any employee, agent or representative.

1.5 PLANS AND SPECIFICATIONS:

A. The Plans are diagrammatic only and indicate the general arrangement of the systems and are to be followed. If deviations from the layouts are necessitated by field conditions, detailed layouts of the proposed departures shall be submitted to the Engineer for approval before proceeding with the work. The Plans are not intended to show every item which may be necessary to complete the systems. All Bidder/Proposers shall anticipate that additional items may be required and submit their Bid accordingly.

B. The Plans and Specifications are intended to supplement each other. No Bidder/Proposer shall take advantage of conflict between them, or between parts of either. Should this condition exist, the Bidder/Proposer shall request a clarification not less than ten (10) days prior to the submission of the proposal so that the condition may be clarified by Addendum. In the event that such a condition arises after work is started, the interpretation of the Engineer shall be final.

C. The Plans and Specifications shall be considered to be cooperative and anything appearing in the Specifications which may not be indicated on the Plans or conversely, shall be considered as part of the Contract and must be executed the same as though indicated by both.

D. Contractor shall make all of their own measurements in the field and shall be responsible for correct fitting. The work shall be coordinated with all other branches of work in such a manner as to cause a minimum of conflict or delay.

E. The Engineer shall reserve the right to make adjustments in location of piping, ductwork, equipment, etc. where such adjustments are in the interest of improving the project.

F. Should conflict, overlap or duplication of work between the various trades become evident, this shall be called to the attention of the Engineer. In such event neither trade shall assume to be relieved of the work which is specified under their branch until instructions in writing are received from the Engineer.

G. Unless dimensioned, the Plans only indicate approximate locations of equipment, piping, ductwork, etc. Dimensions given in figures on the Plans shall take precedence over scaled dimensions and all dimensions, whether given in figures or scaled, shall be verified in the field to insure no conflict with other work.

H. Each Bidder/Proposer shall review all Plans in the Contract Documents to ensure that the work they intend to provide does not create a conflict with or affect the work of others in any way. Where such effect does occur, it shall be the Bidder/Proposer's responsibility to satisfactorily eliminate any such conflict or effect prior to the submission of their proposal. Each Bidder/Proposer shall in particular ensure that there is adequate space to install their equipment and materials. Failure to do so shall result in the correction of such encroachment conflict or effect of any work awarded the Bidder/Proposer and shall be accomplished fully without expense to others and that they are reasonably accessible for maintenance. Check closely all mechanical and electrical closets, chases, ceiling voids, wall voids, crawl spaces, etc., to insure adequate spaces.

I. Where on the Plans a portion of the work is drawn out and the remainder is indicated in outline, or not indicated at all, the parts drawn out shall apply to all other like portions of the work. Where ornamentation or other detail is indicated by starting only, such detail shall be continued throughout the courses or parts in which it occurs and shall also apply to all other similar parts of the work, unless otherwise indicated.

J. Details not usually shown or specified, but necessary for the proper installation and operation of systems, equipment, materials, etc., shall be included in the work, the same as if herein specified or indicated.

K. Where within the Contract Documents the word “typical” or “typ.” is used, it shall mean that the work method or means indicated as typical shall be repeated in and each time it occurs whether indicated or not.

L. Each Contractor shall evaluate ceiling heights specified on Architectural Plans. Where the location of equipment or systems may interfere with ceiling heights or maintenance and access of equipment or systems, the Contractor shall call this to the attention of the Engineer in writing prior to making the installation. Do not install equipment or systems in the affected area until the conflict is resolved. Any such changes shall be anticipated and requested sufficiently in advance so as to not cause extra work or cost incurred on the part of the Contractor or unduly delay the work.

M. The Contractor shall provide a layout confirmation of equipment rooms to verify that all of the equipment submitted and approved will in fact fit into the proposed space and have adequate clearance for service. See COORDINATION DRAWINGS SECTION.

1.6 EQUIPMENT AND MATERIALS SUBSTITUTIONS OR DEVIATIONS:

A. When any Contractor requests approval of materials and/or equipment of different physical size, weight, capacity, function, color, access, that the design allows for it shall be understood that such substitution, if approved, will be made without additional cost to anyone other than the Contractor requesting the change regardless of changes in connections, space requirements, electrical characteristics, etc. from that indicated, electrical service, etc. In all cases where substitutions affect other trades, the Contractor requesting such substitutions shall advise all such Contractors of the change and shall compensate them for all necessary changes in their work. Any Plans, Specifications, Diagrams, etc., required to describe and coordinate such substitutions or deviations shall be professionally prepared at the responsible Contractor's expense. Review of Shop Drawings by the Engineer does not in any way absolve the Contractor of this responsibility.

B. Notwithstanding any reference in the Specifications to any article, device, product, material, fixture, form, or type of construction by name, make or catalog number, such reference shall be interpreted as establishing a standard of quality and shall not be construed as limiting competition; any devices, products,

materials, fixtures, forms, or types of construction which, in the judgment of the Engineer, are equivalent to those specified are acceptable, provided the provisions of this Part are met. Requested substitutions shall be submitted to the Engineer a minimum of ten (10) days prior to Bid. If this procedure is not followed, the substitution will be rejected. If prevailing laws of cities, towns, states, or countries are more stringent than these specifications regarding such substitutions, then those laws shall prevail over these requirements.

C. Wherever any equipment and material is specified exclusively only such items shall be used unless substitution is accepted in writing by the Engineer.

D. Each Bidder/Proposer shall furnish along with their proposal a list of specified equipment and materials which is to be provided. Where several makes are mentioned in the Specifications and the Contractor fails to state which, they propose to furnish, the Engineer shall choose any of the makes mentioned without change in price. Inclusion in this list shall not ensure that the Engineer will approve shop drawings unless the equipment, materials, etc., submitted in shop drawings are satisfactorily comparable to the items specified and/or indicated.

1.7 QUALIFICATIONS OF CONTRACTOR/WORKERS:

A. All Contractors and their subcontractors bidding this project must have been a licensed company for a minimum of three (3) years to qualify to Bid this project. Individual employee experience does not supersede this requirement.

B. All plumbing subcontractors bidding the plumbing scope of work must have completed one project of 70% this subcontract cost size and two projects of 50% this subcontract cost size.

C. The Contractor shall hold all required licenses in the State which the work is to be performed.

D. All plumbing work shall be accomplished by Journeymen Plumbers under the direct supervision of a Master Plumber as defined under State Plumbing Law Regulations and Code. Proof and Certification may be requested by the Engineer.

E. All insulation and pipe fitting work shall be installed by workers normally engaged in this type work.

F. All automatic control systems shall be installed by workers normally engaged or employed in this type work.

G. All special systems (Controls, etc.) shall be installed only by workers normally engaged in such services. Exception to this specification may only be made in writing by the Engineer.

H. All electrical work shall be accomplished by Licensed Journeymen electricians under the direct supervision of a licensed Electrician. All applicable codes, utility company regulations, laws and permitting authority of the locality shall be fully complied with by the Contractor.

1.8 NOISE, VIBRATION OR OSCILLATION:

A. All work shall operate under all conditions of load without any sound or vibration which is objectionable in the opinion of the Engineer. In case of moving machinery, sound, or vibration noticeable outside of room in which it is installed, or annoyingly noticeable inside its own room, will be considered objectionable. Sound or vibration conditions considered objectionable by the Engineer shall be corrected in an approved manner by the Contractor at their expense.

B. All equipment subject to vibration and/or oscillation shall be mounted on vibration supports whether indicated or not suitable for the purpose of minimizing noise and vibration transmission and shall be isolated from external connections such as piping, ducts, etc. by means of flexible connectors, vibration absorbers, or other approved means.

C. The Contractor shall provide supports for all equipment they furnish. Supports shall be liberally sized and adequate to carry the load of the equipment and the loads of attached equipment, piping, etc. All equipment shall be securely fastened to the structure either directly or indirectly through supporting members by means of bolts or equally effective means. If strength of supporting structural members is questionable, contact Engineer.

1.9 EQUIPMENT/CONTROLS STARTUP & VERIFICATION:

A. The Contractor and their Subcontractors shall include in the bid to provide equipment and startup and verification for ALL Systems specified for this project.

B. A pre-start-up conference shall be held with the Architect, Engineer, Owner, General Contractor, Mechanical Contractor, Electrical Contractor, Controls Contractor, Test and Balance Contractor, and the Manufacturer's providing startup services. The purpose of this meeting will be to discuss the goals, procedures, etc. for start-up.

C. Specific line-items shall be included on the schedule of values by each Trade for "equipment and controls startup". These line-item values shall be approved by the Engineer. The General Contractor, Owner and the Engineer's Field Inspector(s) shall closely monitor progress and quality of the equipment and controls startup and may withhold pay requests as deemed appropriate until satisfactorily completed.

D. Specific startup/verification specifications are included throughout the Project Specifications. In general, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians, not third party contractors, and shall complete and submit start-up reports/checklists. The Contractor shall have appropriate trades on site to correct all deficiencies noted by the factory representative. For each deficiency noted, documentation of corrective action (including date and time) shall be submitted to the Engineer and Owner. Where factory start-up is not specified for a particular piece of equipment or system, the Contractor shall be responsible to perform start-up. All information shall be completed by the Contractor and submitted to the Owner/Engineer prior to acceptance of the equipment.

E. The Contractor shall be responsible for completion of Manufacturer's Checklists. Factory authorized startup is required for all equipment. Unless noted otherwise, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians and shall complete and submit start-up reports/checklists. This shall include the following:
   1. Water Heating System

F. The manufacturer's recommended startup procedures and checklists will be acceptable for use in the project. All startup/verification process shall be thoroughly documented by the Contractor and shall include the time and date when performed.

1.10 HAZARDOUS MATERIALS:

A. The Contractor is hereby advised that it is possible that asbestos and/or other hazardous materials are or were present in this building or site.

B. Any worker, occupant, visitor, inspector, etc., who encounters any material of whose content they are not certain shall promptly report the existence and location of that material to the Contractor and/or Owner. The Contractor shall, as a part of their work, ensure that their workers are aware of this potential and what they are to do in the event of suspicion. The Contractor shall also keep uninformed persons from the premises during construction. Furthermore, the Contractor shall insure that no one comes near to or in contact with any such material or fumes therefrom until its content can be ascertained to be non-hazardous.

C. CMTA, Inc., Consulting Engineers, have no expertise in the determination of the presence of hazardous materials. Therefore, no attempt has been made by them to identify the existence or location of any such material. Furthermore, CMTA nor any affiliate thereof will neither offer nor make any recommendations relative to the removal, handling, or disposal of such material.

D. If the work interfaces, connects or relates in any way with or to existing components which contain or bear any hazardous material, asbestos being one, then, it shall be the Contractor's sole responsibility to contact the Owner and so advise them immediately.

E. The Contractor by execution of the contract for any work and/or by the accomplishment of any work thereby agrees to bring no claim relative to hazardous materials for negligence, breach of contract, indemnity, or any other such item against CMTA, its principals, employees, agents, or consultants. Also, the Contractor further agrees to defend, indemnify, and hold CMTA, its principals, employees, agents, and consultants, harmless from any such related claims which may be brought by any subcontractors, suppliers or any other third parties.

F. No asbestos or mercury containing materials shall be installed in this project.

G. It is the policy of the University that no asbestos - containing materials are to be purchased by the University, supplied by any person supplying to the University or installed in or on university property by any person performing work for the University. Furthermore, all products marked “May contain Mineral Fiber” will be assumed to contain asbestos unless the manufacturer provides written certification that no asbestos fibers are present in the product and identifies the fibers for which the product is marked. An exception to this rule can be made where a faculty or staff member certifies that the use of asbestos is essential to an ongoing research or production project and works with Environmental Health and Safety Department to ensure that the material is used, stored, and disposed of in safe and legal manner.

PART 2 – PRODUCTS – (NOT APPLICABLE)

PART 3 – EXECUTION

3.1 EXAMINATION OF SITE AND CONDITIONS:

A. Each Bidder/Proposer shall inform themselves of all of the conditions under which the work is to be performed, the site of the work, the structure of the ground, above and below grade, the obstacles that may be encountered, the availability and location of necessary facilities and all relevant matters concerning the work.

B. Each Bidder/Proposer shall also fully acquaint themselves with all existing conditions as to ingress and egress, distance of haul from supply points, routes for transportation of materials, facilities and services, availability of utilities, etc. A proposal shall cover all expenses or disbursements in connection with such matters and conditions. No allowance will be made for lack of knowledge concerning such conditions after Bids are accepted.

3.2 CODES, RULES, PERMITS, FEES, INSPECTIONS, REGULATIONS, ETC.:

A. The Contractor shall give all necessary notices, obtain, and pay for all permits, government sales taxes, fees, inspections, and other costs, including all utility connections, meters, meter settings, taps, tap fees, extensions, etc. in connection with their work. They shall also file all necessary plans, prepare all documents, and obtain all necessary approvals of all governmental departments and/or the appropriate municipality or utility company having jurisdiction, whether indicated or specified or not. They shall also obtain all required certificates of inspection for their work and deliver same to the Engineer before request for acceptance and final payment for the work.

B. Ignorance of Codes, Rules, regulations, utility company requirements, laws, etc., shall not diminish or absolve Contractor's responsibilities to provide and complete all work in compliance with such.

C. The Contractor shall include in their work, without extra cost, any labor, materials, services, apparatus, and Plans in order to comply with all applicable laws, ordinances, rules and regulations, whether or not indicated or specified.

D. All materials furnished and all work installed shall comply with the National Fire Codes of the National Fire Protection Association, with the requirements of local utility companies, or municipalities and with the requirements of all governmental agencies having jurisdiction.

E. All materials and equipment so indicated and all equipment and materials for the electrical portion of the mechanical systems shall bear the approval label of or shall be listed by the Underwriters' Laboratories (UL), Incorporated. Each packaged assembly shall be approved as a package. Approval of components of a package shall not be acceptable.

F. All plumbing work is to be constructed and installed in accordance with applicable codes, Plans and Specifications which have been approved in their entirety and/or reflect any changes requested by the Authority Having Jurisdiction. Plumbing work shall not commence until such Plans are in the possession of the Plumbing Contractor.

G. The Contractor shall furnish three (3) copies of all Final Inspection Certificates obtained to the Engineer when work is complete. Final payment for work will be contingent upon compliance with this requirement.

H. Where minimum code requirements are exceeded in the Design, the Design shall govern.

I. The Contractor shall insure that their work is accomplished in accord with the OHSA Standards and that they conduct their work and the work of their personnel in accord with same.

J. All work relating to the handicapped shall be in accord with regulations currently enforced by the Authority Having Jurisdiction and the American Disabilities Act.

K. All pressure vessel installations shall comply with the State, and/or Federal Code applicable. A Certificate of Final Boiler Inspection shall be required.

L. Work in elevators, elevator shafts and elevator equipment rooms shall comply with the Elevator Code enforced by the Authority Having Jurisdiction.

M. All work in conjunction with a natural gas installation shall, in addition to all other Codes, Rules, Regulations, Standards, etc., comply with the requirements of the local gas supplier and/or standards and recommendations of the American Gas Association.

N. All work in relation to domestic water systems shall, in addition to all other Codes, Rules, Regulations and Standards, be in compliance with the requirements of the local water utility company.

O. All work in relation to the installation of sanitary shall, in addition to all other Codes, Rules, Regulations and Standards, be in compliance with the local agency governing such installations.

P. Discharge of any toxic, odorous or otherwise noxious materials into the atmosphere or any system shall be subject to regulations of the Environmental Protection Agency (EPA) and/or the air pollution control commission. If in doubt, contact the State Department for Environmental Protection.

Q. Where conflict arises between any code and the Plans and/or Specifications, the code shall apply except in the instance where the Plans and Specifications exceed the requirements of the code. Any changes required as a result of these conflicts shall be brought to the attention of the Engineer at least ten (10) days prior to bid date, otherwise the Contractor shall make the required changes at their own expense.

3.3 SUPERVISION OF WORK:

A. The Contractor shall personally supervise the work for which they are responsible or have a competent superintendent, approved by the Engineer, on the work at all times during progress with full authority to act on behalf of the Contractor.

3.4 CONDUCT OF WORKERS:

A. The Contractor shall be responsible for the conduct of all workers under their supervision. Misconduct on the part of any worker to the extent of creating a safety hazard, or endangering the lives and property of others, shall result in the prompt removal of that worker. The consumption of alcoholic beverages or other intoxicants, narcotics, barbiturates, hallucinogens or dehabilitating drugs on the job site is strictly forbidden.

3.5 COOPERATION AND COORDINATION WITH OTHER TRADES:

A. The Contractor shall give full cooperation to all other trades and shall furnish in writing with copies to the Engineer, any information necessary to permit the work of other trades to be installed satisfactorily and with the least possible interference or delay.

B. Where any work is to be installed in close proximity to, or will interfere with work of other trades, each shall cooperate in working out space conditions to make a satisfactory adjustment. If so, directed by the Engineer, the Contractor shall prepare composite working drawings and sections at a suitable scale not less than ¼" = 1'-0", clearly indicating how their work is to be installed in relation to the work of other trades, or so as not to cause any interference with work of other trades. Make the necessary changes in the work to correct the condition without extra charge.

C. The Contractor shall furnish to other trades, as required, all necessary templates, patterns, setting plans, and shop details for the proper installation of work and for the purpose of coordinating adjacent work.

3.6 GUARANTEES AND WARRANTIES:

A. The Contractor shall guarantee all equipment, apparatus, materials, and workmanship entering into their Contract to the best of its respective kind and shall replace all parts at their own expense, which are proven defective within the time frame outlined in the General Conditions of the Contract. The effective date of completion of the work shall be the date of the Project's Statement of Substantial Completion. Items of equipment which have longer guarantees, as called for in these Specifications, shall have warranties and guarantees completed in order, and shall be in effect at the time of final acceptance of the work by the Engineer. The Contractor shall present the Engineer with such warranties and guarantees at the time of final acceptance of the work. The Engineer shall then submit these warranties, etc. to the Owner. The Owner reserves the right to use equipment installed by the Contractor prior to date of final acceptance. Such use of equipment shall not invalidate the guarantee except that the Owner shall be liable for any damage to equipment during this period, due to negligence of their operator or other employees. Refer to other sections for any special or extra warranty requirements.

B. All gas fired heat exchangers shall have 15 year warranty.

C. Provide all warranty certificates to Owner. All warranties begin starting at the substantial completion date, submit warranty certificates accordingly.

3.7 COST BREAKDOWNS (SCHEDULE OF VALUES):

A. Within thirty (30) days after acceptance of the Contract, the Contractor shall furnish to the Engineer, one copy of a detailed cost breakdown on each respective area of work. These cost breakdowns shall be made in a format approved by the Engineer. Payments will not be made until satisfactory cost breakdowns are submitted.

B. The breakdown shall be minimally as follows. Material and labor shall be listed separately. Pay special attention to required withholding percentages for startup, testing, documentation, acceptance, owner training, etc.:
   1. Shop Drawings

2. Motor Load Coordination with other subcontractors
3. Record Drawings & Acceptance
4. O&M Manuals & Acceptance
5. Owner Training & Acceptance
6. Identification Materials & Labor
7. Piping Materials & Labor
8. Piping Testing, Cleaning, Documentation, Acceptance, etc.
9. Piping Purging, Flushing, Cleaning
10. Insulation (Piping) Materials & Labor
11. Plumbing Materials, Piping & Labor
12. Plumbing Shop Fabrication
13. Domestic Water Heater Equipment & Labor
14. Domestic Water Heater Startup, Testing, Documentation, Training, Acceptance, etc.
15. Test and Balance Materials & Labor
16. Test and Balance Pre-Testing
17. Test and Balance Initial Report, Final Report and Acceptance

3.8 CHANGES IN WORK:

A. REFER TO GENERAL AND SPECIAL CONDITIONS.

3.9 CLAIMS FOR EXTRA COST:

A. REFER TO GENERAL AND SPECIAL CONDITIONS.

3.10 MATERIALS AND WORKMANSHIP:

A. All equipment, materials and articles incorporated in the work shall be new and of comparable quality to that specified. Each Bidder/Proposer shall determine that the materials and/or equipment they propose to furnish can be brought into the building(s) and installed within the space available. In certain cases, it may be necessary to remove and replace walls, floors and/or ceilings and/or disassemble/reassemble the materials and equipment and this work shall be the responsibility of the Contractor, whether specifically initiated or not.

B. All equipment shall be installed so that all parts are readily accessible for inspection, maintenance, replacement of fans, motors, coils, filters, etc. Extra compensation will not be allowed for relocation of equipment for accessibility or for dismantling equipment to obtain entrance into the building(s). Insure, through coordination that no other Contractor seals off access to space required for equipment materials, etc.

C. Materials and equipment shall bear Underwriters' Laboratories label where such a standard has been established, where applicable.

D. Each length of pipe, fitting, trap, fixture, and device used in the plumbing or drainage systems shall be stamped or indelibly marked with the weight or quality thereof and with the manufacturer's mark or name.

E. All equipment shall bear the manufacturer's name and address. All electrically operated equipment shall bear a name plate indicating required horsepower, voltage, phase, and ampacity. Pumps and fans shall have a data plate indicating horsepower, pressure, and flow rate.

3.11 TEMPORARY SERVICES:

A. The Contractor shall arrange any temporary water, electrical and other services which may be required to accomplish the work. Refer also to General and Special Conditions.

B. All temporary services shall be removed by Contractor prior to completion of work.

3.12 SURVEY, MEASUREMENTS AND GRADE:

A. The Contractor shall lay out their work and be responsible for all necessary lines, levels, inverts, elevations, and measurements. The Contractor must verify the figures shown on the Plans before laying out the work and will be held responsible for any error resulting from failure to do so.

B. The Contractor shall base all measurements, both horizontal and vertical from established bench marks. All work shall agree with these established lines and levels. Verify all measurements at the site and check the correctness of same as related to the work.

C. Should the Contractor discover any discrepancy between actual measurements and those indicated which prevents following good practice or the intent of the contract documents, the Contractor shall promptly notify the Engineer and shall not proceed with this work until the Contractor has received instructions from the Engineer on the disposition of the work.

3.13 PROTECTION OF EQUIPMENT:

A. The Contractor shall be entirely responsible for all material and equipment they furnish in connection with their work and special care shall be taken to properly protect all parts thereof from damage during the construction period. Such protection shall be by a means acceptable to the Engineer. All piping, etc., shall be properly plugged or capped during construction in a manner approved by the Engineer. Equipment damaged, stolen, or vandalized while stored on site, either before or after installation, shall be repaired or replaced by the Contractor at their expense.

3.14 REQUIRED CLEARANCES FOR ELECTRICAL EQUIPMENT:

A. The NEC has specific required clearances above, in front, and around electrical gear, panels etc. The Contractor shall not install any piping, equipment, etc., in the required clearance. If any appurtenance is located in the NEC required clearance, it shall be relocated at no additional cost. Coordinate with the Electrical Contractor prior to any work.

3.15 EQUIPMENT SUPPORT:

A. Each piece of equipment, apparatus, piping, or conduit suspended from the ceiling or mounted above the floor level shall be provided with suitable structural support, pipe stand, platform, or carrier in accordance with the best recognized practice. Such supporting or mounting means shall be provided by the Contractor for all equipment and piping. Exercise extreme care that structural members of building are not overloaded by such equipment. Provide any required additional bracing, cross members, angles, support, etc. Do not support items from roof/floor deck or bridging.

3.16 PIPE MOUNTING HEIGHTS:

A. All exposed or concealed equipment, piping, etc., shall be held as high as possible unless otherwise noted and coordinated with all other trades. Exposed piping shall, insofar as possible, run perpendicular or parallel to the building structure. Refer to Plans for minimum heights of ducts and piping. Minimum height above ceilings shall be 6” clear including insulation, unless otherwise noted.

3.17 BROKEN LINES AND PROTECTION AGAINST FREEZING:

A. No conduits, piping, etc. carrying water or any other fluid subject to freezing shall be installed in any part of the building where danger of freezing may exist without adequate protection being given by the Contractor whether or not insulation is specified or indicated on the particular piping. All damages resulting from broken and/or leaking lines shall be replaced or repaired at the Contractor's own expense. Do not install piping across or near openings to the outside whether or not they are carrying static or

moving fluids. Insulation on piping does not necessarily ensure that freezing will not occur. If in doubt, contact the Engineer.

3.18 WEATHERPROOFING:

A. Where any work pierces waterproofing including waterproof concrete, the method of installation shall be as specified and approved by the Architect and Engineer before work is performed. The Contractor shall furnish all necessary sleeves, caulking and flashing required to make openings permanently watertight.

B. Wherever work penetrates roofing, it shall be done in a manner that will not diminish or void the roofing guarantee or warranty in any way. Coordinate all such work with the roofing installer.

3.19 FINAL CONNECTIONS TO EQUIPMENT:

A. The Contractor shall finally connect plumbing services (water, sanitary, gas, etc.), to any terminal equipment, appliances, kitchen equipment, etc., provided under this and/or other divisions of the work. Various equipment connections indicated are based upon “basis of design” equipment selections. Should alternate equipment be purchased by the General Contractor, then this Contractor shall make the necessary provisions in the Bid for any and all differences. Change Orders shall not be considered for any differences due to alternate equipment purchase. Such connections shall be made in strict accord with current codes, safety regulations and the equipment manufacturer’s recommendations. If in doubt, contact the Engineer prior to installation.

3.20 ACCESSIBILITY:

A. The Contractor shall be responsible for the sufficiency of the size of shafts and chases, the adequate clearance in double partitions and ceilings for the proper installation of their work. They shall cooperate with all others whose work is in the same space. Such spaces and clearances shall, however, be kept to the minimum size required.

B. The Contractor shall locate and install all equipment so that it may be serviced and maintained as recommended by the manufacturer. Allow ready access and removal of the entire unit and/or parts such as valves, filters, fan belts, motors, prime shafts, controls, coils, etc.

C. Whether shown on the Plans or not, the Contractor shall provide in the Bid access panels for each concealed shut-off valve, motorized control damper, manual air damper or other device requiring service as shown on Engineer's Plans or as required. Locations of these panels shall be identified in sufficient time to be installed in the normal course of work. Change orders for access panels will not be accepted.

3.21 SCAFFOLDING, RIGGING AND HOISTING:

A. The Contractor shall furnish all scaffolding, rigging, hoisting and services necessary for erection and delivery onto the premises of any equipment and apparatus furnished. All such temporary appurtenances shall be set up in strict accord with OHSA Standards and Requirements. Remove same from premises when no longer required.

3.22 CONCRETE WORK:

A. The Contractor shall be responsible for the provisions of all concrete work required for the installation of any of their systems or equipment. The Contractor may, at their option, arrange with the others to provide the work. This option, however, will not relieve the Contractor of their responsibilities relative to dimensions, quality of workmanship, locations, etc.

B. In the absence of other concrete Specifications, all concrete related to Mechanical work shall be 3500 psi minimum compression strength at 28 days curing, slump: 4” ± 1”, air entrainment 4.5% water to cement ratio 0.5 and shall conform to the standards of the American Concrete Institute Publication AC1-318.

Heavy equipment shall not be installed on pads for at least seven (7) days after pour. Insert 6-inch steel dowel rods into new and existing floors to anchor pads.

C. All concrete pads shall be complete with all pipe sleeves, anchor bolts, reinforcing steel, concrete, etc. as required. Pads larger than 18" in width shall be reinforced with ½" deformed round bars on 6" centers both ways. Bars shall be approximately 2" above the bottom of the pad. All parts of pads and foundations shall be properly rodded or vibrated. If exposed parts of the pads and foundations are rough or show honeycomb after removing forms, all surfaces shall be rubbed to a smooth surface. Chamfer all vertical edges ¾" and tool horizontal edges with ¾" radius.

D. In general, unless otherwise noted, concrete pads for equipment and piping penetrations shall be a minimum of 4" thick, extend six (6) inches beyond the equipment's base dimensions. Where necessary, extend pads 30 inches beyond base or overall dimensions to allow walking and servicing space.

3.23 RESTORATION OF NEW OR EXISTING LANDSCAPING, PAVING, SURFACES, ETC.:

A. The Contractor shall at their expense restore to their original conditions all paving, curbing, surfaces, drainage ditches, structures, fences, landscaping, existing or new building surfaces and appurtenances, and any other items damaged or removed by their operations. Replacement and repairs shall be in accordance with good construction practice; by qualified tradesman and shall match materials employed in the original construction of the item and shall be to the satisfaction of the Owner and/or Engineer.

3.24 MAINTENANCE OF EXISTING UTILITIES AND LINES:

A. The locations of all piping, conduits, cables, utilities, and manholes existing, or otherwise, that comes within the contract construction site, shall be subject to continuous uninterrupted service with no other exception than the Owner of the utilities permission to interrupt same temporarily. Provide a seven (7) day written notice to Engineer, Architect and Owner prior to interrupting any utility service or line.

B. Known utilities and lines as available to the Engineer are shown on the Plans. However, it is additionally required that, prior to any excavation being performed, each Contractor ascertain and mark all utilities or lines that would be endangered by the excavation. Hand dig if required to locate. Contractor shall bear costs of repairing damaged utilities.

C. If utilities or lines occur in the earth within the construction site, the Contractor shall probe and locate the lines prior to machine excavation in the respective area. Hand dig if required to locate.

D. Cutting into existing utilities and services shall be performed in coordination with and as designated by the Owner of the utility. The Contractor shall work continuously to restore service(s) upon deliberate or accidental interruption, providing premium time and materials as needed without extra claim to the Owner.

E. The Contractor shall repair to the satisfaction of the Owner and Engineer, any surfaces or subsurface improvements damaged during the course of the work, unless such improvement is shown to be abandoned or removed.

F. Machine excavation shall not be permitted with ten feet of gas lines, fuel lines, electrical lines or lines carrying combustible and/or explosive materials. Hand excavate only in accord with utility company, agency or other applicable laws, standards or regulations.

G. Protect all new or existing lines from damage by traffic, etc. during construction. Repairs or replacement of such damage shall be at the sole expense of the party responsible.

H. Protect existing trees, indicated to remain with fencing or other approved method. Hold all new subsurface lines outside the drip line of trees, offsetting as necessary to protect root structures. Refer to planting or landscaping plans, or in their absence, consult with the Architect.

3.25 CLEANING:

A. The Contractor shall, at all times, keep the area of their work presentable to the public and clear from rubbish and debris caused by their operations; and at the completion of the work, they shall remove all rubbish, debris, all of their tools, equipment, temporary work, and surplus materials from and about the premises, and shall leave the area clean and ready for use. If the Contractor does not attend to such cleaning upon request, the Engineer may cause cleaning to be done by others and charge the cost of same to the Contractor. The Contractor shall be responsible for all damage from fire which originates in, or is propagated by, accumulations of their rubbish or debris.

B. After completion of all work and before final acceptance of the work, the Contractor shall thoroughly clean all equipment and materials and shall remove all foreign matter such as grease, dirt, plaster, labels, stickers, etc., from the exterior of piping, equipment, fixtures and all other associated or adjacent fabrication.

C. Piping shall be kept clean at all times. Piping stored on the job site shall be placed a minimum of 4" above the floor and shall be completely covered in plastic. Do not install the piping or insulation (pipe or duct) if the building is not "dried-in". If this is required, the entire lengths of duct shall be covered in plastic to protect. The Owner/Engineer may periodically inspect that these procedures are followed.

3.26 INSPECTION, APPROVALS AND TESTS:

A. Before requesting a final review of the installation from the Architect and/or Engineer, each Contractor shall thoroughly inspect their installations to assure that the work is complete in every detail and that all requirements of the Contract Documents have been fulfilled. Failure to accomplish this may result in charges from the Architect and/or Engineer for unnecessary and undue work on their part.

B. The Contractor shall provide as a part of this Contract any required Agency inspection, licensed, and qualified to provide such services. All costs incidental to the provisions of inspections shall be borne by the Contractor.

C. The Contractor shall advise each Inspecting Agency in writing, with an informational copy of the correspondence to the Architect and/or Engineer, when they anticipate commencing the work. Inspections shall be scheduled for rough-in as well as finished work. The rough-in inspections shall be divided into as many inspections as may be necessary to cover all rough-in without fail. Failure of the Inspecting Agency to inspect the work in a timely manner and submit the related reports may result in the Contractor having to expose concealed work not so inspected. Such exposure will be at the expense of the responsible Contractor.

D. Approval by an Agency Inspector does not relieve the Contractor from the responsibilities of furnishing equipment having a quality of performance equivalent to the requirements set forth in these Plans and Specifications. All work under this contract is subject to the review of the Architect and/or Engineer, whose decision is binding.

E. Before final acceptance, the Contractor shall furnish the original and three (3) copies of the certificates of final approval by the Agency Inspector to the Engineer with one copy of each to the appropriate government agencies, as applicable. Final payment for the work shall be contingent upon completion of this requirement.

3.27 ABOVE-CEILING AND FINAL PUNCH LISTS:

A. The Contractor shall review each area and prepare and complete their own punch list for each of the subcontractors as required for the Project Schedule.

B. Seven (7) days notice shall be given to the Engineer for review of above ceiling work that will be concealed by tile or other materials. Seven (7) days notice shall be given to the Engineer for review of below ceiling work and final inspection.

C. When all work from the Contractor's punch list is complete at each of the major Project Stages and prior to completing ceiling installations (or at the final punch list stage), the Contractor shall request that the Engineer develop a punch list. This request is to be made in writing seven (7) days prior to the proposed date. After all corrections have been made from the Engineer's punch list, the Contractor shall review and initial off on each item. This signed-off punch list shall be submitted to the Engineer. The Engineer shall return to the site once to review each punch list and all work prior to the ceilings being installed and at the final punch list review. The Contractor's representative may be requested at the inspections.

D. If additional visits are required by the Engineer to review work not completed by this review, the Engineer shall be reimbursed directly by the Contractor by check or money order (due net 10 days from date of each additional visit) at a rate of $125.00 per hour plus travel expense for extra trips required to complete either of the above ceiling, below ceiling or final punch lists.

3.28 OPERATING INSTRUCTIONS:

A. Upon completion of all work and all tests, each Contractor shall furnish the necessary skilled labor and helpers for operating the systems and equipment for a period of three (3) days of eight (8) hours each, or as otherwise specified. Refer to Section HVAC EQUIPMENT for additional requirements. During this period, instruct the Owner or their representatives fully in the operations, adjustment, and maintenance of all equipment furnished. Give at least seven (7) days written notice to the Owner, Architect and Engineer in advance of this training period. The Engineer may attend any such training sessions or operational demonstrations. The Contractor shall certify in writing to the Engineer that such demonstrations have taken place, noting the date, time and names of the Owner's representatives that were present.

B. Each Contractor shall furnish three complete bound sets for approval to the Engineer instructions for operating and maintaining all systems and equipment included in this contract. All instructions shall be submitted in draft form, for approval, prior to final issue. Manufacturer's advertising literature or catalogs will not be acceptable for operating and maintenance instructions. Refer to Specification Section SHOP DRAWINGS for additional detail.

C. Each Contractor, in the above mentioned instructions, shall include the maintenance schedule for the principal items of equipment furnished under this contract and a detailed, easy to read parts list and the name and address of the nearest source of supply.

3.29 RECORD DRAWINGS:

A. The Contractor shall insure that any deviations from the Design are as they occur recorded in red, erasable pencil on record drawings kept at the jobsite. The Engineer shall review the record documents from time to time to ensure compliance with this specification. Compliance shall be a contingency of final payment. Pay particular attention to the location of under floor sanitary and water lines, shut-off valves, cleanouts, and other appurtenances important to the maintenance and operation of Mechanical Systems. Also, pay particular attention to Deviations in the Control Systems and all exterior utilities. Keep information in a set of drawings set aside at the job site especially for this purpose and deliver to the Engineer upon completion of the work.

B. All underground utilities/piping installed as part of this project shall be surveyed by a land surveyor licensed in the State in which the project is being constructed. The survey shall include actual pipe depths to top of pipe every 100 feet in length. The survey shall also include benchmarks dimensions relative to above grade, fixed structures. The survey shall be furnished on a compact disc in AutoCad ".dwg" format and ".pdf" format. The survey information shall be included in the closeout documentation.

3.30 COMMISSIONING: CONTRACTOR RESPONSIBILITIES:

A. Contractor shall assign representatives with expertise and authority to act on its behalf and shall schedule them to participate in and perform commissioning process activities including, but not limited to, the following:
   1. Evaluate performance deficiencies identified in test reports and, in collaboration with entity responsible for system and equipment installation, recommend corrective action.
   2. Cooperate with the CxA for resolution of issues recorded in the Issues Log.
   3. Attend commissioning team meetings.
   4. Integrate and coordinate commissioning process activities with construction schedule.
   5. Complete electronic construction checklists as Work is completed and provide to the Commissioning Authority.
   6. Review and accept commissioning process test procedures provided by the Commissioning Authority.
   7. Complete commissioning process test procedures.

END OF SECTION 220500

SECTION 220501 - SCOPE OF THE PLUMBING WORK

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR PLUMBING and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

1.2 SCOPE

A. The Plumbing work for this Contract shall include all labor, materials, equipment, fixtures, excavation, backfill and related items required to completely install, test, place in service and deliver to the Owner the complete mechanical systems in accordance with the accompanying plans and all provisions of these specifications. This work shall primarily include but is not necessarily limited to the following paragraphs.

B. Installation of all equipment per the manufacturer’s instruction, whether specifically detailed or not.

C. Provide all required motor starters, etc. not provided under the electrical sections.

D. Thorough instruction of the Owner’s maintenance personnel in the operation and maintenance of all mechanical equipment.

E. Thorough coordination of the installation of all piping, equipment, and any other material with other trades to insure no conflict in installation.

F. Approved supervision of the plumbing work.

G. Procurement of all required inspections, including fees for all inspection services and submission of final certificates of inspection to the Engineers.

H. Cutting, patching, sleeving, concrete work, etc., required to construct the plumbing systems.

I. Equipment and controls start-up, verification and documentation as specified.

J. Record drawings, final inspection certificates, test results, O & M documentation, warranty certification, spare parts, and other specified closeout documentation.

K. Required schedule of values breakdown.

L. Pipe and equipment identifications.

M. Preinstallation meetings and equipment mockups.

N. Domestic hot, cold, and recirculating hot water system.

O. Soil, waste, and vent systems.

P. All plumbing equipment.

Q. All insulation associated with plumbing systems.

R. All required pressure testing, flushing, purging, pressure and flow testing requirements.

S. Complete natural gas piping systems.

T. All required controls, including self checkout and commissioning.

END OF SECTION 220501

SECTION 220502 - SHOP DRAWINGS, MAINTENANCE MANUALS AND PARTS LISTS

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR PLUMBING and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

1.2 SCOPE

A. The Contractor shall prepare and submit to the Engineer, through the Prime Contractor and the Architect within thirty (30) days after the date of the Contract, required copies of all shop drawings, certified equipment drawings, installation, operating and maintenance instructions, samples, wiring diagrams, etc. on all items of equipment specified hereinafter. Refer to Division 1 requirements for shop drawing submittal requirements.

B. Provide all shops in electronic/PDF format. The Engineer’s comments will be returned in electronic format.

C. Each shop drawing and/or manufacturers descriptive literature shall have the proper notation indicated on it selecting equipment, accessories and features and shall be clearly referenced to the specifications, schedules, fixture numbers, etc., so that the Engineer may readily determine what the Contractor proposes to furnish. All data and information schedules indicated or specified shall be noted on each copy of each submittal.

D. Submittal data shall include specification data including metal gauges, finishes, accessories, etc. Also, the submittal data shall include certified performance data, wiring diagrams, dimensional data, and a spare parts list. Submittal data shall be reviewed by the Engineer before any equipment or materials is ordered or any work is begun in the area requiring the equipment.

E. All submittal data shall have the stamp of approval of the Contractor submitting the data as well as the Prime Contractor and the Architect to show that the drawings have been reviewed by the Contractor. Any drawings submitted without these stamps of approval may not be considered and will be returned for proper resubmission.

F. The Contractor shall make any corrections or changes required by the Engineer and shall re-submit for final review as outlined above.

G. It shall be noted that review of shop drawings by the Engineer applies only to conformance with the design concept of the project and general compliance with the information given in the Contract Documents. In all cases, the Contractor alone shall be responsible for furnishing the proper quantity of equipment and/or materials required, for seeing that all equipment fits the available space in a satisfactory manner and that piping, electrical and all other connections are suitably located. The Contractor shall also coordinate piping side connections.

H. The Engineer’s review of shop drawings, schedules or other required submittal data shall not relieve the Contractor from responsibility for adaptability of the item to the project; compliance with applicable codes, rules, regulations, and information that pertains to fabrication and installation; dimensions. weight and quantities; electrical characteristics; and coordination of the work with all other trades involved in this project.

I. Prior to ordering any materials or rough-in of any kind, the Contractor shall be responsible for final coordination of all electrical requirements (i.e. voltage, phase, circuit breaker, wire sizing, etc.) with the Electrical Contractor. There will be no change in the Contract Amount for any discrepancies. A final coordination meeting shall be held with the Architect, Owner, Engineer, Prime Contractor, Mechanical Contractor, Electrical Contractor, and their sub-contractors.

J. Equipment shall not be ordered and no final rough-in connections, etc., shall be accomplished until reviewed equipment shop drawings are in the hands of the Contractor. It shall be the Contractor's responsibility to obtain reviewed shop drawings and to make all connections, etc. in the neatest and most workmanlike manner possible. The Contractor shall coordinate with all the other trades having any connections, roughing-in, etc. to the equipment.

K. If the Contractor fails to comply with the requirements set forth above, the Engineer shall have the option of selecting any or all items listed in the Specifications or on the Drawings; and the Contractor shall be required to furnish all materials in accordance with this list.

L. Colors for equipment in other than mechanical spaces shall be selected from the Manufacturer's standard and factory optional colors unless noted otherwise on the Plans. Color samples shall be furnished with the shop drawing submission for such equipment.

M. All submittals for equipment shall include all information specified and scheduled. This shall include water pressure drops, RPM, noise data, horsepower, voltage motor type, steel or aluminum construction, and all accessories clearly marked.

N. All items listed in the schedules shall be submitted for review in a tabular form similar to the equipment schedule. All items submitted shall be designated with the same identifying tag as specified on each sheet.

O. Any submittals received in an unorganized manner without options to be provided specifically noted and with incomplete data will be returned for resubmittal.

PART 2 – PRODUCTS

2.1 Shop Drawings, descriptive literature, technical data and required schedules shall be submitted on the following:

Access Doors
Domestic Hot Water Heater (2.2.A)
Chemical Treatment and Test Reports
Firestopping (2.2.B)
Floor Drains
Insulation
Plumbing Fixtures, Fittings and Trim (2.2.A)
Plumbing Specialties (2.2.A)
Pumps and Hydronic Specialties (2.2.A)
Controls & Components (2.2.B)
Valves

(Refer to the corresponding Special Notes.)

2.2 SPECIAL NOTES:

A. For all items above, upon substantial completion of the project, the Contractor shall deliver to the Engineer (in addition to the required Shop Drawings) three (3) complete copies of operation and maintenance instructions and parts lists for each item above. Where available, documents shall include at least:

1. Detailed operating instructions
2. Detailed maintenance instructions including preventive maintenance schedules.
3. Addresses and phone numbers indicating where parts may be purchased.
4. Expanded parts drawings, parts lists, service manuals, schematics, wiring diagrams.
5. Master air filter list including equipment identification, filter size, filter quantity, and supplier contact information.
6. Start-up reports, service records and test reports.

B. The Contractor shall submit project specific UL listed firestopping installation drawings to the authority having jurisdiction where required for their approval as required.

PART 3 – EXECUTION – (NOT APPLICABLE)

END OF SECTION 220502

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SECTION 220513 - ELECTRIC MOTORS AND OTHER ELECTRICAL REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR PLUMBING and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractor’s attention is directed to Specification Section FACILITY MONITORING SYSTEM.

C. The Contractor’s attention is directed to Specification Section INSTRUMENTATION AND CONTROL FOR HVAC.

1.2 SCOPE

A. Through coordination with other Contractors, Vendors and Suppliers associated with this Project, this Contractor shall insure a complete, 100% functional, tested, inspected, and approved systems. Claims for additional cost or change orders will immediately be rejected. Refer to Specification Section – HVAC EQUIPMENT for additional requirements. All equipment shall be furnished for a single point electrical connection unless specifically excluded as a requirement.

B. Prior to ordering any materials or rough-in of any kind, the Mechanical Contractor shall be responsible for final coordination of all electrical requirements (i.e., voltage, phase, circuit breaker, wire sizing, etc.) with the Electrical Contractor. There will be no change in the Contract Amount for any discrepancies. A final coordination meeting shall be held with the Architect, Owner, Engineer, General Contractor, Mechanical Contractor, Electrical Contractor, and their sub-contractors.

PART 2 – PRODUCTS

2.1 MOTORS

A. The following are basic requirements for simple or common motors. For special motors, more detailed and specific requirements are specified in the individual equipment specifications and drawing schedules.

B. Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads.

C. Motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range.

D. Motors shall be capable of frequency of starts as indicated by automatic control system and not less than five (5) evenly time spaced starts per hour for manually controlled motors.

E. Motors shall have a 1.15 service factor for poly-phase motors and 1.35 service factor for single phase motors.

F. Motors shall have a temperature rating for 40 deg C ambient environment with maximum 90 deg C temperature rise for continuous duty at full load with 1.15 service factor and Class B insulation.

G. Unless otherwise noted or required by application, motors shall confirm to NEMA Standard MG 1 (Table 12-10) for general purpose, continuous duty, horizontal, T-frame, single speed, design “A” or “B”. Utilize design "C" motors where required for high starting torque.

H. Motor frames shall be NEMA Standard No. 48 or 56. Use driven equipment (pumps, etc.) manufacturer's standards to suit specific application.

I. Provide inverter rated motors where variable frequency drives are utilized. Motor shall be premium efficiency type with Class F insulation and shall conform to NEMA MG 1 parts 30 and 31. Inverter duty rated motors shall have a temperature rating for 40 deg C ambient environment with maximum of 105 deg C temperature rise.

J. Motor bearings shall be ball or roller bearings with inner and outer shaft seals. Bearings shall be re-greaseable, except permanently sealed where motor is normally inaccessible for regular maintenance. Bearings shall be designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor.

K. Motor enclosure type shall be open drip-proof motors for indoor use where satisfactorily housed or remotely located during operation. Enclosures shall be guarded drip-proof type motors where exposed to contact by employees or building occupants. Enclosure shall be weather protected Type I for outdoor use or Type II where not housed.

L. Provide built-in thermal overload protection and, where required, internal sensing device suitable for signaling and stopping motor at starter.

M. Provide energy efficient motors with a minimum EPACT efficiency in accordance with NEMA MG 1, Table 12-10 for 1800 rpm, enclosed motors. If efficiency not specified, motors shall have a minimum efficiency as listed below:

1 hp - 82.5%	7.5 hp – 89.5%	30 hp – 92.4%
1.5 hp – 84.0%	10 hp – 89.5%	40 hp – 93%
2 hp – 84%	15 hp – 91%	50 hp – 93%
3 hp – 87.5%	20 hp – 91%	60 hp – 93.6%
5 hp – 87.5%	25 hp – 92.4%	75 hp – 94.1%

N. On the motor nameplate, indicate the full identification of manufacturer, ratings, characteristics, construction, special features and similar information.

2.2 MOTOR STARTERS:

A. Provide motor starters where indicated on the mechanical equipment schedules or elsewhere in the Contract Documents.

B. Motor starters shall be NEMA style. Their sizing and installation shall be coordinated with the equipment manufacturer's requirements and in accordance with the National Electrical Code.

C. All starters shall be size 0 minimum. They shall be constructed and tested in accord with latest edition of NEMA standards. All starters shall be across-the-line magnetic type, unless indicated otherwise. On motors of 20 H.P. or greater rating, the supplier shall provide starters capable of limiting inrush currents. These shall be the reduced voltage open-transition type. Do not utilize closed transition starters unless specifically indicated.

D. Magnetic starters shall be furnished with the following characteristics and accessories as a minimum. See remaining paragraphs of the Part and mechanical schedules for further requirements.

E. Contacts shall be silver-alloy, double-break type except NEMA size 8 and 9 shall be single-break type. Contacts shall be replaceable without removal of wiring or removal of starter from enclosure. Number of contacts shall be as required for service indicated. Contacts shall be gravity dropout type, positive operation.

F. Coil voltage shall be 120 volts, A.C., 60 HZ or less, as required to suit control systems available voltages. Coils shall be of molded construction, except for size 8 and 9 which shall be hand wound. Provide coil clearing contact as required.

G. Provide control transformer of adequate K.V.A. as required on all starters with line-to-line voltages higher than 120 volts A.C. Provide fuse block and slow-blow fuse to protect control transformer per NEMA, N.E.C. and U.L.

H. Provide hand-off-auto selector switch in face of starter, wired into hand and off switch positions. Auto position (if needed) to be field wired as indicated for automatic control.

I. Provide NEMA Class 20 resetable overload relays, accurately sized to the motor nameplate rating of the motor served and the temperature differential between motor and controller. Overloads shall be easily replaceable, and resetable without opening enclosure, via a push button or similar means. Class 10 or Class 30 overloads may be used depending on type of motor duty encountered.

J. Provide at least one N.O. auxiliary contact (field-convertible to N.C. operation) with each starter. All starters shall have space for two additional single-pole contacts.

K. All starters shall be thru-wiring type.

L. Provide phase failure sensing relay to open starter coil circuit (on loss of one or more phases) on all three-phase starters controlling motors of 7½ H.P. or larger.

2.3 ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT:

A. All mechanical equipment shall be provided for single point electrical connection unless noted otherwise.

B. The equipment manufacturer shall provide internally mounted fuses with the equipment, as required, to comply with the U.L. listing on the equipment name plate. (i.e., hermetically sealed compressors or equipment with name plate data that recommends or requires fuse protection.) See also, National Electrical Code, Article 440, Part C, and other applicable sections of the N.E.C.

C. It shall be the Contractor's responsibility to assure that all mechanical equipment requiring electrical connections be provided with all required proper wiring, electrical protective devices, disconnecting means and electro-mechanical starting units to properly match the mechanical equipment requirement.

D. Each separate contractor engaged for the project shall coordinate with all other trades to ensure all necessary equipment and labor is included for fully functioning mechanical systems, installed per Code and Project requirements.

E. Refrigeration condensing units with internal compressors shall be furnished with integral starter.

F. All interlock or other control wiring, unless specifically noted otherwise, is the responsibility of this Contractor.

G. All equipment shall be suitably enclosed. All enclosures for equipment shall be rated and approved for the environment in which it operates. (i.e., NEMA 1, NEMA 3R, NEMA 7, NEMA 12, etc.) Verify the requirement with the installation condition if not indicated on the plans.

H. Observe the following standards for manufacture of equipment and in selection of components: (1) Starters, control devices and assemblies - NEMA (I.E.C. style not acceptable), (2) Enclosures for electrical equipment – NEMA, (3) Enclosed switches – NEMA, (4) All electrical work, generally NFPA 70, (5) All electrical work in industrial occupancies - J.I.C. standards, (6) All electrical components and materials - U.L. listing required.

I. Where scheduled on the drawings, provide disconnect switches and contactors. Disconnect switches shall be fusible type or circuit breaker type.

2.4 REQUIREMENTS FOR MECHANICAL EQUIPMENT 3/4 H.P. OR LESS:

A. This section describes requirements for small mechanical equipment such as (but not limited to) package terminal heating/cooling units, VAV boxes, unit heaters, unit ventilators, exhaust fans, fans, fan coil units, cabinet heaters, DDC temperature control panels, etc.

B. Small equipment with motor(s) of 3/4 H.P., single phase or less are generally not required to be furnished with starter(s), unless otherwise noted. For such equipment, provide integral contactor or horsepower-rated relay where controlled by thermostat or other type of switch. Contactors or relays shall be as recommended by the manufacturer of the equipment.

C. Provide transformer within unit as required to provide low voltage A.C. for thermostat control.

D. Provide internal fusing for unit motor and other loads in fuse block or in-line fuseholder.

E. Where externally mounted disconnecting means is required and would be impractical, unsightly or inappropriate in the judgment of the Engineer, disconnects shall be located within the unit. These disconnects may be fusible H.P.-rated snap switches or manual starters with overload elements, as required. Locate this and other electrical equipment within enclosure where easily accessible behind access panel or door on unit, and as acceptable to the electrical inspector or local authority having jurisdiction.

PART 3 – EXECUTION: (NOT APPLICABLE)

END OF SECTION 220513

SECTION 220515 - SLEEVING, CUTTING, PATCHING, REPAIRING AND FIRESTOPPING

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR PLUMBING and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

1.2 SCOPE

A. The Contractor shall be responsible for all openings, sleeves, trenches, etc., that may be required in floors, roofs, ceilings, walls, etc., and shall coordinate all such work with the General Contractor and all other trades. Coordinate with the General Contractor, any openings which they are to provide before submitting a bid proposal in order to avoid conflict and disagreement during construction. Improperly located openings shall be reworked at the expense of the Contractor.

1.3 All work improperly performed or not performed as required in this section, shall be corrected by the General Contractor at the responsible Contractor’s expense.

PART 2 – PRODUCTS:

2.1 SLEEVES

A. Cast iron or Schedule 40 steel sleeves shall be installed through all walls where pipe enters the building below grade. Sleeves shall be flush with each face of the wall and shall be sufficiently larger than the entering pipe to permit thorough caulking between pipe and sleeve for water proofing. Horizontal sleeves passing through exterior walls or where there is a possibility of water leakage and damage shall be caulked watertight. Utilize “Link-Seal” at these locations.

B. In all cases, sleeves shall be at least two pipe sizes larger than nominal pipe diameter plus insulation. Sleeves through walls and floors shall be cut off flush with inside surface unless otherwise indicated.

C. Vertical sleeves in roofs shall be flashed and counterflashed with lead (4 lb.) or 16 oz. copper and welded or soldered to piping, lapped over sleeve and properly weather sealed. Where sleeves pass through roof construction, sleeves shall extend minimum of 12" above the roof.

2.2 FIRE STOPPING

A. Firestopping materials include (but are not limited to) wraps, strips, caulks, moldable putties, restricting collars with steel hose clamps, damming materials, composite sheets, fire dam caulks, steel sleeves, etc.

B. The following indicates the 3M penetration details for uninsulated pipe penetration of various wall and floor construction types (the list is not inclusive):
   1. One, two or three hour fire rated concrete floor - 3M #5300-MPC8.
   2. One, two or three hour fire rated solid or block concrete wall - 3M #5300-MPC16 or 3M #5300-MPC26.
   3. One hour fire rated gypsum wallboard - 3M #5300-MPC7.
   4. Two hour fire rated gypsum wallboard - 3M #5300-MPC7.

C. The following indicates the 3M penetration details for insulated pipe penetrations of various wall and floor construction types (the list is not inclusive):
   1. One, two and three hour fire rated concrete floor - 3M #5300-IMP2.
   2. One, two and three hour concrete block wall - 3M #5300-IMP2.

3. One hour fire rated gypsum wallboard - 3M #5300-IMP4.
4. Two hour fire rated gypsum wallboard - 3M #IMP7.

PART 3 – EXECUTION:

3.1 The Contractor shall plan their work ahead and shall place sleeves, frames or forms through all walls, floors and ceilings during the initial construction, where it is necessary for piping, conduit, etc., to route through; however, when this is not coordinated, the Contractor shall then do all cutting and patching required for the installation of their work, or pay other trades for doing this work when so directed by the Engineer. Any damage caused to the building by this Contractor shall be corrected or rectified at their expense.

3.2 The Contractor shall notify other trades in due time where they will require openings or chases in new concrete, masonry, etc. Set all concrete inserts and sleeves for their work. Failing to coordinate, Contractor shall cut openings for the work and patch same as required at their expense with qualified tradesman.

3.3 The Contractor shall be responsible for properly shoring, bracing, supporting, etc., any existing and/or new construction to guard against cracking, settling, collapsing, displacing, or weakening while openings are being made. Any damage occurring to the existing and/or new structures, due to failure to exercise proper precautions or due to action of the elements shall be promptly and properly corrected to the satisfaction of the Engineer.

3.4 CUTTING:

A. All openings in plaster, gypsum board or similar materials, shall be framed by means of plaster frames, casing beads, or angle members as required. The intent of this requirement is to provide smooth, even termination of wall, floor, and ceiling finishes as well as to provide a fastening means for devices, etc.

B. The Contractor shall coordinate all openings in masonry walls with the General Contractor; and, unless otherwise indicated in the Contract Documents, shall provide lintels for all openings required for the mechanical work such as louvers, exhaust fans, etc. Prime paint all lintels. Lintels shall be sized as follows:
   1. New Openings under 48" in width: Provide one 3½"x3½"x3/8" steel angle for each 4" of masonry width. Lintel shall have 8" bearing on each end.
   2. New Openings over 48" in width: Consult with Structural Engineer.

C. No cutting shall be performed at location that will weaken the structure and unnecessary cutting must be avoided. If in doubt, contact the Engineer.

D. Pipe openings in slabs and walls shall be cut with core drill. Hammer devices will not be permitted. Edges of trenches and large openings shall be scribe-cut with a masonry saw.

3.5 PATCHING, REPAIRING AND FINISHING:

A. Patching and repairing made necessary by work performed under this Division shall be included as a part of the work and shall be done by skilled workers of the trade. The work shall be performed in strict accordance with the provisions herein before specified to match adjacent surfaces and in a manner acceptable to the Engineer.

B. Where portions of existing sites, lawns, shrubs, paving, etc. are disturbed for installation of work of this Division, such items shall be repaired and/or replaced back to original or better condition to the satisfaction of the Engineer.

C. Piping passing through floors, ceilings and walls in finished areas shall be fitted with chrome plated brass escutcheon trim pieces of sufficient outside diameter to amply cover the sleeved openings and an inside diameter to closely fit the pipe/duct around which it is installed.

D. Flanged metal collars shall be provided around all pipes, etc. at all wall penetrations, both sides. Penetrations through any wall will require the installation of flanged collars. Openings shall not be any larger than 2" in any direction than the piping/duct passing through the wall. Openings larger than this requirement shall also be infilled to match adjacent construction. Fill void with insulation for sound reduction.

3.6 FIRESTOPPING:

A. Provide shop drawings indicating penetration detail for each type of wall and floor construction. Shop drawings must be specific for each individual type of penetration (one hour fire rated gypsum wall board with insulated metal pipe penetration, etc.) Provide copies to the authority having jurisdiction if required.

B. All pipes ducts penetrating fire rated floors and walls shall be firestopped by this Contractor. All firestopping products and assemblies installed shall be UL listed.

C. Where the installation of conduit, ducts, piping, etc. requires the penetration of fire or smoke rated walls, ceilings or floors, the space around such conduit, duct, pipe, etc., shall be tightly filled with an approved non-combustible fire insulating material and properly sealed to maintain the rating integrity of the wall, floor or ceilings affected.

D. The manufacturer of the firestopping materials shall provide on site training for the installing Contractor. The training session shall demonstrate to the Contractor the proper installation techniques for all the firestopping materials.

E. The following indicates the 3M penetration details for uninsulated pipe penetration of various wall and floor construction types (the list is not inclusive):
   1. One, two or three hour fire rated concrete floor - 3M #5300-MPC8.
   2. One, two or three hour fire rated solid or block concrete wall - 3M #5300-MPC16 or 3M #5300-MPC26.
   3. One hour fire rated gypsum wallboard - 3M #5300-MPC7.
   4. Two hour fire rated gypsum wallboard - 3M #5300-MPC7.

F. Multiple pipes penetrating fire rated floors and walls may be firestopped as a group. Submit details for specific applications if this method of firestopping is chosen.

END OF SECTION 220515

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SECTION 230517 – METERS AND GAGES FOR PLUMBING PIPING

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR PLUMBING and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. Each Contractor’s attention is also directed to Specification Section SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR PLUMBING, and provide all documentation called for therein.

1.2 SCOPE

A. The Contractor shall include all meters, thermometers, pressure gauges and/or compound gauges at the locations indicated. All pressure gauges and/or compound gauges shall be provided with ¼ turn ball valves to allow the gauge to be removed and replaced without shutting down system.

PART 2 – PRODUCTS:

2.1 THERMOMETERS AND PRESSURE GAUGES:

A. Gauges and thermometers shall be Miljoco, Marsh, Trerice, or Weksler.

B. Digital thermometers shall be solar powered industrial thermometer. The range shall be -50°F/300°F with an accuracy of 1% or 1°, whichever is greater. The display shall be a 3/8” LCD digit. Use where specifically indicated on the drawings.

C. Water thermometers shall be blue-reading spirit liquid-in-glass type with 9” scale, powder coated cast aluminum case and stem socket of length as required by system. Accuracy to be plus or minus 1 scale division. Lens to be plastic. Hot water thermometer shall have a 30°F to 240°F range and chilled water thermometer shall have a 0°F to 120°F range.

D. Pressure gauges shall be Bourdon Type, circular, 4-1/2" face, black letters on white face graduated in 2 PSI or less and shall be manufactured for service intended. Provide with pig tail connectors and gauge cocks. Accuracy to be plus or minus 1%. Water pressure gauges shall have 0 to 100 PSI range.

2.2 METERS

A. POTABLE and IRRIGATION WATER FLOW METER: **Yokogawa Magnetic Meter AXF___C-E1AL1L-BA11-21B/FF1**, Rosemount or Krohne equal, Magnetic Flow Meter, Integral digital indicator w/ HART 5/7 protocol, 4-20mA output, 150 lb. ANSI Flanged, 120V power, SS316L electrode material and grounding ring, PFA lining, FM Explosion Proof hazardous area certification. Install flow meter with sufficient pipe diameters as recommended by manufacturer. Provide factory authorized start-up verification of operation and calibration.

B. BUILDING NATURAL GAS METER: **NORGAS MDN-_M Rotary Gas Meter**. Coordinate flow body sizing and flanges with manufacturer. Provide with pulse output and manufacturers cable. Coordinate cable length with the TCC. The entire system shall be factory calibrated and programmed for particular system where installed. Furnish a certificate of calibration. Install meter per manufacturer’s recommendations with sufficient pipe diameters as recommended by manufacturer. Provide factory authorized start-up verification of operation and calibration.

C. SUB-METER NATURAL GAS METER: **NORGAS NG4 Gas Meter**. Coordinate Flow body sizing and flanges with manufacturer. Provide with pulse output and coordinate with the TCC. The entire system shall be factory calibrated and programmed for particular system where installed. Furnish a certificate of calibration. Install meter per manufacturer's recommendations with sufficient pipe diameters as recommended by manufacturer. Provide factory authorized start-up verification of operation and calibration.

PART 3 – EXECUTION:

3.1 INSTALLATION

A. All thermometers, meters and pressure gauges shall be readable from a standing position on the floor. Mount thermometers in approved wells. Do not make direct contact of base with fluid in pipe. Pressure gauges and thermometers subject to vibration shall be mounted remotely away from vibrating pipe surface, etc. with flexible tubing.

B. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.

C. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

D. Install thermowells with extension on insulated piping.

E. Fill thermowells with heat-transfer medium.

F. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

G. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.

H. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.

I. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

J. Install remote-mounted pressure gages on panel.

K. Install valve and snubber in piping for each pressure gage for fluids (except steam).

L. Install valve and syphon fitting in piping for each pressure gage for steam.

M. Install test plugs in piping tees.

N. Install flow indicators in piping systems in accessible positions for easy viewing.

O. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.

P. Install flowmeter elements in accessible positions in piping systems.

Q. Install flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.

R. Install permanent indicators on walls or brackets in accessible and readable positions.

S. Install connection fittings in accessible locations for attachment to portable indicators.

T. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.

U. Install thermometers in the following locations:

V. Install test plugs in the following locations:

3.2 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

B. Connect flowmeter-system elements to meters.

C. Connect flowmeter transmitters to meters.

3.3 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

B. Adjust faces of meters and gages to proper angle for best visibility.

END OF SECTION 230519

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SECTION 220519 – THERMOMETERS, PRESSURE GAUGES AND OTHER MONITORING INSTRUMENTS

PART 1 – GENERAL:

1.1 The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR PLUMBING and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

1.2 The Contractor shall include all thermometers, pressure gauges and/or compound gauges at the locations indicated. All pressure gauges and/or compound gauges shall be provided with ¼ turn ball valves to allow the gauge to be removed and replaced without shutting down system.

PART 2 – PRODUCTS:

2.1 THEMOMETERS AND PRESSURE GAUGES:

A. Gauges and thermometers shall be Miljoco, Marsh, Trerice, or Weksler.

B. All thermometers and pressure gauges shall be readable from a standing position on the floor. Mount thermometers in approved wells. Do not make direct contact of base with fluid in pipe. Pressure gauges and thermometers subject to vibration shall be mounted remotely away from vibrating pipe surface, etc. with flexible tubing.

C. Digital thermometers shall be solar powered industrial thermometer. The range shall be -50°F/300°F with an accuracy of 1% or 1°, whichever is greater. The display shall be a 3/8” LCD digit. Use where specifically indicated on the drawings.

D. Water thermometers shall be blue-reading spirit liquid-in-glass type with 9” scale, powder coated cast aluminum case and stem socket of length as required by system. Accuracy to be plus or minus 1 scale division. Lens to be plastic. Hot water thermometer shall have a 30°F to 240°F range and chilled water thermometer shall have a 0°F to 120°F range.

E. Pressure gauges shall be Bourdon Type, circular, 4-1/2" face, black letters on white face graduated in 2 PSI or less and shall be manufactured for service intended. Provide with pig tail connectors and gauge cocks. Accuracy to be plus or minus 1%. Water pressure and low pressure steam gauges shall have 0 to 100 PSI range and medium/high pressure steam gauges shall have 0 to 200 PSI range.

F. Provide direct mount Bimetal dial thermometers in HVAC ductwork. Thermometer shall be 3" diameter, with polycarbonote plastic lens and stainless steel case. Air temperature range shall be 25°F to 125°F.

PART 3 – EXECUTION:

3.1 METERS:

A. Industrial grade thermometers and pressure gauges.

END OF SECTION 220519

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SECTION 220523 – VALVES FOR PLUMBING

PART 1 – GENERAL:

1.1 The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR PLUMBING and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

1.2 Each Contractor shall provide all valves required to control, maintain, and direct flow of all fluid systems indicated or specified. This shall include but may not be limited to all valves of all types including balancing valves, air vents, drain valves, check valves, special valves for special systems, etc., for all Mechanical Systems.

1.3 ACCEPTABLE MANUFACTURERS: Apollo, Nibco, and approved equal.

1.4 The following type valves shall not be acceptable: Zinc, plastic, fiber or non-metallic.

1.5 Each type of valve shall be of one manufacturer, i.e., ball valves, one manufacturer, butterfly valves, one manufacturer, check valves, one manufacturer, etc.

1.6 All valves shall comply with current Federal, State and Local Codes. All valves shall be new and of first quality. All valves shall be designed and rated for the service to which they are applied. Zinc, plastic, fiber, or non-metallic valves shall not be acceptable.

1.7 Contractor shall provide colored tape on ceiling tile where valves are located above ceiling. Provide access panels where valves are located above hard ceiling.

PART 2 – PRODUCTS:

2.1 SITE WATER APPLICATIONS:

A. REFER TO CIVIL PLANS

2.2 DOMESTIC WATER APPLICATIONS:

A. GATE VALVE (2" AND UNDER): Use ball valves as specified.

B. GATE VALVE (2½” AND LARGER): Gate valve shall have bronze body, bonnet, and solid wedge. Gate valve shall be rising stem with bolted bonnet and solid wedge. Valve shall have rated for 150 psi working pressure. Gate valve shall be Nibco T-134 for threaded ends or Nibco S-134 for solder ends.

C. CHECK VALVE (2" AND UNDER): Check valve shall have bronze body, disc, and hinge. check valve shall be Y-pattern type, horizontal swing, renewable disc and rated for 150 psi working pressure. Check valve shall be Nibco T-413 for threaded ends or Nibco S-413 for solder ends.

D. BALL VALVES (2½”-3”): Ball valve shall have bronze body, ball, and reinforced, watertight seat. Valve handle shall only require quarter turn to go from full open to full close. The handle shall be removable with vinyl grip. Valve shall be rated for 250 degrees F water temperature and 200 psi working pressure. Ball valve shall be Nibco T-580 for threaded ends and Nibco S-580 for solder ends. Provide extended handles for all ball valves installed in an insulated system.

E. TWO PIECE BALL VALVE (2" AND UNDER): 2 in. and smaller - class 125, 200 WOG cast bronze, two-piece construction, lead free, full-port, soldered ends, and stainless steel trim. 2- 1/2 in. and larger - class 125 iron body.

F. STRAINERS (2" AND UNDER): Watts 77S Series "Y" type strainer with cast iron body and threaded ends. Screen shall be 20 mesh stainless steel. Strainer shall be provided with cleanout plug and be rated for 200 psi working pressure.

G. STRAINERS (2½" AND LARGER): Watts 77F Series "Y" type strainer with semi-steel body and flanged ends. Screen shall be 20 mesh stainless steel. Strainer shall be provided with bolted cleanout and be rated for 200 psi working pressure.

H. PRESSURE REDUCING VALVES: Watts #U5B water pressure reading valve with bronze body, bolted bonnet, integral stainless steel strainer and outlet water pressure gauge. Internal disc, diaphragm and stainless steel seat shall all be removable. Valve shall be rated for inlet water pressures up to 300 psi. Water pressure reducing valves shall be provided for all equipment where water pressure exceeds the equipment manufacturer's ratings.

I. VACUUM BREAKERS: Watts #288A atmospheric type vacuum breaker with brass body. Vacuum breaker shall be rated for 210 degrees F and 125 psi working pressure and shall meet ASSE Standard 1001.

J. SWING CHECK VALVE: 2 in. and smaller, class 125 cast bronze, threaded ends, 2-1/2 in. and larger, class 125, cast iron body, flanged ends

K. DOUBLE CHECK VALVE: Double check valve shall have bronze body construction and be provided with inlet strainer, two (2) gate valves for isolation and three (3) test ports. Assembly shall be rated for 110 degrees F water temperature and 175 psi water pressure. Assembly must meet requirements of AWWA Standard C506. For sizes 2" and less, provide Watts #900 (or equal) with threaded ends. For sizes 2½" and larger, provide Watts #709 (or equal) with flange ends.

L. REDUCED PRESSURE BACKFLOW PREVENTERS: Reduced pressure backflow preventers shall be provided with inlet strainer, two (2) gate valves for isolation, three (3) test ports and air gap fitting. Assembly shall be rated for 110 degrees F water temperature and 175 psi water pressure. RPBP shall be UL listed and meet AWWA C511 standards. Watts #909 or equal by Wilkins or Conbraco. All valves 3" and less in size shall bronze body construction, over 3" in size shall have epoxy coated cast iron bodies. Assemblies 2" and under in size shall have threaded ends, over 2" in size shall have flange ends. Perform backflow preventer test and provide results with closeout documentation.

M. BALANCING VALVE: Bell & Gossett "Circuit Setter" Model CB or equal balancing valve. All valves to be of bronze body/brass ball construction with glass and carbon filled TFE seat rings. Valves to have differential pressure read-out ports across valve seat area. Read-out ports to be fitted with internal EPT inserts and check valves. Valve bodies to have 1/4" NPT tapped drain/purge port. Valves to have memory stop feature to allow valve to be closed for service and then reopened to set point without disturbing balance position. All valves to have calibrated nameplates to assure specific valve settings. Valves shall be designed for positive shut-off.

2.3 NATURAL GAS APPLICATIONS:

A. GAS BALL VALVE (2" AND LESS): Class 125, 200 WOG cast bronze, two-piece construction full-port, threaded ends, 2-1/2 in. and larger, 175 WOG lubricated plug type, semi steel body, flanged ends.

PART 3 – EXECUTION (NOT APPLICABLE)

END OF SECTION 220523

SECTION 220529 - HANGERS, CLAMPS, ATTACHMENTS, ETC. FOR PLUMBING

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR PLUMBING and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. Each Contractor's attention is also directed to Specification Section PIPE, PIPE FITTINGS AND SUPPORT.

1.2 SCOPE

A. This section includes, but is not limited to, furnishing, and installing supports, anchors, and accessories for piping, ductwork, equipment, etc. Furnishing and installing shall be by each trade for the completion of their work as directed in this Section.

PART 2 – PRODUCTS:

2.1 HANGERS, CLAMPS, ATTACHMENTS SCHEDULE:

A. ACCEPTABLE MANUFACTURERS: Grinnell, Elcen, Fee & Mason.
1. All hangers, clamps and attachments shall be manufactured products.
2. Pipe Rings (2” pipe and smaller) – adjustable swivel split ring or split pipe ring.
3. Pipe Clevis (2.5” pipe and larger) – adjustable wrought clevis type.
4. Pipe Clevis (All pipe sizes) – steel clevis for insulated pipe.
5. Riser Clamps (All pipe sizes) – extension pipe or riser clamp.
6. Beam Clamps (All pipe sizes) – malleable beam clamp with extension piece.
7. Brackets (All pipe sizes) – medium weight steel brackets.
8. Concrete Inserts (All pipe sizes) – wrought or wedge type inserts.
9. Concrete Fasteners (All pipe sizes) – self-drilling concrete inserts.
10. Rod Attachments (All pipe sizes) – extension piece, rod coupling, forged steel turnbuckle
11. U-bolts (All pipe sizes) – standard u-bolt.
12. Welded Pipe Saddles (All pipe sizes) – pipe covering protection saddle sized for thickness of insulation.
13. Pipe Roll (All pipe sizes) – adjustable swivel pipe roll.
14. Protection Saddle (All pipe sizes) – 180 degree coverage, sheet metal pipe protection saddle.
15. Hanger Rods (All pipe sizes) – Steel, diameter of hanger threading.
16. Concrete Channel Inserts (All pipe sizes) – continuous heavy duty slot inserts unistrut.
17. Adjustable Spot Inserts (All pipe sizes) – continuous heavy duty spot insert unistrut.
18. Miscellaneous steel such as steel angles, rods, bars, channels, etc used in framing for supports, fabricated brackets, anchors, etc. shall confirm to ASTM-A-7.

PART 3 – EXECUTION:

3.1 Supporting and hanging shall be done so that excessive load will not be placed on any one hanger so as to allow for proper pitch and expansion of piping.

3.2 Hangers and supports shall be placed as near as possible to joints, turns, and branches.

3.3 For concrete construction, utilize adjustable concrete inserts for fasteners. Expansion anchors and power driven devices may be used when approved in writing by the Architect/Engineer.

3.4 Utilize beam clamps with retaining straps or concrete inserts for fastening to steel joists and beams. Expansion anchors in masonry construction. Do not support piping or ductwork from bridging or metal decking.

3.5 When piping is routed in joists, piping shall be top mounted on trapeze type hangers with each pipe individually clamped to trapeze hanger. Do not support piping or ductwork from bridging angles.

3.6 Trapeze hangers are utilized where possible to rack piping together.

3.7 Horizontal piping hangers - insulated piping shall have steel hanger around insulation with rigid insulation above shield. Use galvanized or zinc plated, adjustable steel clevis hangers.

3.8 Install all miscellaneous steel other than designed building structural members as required to provide means of securing hangers, supports, etc., where piping does not pass directly below or cross structural elements.

3.9 Piping shall not be supported by the equipment to which it is connected. Support all piping so as to remove any load or stress from the equipment.

3.10 Where piping, etc., is routed vertically, approved riser clamps, brackets or other means shall be utilized at approximately 10'-0" center to center minimum. An approved adjustable base stand or fitting on concrete support base shall be utilized at the base of the vertical run. Size to fit bare pipe, copper plated for copper piping.

3.11 Where piping is routed along walls, knee braced angle frames, etc. pipe brackets with saddles, clamps, and rollers mounted on structural brackets fastened to walls or columns shall be used.

3.12 Support all ceiling hung equipment with approved vibration isolators.

3.13 Where copper tubing is specified, hangers shall be of copper clad type when piping is uninsulated.

3.14 Uninsulated piping hung from above shall be supported with ring and clevis type pipe hangers. Uninsulated piping mounted on trapeze (when allowed) and wall bracket type support shall be held in place with U-bolts. U-bolts shall allow for axial movement in the piping. Support all piping so as to prevent excessive movement.

3.15 All insulated piping shall be supported with clevis type and pipe roll hangers. Hangers shall be sized to allow the pipe insulation to pass through the hangers. Install insulation protection saddles at all hanger locations. Welded pipe saddles shall be installed at all hangers on piping 5" and larger. The pipe saddles shall be sized for the thickness of insulation used. Hangers shall fit snugly around outside of insulation saddles.

3.16 Under no conditions will perforated band iron or steel wire driven hangers be permitted.

3.17 Support steel and copper piping at a minimum of eight (8) foot intervals for piping 3" and smaller and ten (10) foot intervals for larger piping. Provide additional support at end of the branches and change of direction.

3.18 Support plastic pipe at intervals not to exceed four (4) feet and at the end of the branches and at the change of direction and shall be installed as to permit freedom of movement. Vertical piping shall be supported at their bases and all upward movement shall not be restricted. Hangers shall be at least one (1) inch wide and shall not compress, distort, cut, or abrade the piping to allow free movement at all times. Support all piping so as to prevent excessive movement.

3.19 Where fireproofing is dislodged/damaged from the building structure due to Contractor's installation of hangers, clamps, etc., it shall be the Contractor's responsibility to repair all dislodged/damaged fireproofing to original fireproofing rating. This shall also include all work performed by their contractors' sub-contractors.

3.20 Ensure that all bolts and nuts are tightened.

END OF SECTION 220529

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SECTION 220553 - IDENTIFICATIONS, TAGS, CHARTS, FOR PLUMBING

PART 1 – GENERAL:

1.1 The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR PLUMBING and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

PART 2 – PRODUCTS:

2.1 TAGS AND CHARTS:

A. Provide and install on each valve 1” in size or greater for all mechanical systems a 1.5" diameter circular bronze or baked phenolic tag fitted to each valve so that it cannot be removed. Each tag shall be embossed consecutively with sequential number identifiers. Number identifiers shall be determined by the Contractor sequentially.

B. Provide typewritten valve charts indicating each valve identifier, the valves service, normal position, and its location. Also furnish one electronic copy on CD in “*.xls” format. One (1) copy of this chart shall be mounted in suitable frame(s) with clear plastic covers in a conspicuous location in each of the major mechanical rooms. Repeat only main valves which are to be operated in conjunction with operations of more than single mechanical room.

C. All emergency shutoff valves shall be identified with a permanent engraved tag hung from the valve with 1-inch high lettering. Emergency shutoff valves shall be identified as any valve whose closure could create an emergency condition in the facility (i.e., natural gas, water, domestic hot water, etc.).

D. Label all control panels and disconnect switches with service and equipment served.

PART 3 – EXECUTION

A. GENERAL

1. Use same identification throughout project design and construction.
2. PIPING IDENTIFICATION:
   a) Concealed piping above accessible ceilings with O.D., including insulation, less than 6": pre-tensioned type pipe markers (ASME A13.1) or stenciled with black letters and black flow arrows.
   b) Concealed piping above accessible ceilings with O.D., including insulation, 6" and larger: Shaped pipe markers (ASME A13.1) or stenciled with black letters and black flow arrows.
   c) Piping runs located above inaccessible ceilings do not require labeling.
   d) Locate pipe markers and flow arrows as follows:
      1) Maximum of 10ft and closer if congested.
      2) Near each valve
      3) Near each branch take off.
      4) Near equipment.
      5) Near origination and termination points
      6) Near where pipe passes through walls (both sides of wall)
      7) Near access doors
      8) On piping above inaccessible ceilings as it enters and immediately after it exits.
   e) All exposed piping in air handling unit mechanical rooms shall be labeled the same as concealed piping above accessible ceilings.

f) All exposed-to-view piping in occupied spaces shall be painted to match the adjacent surfaces. Do not paint metal jackets.

g) All exposed piping in Boiler Room and Main Mechanical Room shall be painted to WCPSS standards as follows (provide black flow arrows):

1) Cold Water- Dark Blue	Sherwin Williams #SW6965
2) Hot Water - Light Red	Sherwin Williams #SW6868
3) Hot Wtr Return-Light Red	Sherwin Williams #SW6868
4) Gas - Yellow	Sherwin Williams #SW6911

h) Underground plastic pipe marker: 6 in. wide x 4 mils thick multi-ply tape, solid aluminum foil core between two (2) layers of plastic tape. Provide in all locations where underground plastic piping is utilized.

3. VALVE IDENTIFICATION:

a) 19 gauge polished brass, 2" diameter, valve tags. Provide on all valves utilized in system. Contractor to furnish valve schedule mounted behind glass in a frame located in main mechanical room.

b) Valve Location Ceiling Markers: 1/2 in. dia. self-adhesive color coded circle. See Appendix A - 22 05 50-Attachment A for information on ceiling grid labels.

c) Provide at all valve locations either on ceiling grid or access panel.

4. EQUIPMENT IDENTIFICATION:

a) Engraved plastic-laminate sign: 1/16 in. thick, fastened with self-tapping stainless steel screws.

1) Lettering sizes: Minimum 1/4" for name of unit where viewing distance is less than 2 ft., 1/2" for distances up to 6 ft, proportionately larger lettering for greater distances. Provide secondary lettering 2/3 to 3/4 of size of principal lettering.

END OF SECTION 220553

SECTION 220570 - EXCAVATION, TRENCHING, BACKFILLING AND GRADING FOR PLUMBING

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR PLUMBING and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

1.2 SCOPE OF WORK

A. The Contractor shall include all excavating, filling, grading, and related items required to complete their work as shown on the drawings and specified herein or as required to complete, connect, and place all mechanical systems in satisfactory operation.

PART 2 – PRODUCTS (NOT USED):

PART 3 - EXECUTION:

3.1 EARTHWORK CLASSIFICATION:

A. Without regard to the materials encountered, all excavation and materials excavated shall be unclassified. Materials to be excavated shall include earth, rock, concrete, or any other obstructions encountered in excavation and/or trenching to install underground utility pipes, tanks, vaults, or other equipment.

B. Include all costs for rock removal, including mass rock and trench rock in the bids. No adjustment in the contract sum will be made on account of the presence or absence of rock, shale, debris, obstructions, or other materials encountered in the excavating. The Contractor shall be responsible for the removal of all materials encountered as required for the installation of the work.

C. It shall be distinctly understood that references to rock, earth, topsoil or any other excavated or non-excavated material or other material on the construction plans, cross section, contract documents, technical specification, or provisions, whether in numbers, words, letters, lines or graphically shown, is solely for information for the Engineer and Owner. This information shall not be taken as an indication of the classification of the material to be excavated, bored, or removed by any method, including drilling, and blasting, or materials not removed. This information shall not be taken as to the quantity of either rock, earth, topsoil, or any other material involved, or the quality of the material such as hardness, wetness, workability, or suitability of the material either during excavation and construction or as a material to be reused during construction.

D. The Contractor shall draw their own conclusions as to the surface and sub-surface conditions to be encountered during construction of this project. The Engineer and Owner do not give any guarantee or warranty as to the accuracy of the data shown and no claim will be considered for additional compensation when the materials encountered are not in accord with the information shown.

E. Refer to Specification Division EARTHWORK located in the Site Work portions of the Specifications and Civil Drawings for additional information. Also refer to the GEOTECHNICAL report (provide for informational purposes only) included in the Front End of the Specifications.

3.2 EXCAVATION:

A. Unless otherwise shown or required, provide separate trenches for sewers, water lines and other underground raceways, with a minimum of 10 feet measured from outside diameter between pipes. In

locations, such as close to buildings where separate trenches for sewers and water lines are impractical, lay the water pipe on a solid shelf at least 2'-0" above the top of the sewer and 2'-0" to the side.

B. Water lines crossing under sewer lines, or crossing less than 2 feet above sewer lines, must be concrete encased for a distance not less than 5 feet on either side of the point of crossover.

C. Excavate trenches of sufficient width for proper installation of the work. Excavate to 6" below the bottom of new pipes for installation of compacted fill.

D. Sheet and brace trenches as necessary to protect workers and adjacent structures. Comply with local regulations or, in the absence thereof, with the latest version of "Manual of Accident Prevention in Construction" by the Associated General Contractors of America and current OSHA Standards. Do not remove sheeting until trench is backfilled sufficiently to protect pipe and/or equipment and prevent injurious caving. Where removal of sheeting and/or bracing is hazardous, leave in place. Cut off such sheeting not to be removed at least 3 feet below finished grade.

E. Rules and regulations governing the respective utilities shall be observed in executing all work under this Division. Active utilities discovered in the course of excavation shall be protected or relocated in accordance with written instructions from the Engineer. Inactive and abandoned utilities encountered in trenching operations shall be removed and abandoned with ends plugged or capped in accord with current codes and safe practice. If in doubt, contact Engineer.

F. Machine excavation shall not be allowed within ten (10) feet of electric lines, natural gas lines or other lines carrying combustible materials. Use only hand tool excavation methods.

G. The removal of rock shall be accomplished by use of hand or power tools only. Blasting shall not be permitted. Any damage to existing structures, piping services, or rock intended for bearing, shall be corrected at the responsible Contractor's expense.

H. Perform final grading of trench bottoms by hand tools; carry machine excavation only to such depth that soil bearing for pipes and raceways will not be disturbed. Grade the bottom of trenches evenly to insure uniform bearing for all piping and raceways. Cut bell holes as necessary for joints and jointmaking. Except as hereinafter specified, bottom of trenches for bell and spigot pipe, flanged pipe, etc. shall be shaped to the lower quadrant of pipe with additional excavation for bell or flange. Piping installed where it rests on bell or flange and/or is supported with blocks or wedges will not be accepted.

I. Keep trenches free from water while construction is in progress. Under no circumstances lay pipe or appurtenances in water. Pump or bail water from bell holes to permit proper joining of pipe. Any dewatering from this Contractor's trenches which is required during construction, shall be included in this Contract.

J. In no case shall excavation work be accomplished that will damage in any way the new structure, existing structures, equipment, utility lines, landscaping to remain, etc. The Contractor shall take the necessary steps to prevent flow of eroded earth by water or landslide onto the property of others, or against the structures. The repair of all such damage or any other damage incurred in the course of excavation shall be at the responsible Contractor’s expense.

K. Use surveyor's level to establish elevations and grades.

L. Machine excavation shall be held a sufficient distance from foundations and footings to insure no damage to same. Contractor shall accept full responsibility and pay for repairs and/or replacement of structural members, footings, etc.

M. The Contractor shall accept the site as it is. Remove all trash, rubbish, and unsuitable material from the site at the completion of excavation work.

N. The Contractor shall provide and maintain barricades, trench plates and temporary bridges around excavations as required for safety. Temporary plates or bridges shall be provided where excavations cross paved areas and walks. The Contractor shall maintain these plates and bridges in a safe and passable condition for all traffic until removal. Refer to OSHA Standards for such installations and comply with same in all details.

O. Pay particular attention to existing utilities and lines to avoid damage. The locations of existing lines which are indicated on the plans were taken unconfirmed from drawings prepared for previous construction and locations are approximate only. Also, certain water, gas, electric, storm and sanitary sewer lines and other underground appurtenances, active or abandoned, may not appear on the drawings. It shall be each Contractor's responsibility to ascertain the location of all lines and excavate with caution in their area.

P. Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction of Engineer. Unauthorized excavation, as well as remedial work directed by Engineer, shall be at Contractor’s expense.

Q. Maintain carefully all benchmarks, monuments and other reference points. If disturbed or destroyed, replace as directed.

3.3 BACKFILL, COMPACTION AND SURFACE REPAIR:

A. Backfilling for Plumbing Work shall include all trenches, manhole pits, tanks and/or any other earth and/or rock openings which are excavated under this Contract. Backfilling shall be carefully performed, and the surface restored to its original level to receive new finish. Wherever trenches and earth openings have not been properly filled and/or settlement occurs, they shall be re-excavated, re-filled and properly compacted, smoothed off and finally made to conform to the level of the original ground surface.

B. All trenches shall be backfilled with a bedding of 6" of manufactured sand or #8 crushed stone after finished excavation. Install the new pipe on the compacted fill material. Install tracer wire on all pipe. Apply any special coatings to the pipe. Also perform all required pressure tests and check the grade of the pipe to ensure that it is correct and free of swags, bows or bends. Once coatings and testing are complete, backfill the pipe bed to 12" above the top of the pipe with specified compacted fill material. Backfill the remainder of the trench with earth (rock and debris free) tamped at 6" intervals. Water settling of backfill is permitted only as an aid to mechanical compacting.

C. Backfill and compact beneath areas to be seeded or sodded within six (6) inches of finished grade. The remaining six (6) inches shall be backfilled with clean topsoil.

D. Backfill and compact beneath concrete slabs, paved areas, walks, etc. shall be brought to proper grade to receive the sub-base and paving. No concrete or paving shall be placed on uncompacted fill or unstable soil.

E. Wherever, in the opinion of the Engineer, the soil at or below the requisite pipe grade is unsuitable for supporting piping, special support shall be provided as directed by the Engineer.

F. Backfill and compaction for natural gas lines shall be in strict accordance with the local utility company or local municipality’s requirements. If in doubt, contact the utility company or local municipality.

G. Unsuitable material and surplus excavated material not required for backfill shall be removed from the site. The location of dump and length of haul shall be the affected Contractor's responsibility.

H. Provide and place any additional fill material from off the site as may be required for backfill. Fill obtained from off site shall be of kind and quality as specified for backfill and the source approved by the Engineer and shall be brought to the site by the Contractor requiring the fill.

I. If not specified or indicated elsewhere in the Contract Documents to be performed by Others, the Contractor shall lay new sod over their excavation work for existing disturbed grassy areas. Level, with adjacent surface, compact and water in accord with sound sodding practice.

J. Control soil compaction during construction providing minimum percentage of density specified for each area classification indicated in the following two paragraphs.

K. At a minimum, fill in grass areas shall be compacted to 90% Standard Proctor Density, ASTM D-698, at moisture content between 2 percent below to a 3 percent above the optimum moisture content or as specified in Specification Division EARTHWORK; whichever is most stringent.

L. At a minimum, fill in concrete or asphalt area shall be compacted to 98% Standard Proctor Density, ASTM D-698, at moisture content between 2 percent below to a 3 percent above the optimum moisture content or as specified in Specification Division EARTHWORK; whichever is most stringent.

M. Place backfill and fill materials evenly adjacent to structures, piping, or conduit to required elevations. Take care to prevent wedging action of backfill against structures or displacement of piping or conduit by carrying material uniformly around structure, piping, or conduit by carrying material uniformly around structure, piping, or conduit to approximately same elevation in each lift.

N. All materials used for backfill around structures shall be of a quality acceptable to the Engineer and shall be free from large or frozen lumps, large rocks, wood, and other extraneous material. All spaces excavated and not occupied by footings, foundations, walls, or other permanent work shall be refilled with earth up to the surface of the surrounding ground, unless otherwise specified, with sufficient allowance for settlement.

O. In making the fills and terraces around the structures, the fill shall be placed in layers not exceeding 8 inches in depth and shall be kept smooth as the work progresses. Each layer of the fill shall be compacted. Sections of the fill immediately adjacent to buildings or structures shall be thoroughly compacted by means of mechanical tamping or hand tamping as may be required by the conditions encountered. All fills shall be placed so as to load structure symmetrically.

P. Rough grading shall be held below finished grade and then the topsoil which has been stockpiled shall be evenly spread over the surface. The grading shall be brought to the levels as specified. Final dressing shall be accomplished by hand work or machine work, or a combination of these methods as may be necessary to produce a uniform and smooth finish to all parts of the regrade. The surface shall be free from clods greater than one inch in diameter. Excavated rock (1” and smaller) may be placed in the fills, but is shall be thoroughly covered. Rock placed in fills shall not be closer than 24 inches from finished grade. Refer to Specification Division EARTHWORK.

Q. Maintenance Settling: Where settling is measurable or observable at excavated areas during Project Warranty Period, remove surface (pavement, concrete or any other surface or finish), add backfill material, compact, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent work and eliminate evidence of restoration.

R. Disposal of Excess Non-organic Soil and Rock: Any excess excavated waste material shall become the property of the Contractor and shall be disposed of by the Contractor off site at no additional cost to the Owner.

S. Unless otherwise directed by the Owner during construction, excess topsoil, and subsoil suitable for fill shall be disposed of by the Contractor off site at no additional cost to the Owner.

3.4 MINIMUM DEPTHS OF BURY TO TOP OF PIPE:

A. In the absence of other indication, the following shall be the minimum depth of bury to top of pipe of exterior utility lines. Check drawings for variations.

1.	Domestic Water Lines	36 inches below final grade.
2.	Storm Lines	24 inches below final grade.
3.	Sanitary Lines	36 inches below final grade.
4.	Natural Gas Lines	36 inches below final grade.
5.	All Other Lines Not Listed	36 inches below final grade.

END OF SECTION 220570

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SECTION 220700 – PLUMBING - INSULATION

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR PLUMBING and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractor's attention is also directed to Specification Section, SHOP DRAWINGS, MAINTENANCE MANUALS AND PARTS LISTS FOR PLUMBING.

1.2 SCOPE

A. Work under this section shall include all labor, equipment, accessories, materials, and services required to furnish and install all insulation, fittings and finishes for all mechanical systems specified herein and/or as indicated.

B. Application of insulation materials shall be performed in accordance with manufacturer's written recommendations. Where thickness of insulation is not specified, use applicable thickness recommended by manufacturer for specific use.

C. Insulation thicknesses shall comply with the latest version of ASHRAE 90.1 and IECC at a minimum.

D. All insulation materials shall be installed per the latest edition of the National Commercial and Industrial Insulation Standards.

E. Insulation shall be installed by a company regularly engaged in the application of insulation and any work deemed unacceptable by the Engineer shall be removed and properly installed at the expense of the Contractor.

F. Unless otherwise specified or allowed, closed cell type insulation shall not be acceptable.

PART 2 – PRODUCTS

2.1 Acceptable Manufacturers - Johns Manville, Knauf, Owens-Corning.

1. Flame/smoke ratings: flame-spread index of 25 or less and smoke-developed index of 50 or less, as tested by ASTM E84 (NFPA 255) method.
2. Formaldehyde Free.
3. Insulate all domestic water piping with the following minimum insulation thickness:
   a) Domestic Cold Water, All Pipe Sizes: 1-inch
   b) Domestic Hot Water & Hot Water Return, Pipe Sizes½" - 1 ½": 1-inch
   c) Domestic Hot Water & Hot Water Return, Pipe Sizes 2" and larger: 2-inch
4. Insulate roof leader horizontal piping with 1-inch thick insulation to include roof drain pan, vertical piping from roof drain, and horizontal piping above ceiling. Insulate vertical piping in exposed locations.
5. Insulation all horizontal sanitary waste piping from floor drains receiving cooling coil condensate with 1 inch thick insulation to prevent sweating.
6. Provide sheet metal saddle at all pipe hangers.

7. Provide rigid insulation at pipe hangers for all insulated piping 2 in. and larger
8. Provide insulation continuously through wall and floor penetrations.
9. Provide 20 gauge galvanized metal jackets on all exposed, insulated, exterior piping. Prime metal jacket with paint grip finish.
10. Provide PVC jacket on all exposed piping in kitchen and associated areas.
11. Provide canvas jacket on all exposed piping in mechanical rooms and interior finished areas. Insulation canvas jacket shall be prepped for painting.
12. Provide pre-fabricated PVC elbows for all changes in direction in piping.

MATERIAL

13. Fiberglass insulation: ASTM C 547 Class I with Type I all service jackets.
14. Exposed insulation - 8 oz. canvas rosin sized cloth jacket.
15. PVC Jacket: 20-mil thick.
16. Fittings: one-piece pre-molded 20-mil thick, PVC fitting covers.
17. Exterior insulation: Polyisocyanurate cellular foam insulation, 65psi compressive strength. (Trymer 3000 series or equal)

PART 3 – EXECUTION

3.1 The Contractor shall photograph any installations prior to concealment.

3.2 General Application Requirements:

A. “Concealed", where used herein, shall mean hidden from sight as in trenches, chases, furred spaces, pipe shafts, or above hung finished ceilings. "Exposed" shall mean that piping or equipment is not "concealed" as defined above. Piping and equipment in service tunnels, mechanical equipment rooms, storage areas, or unfinished rooms is to be considered "exposed".

B. Insulation shall be applied on clean, dry surfaces in a neat and workmanlike manner reflecting the best current practices in the trade. Insulation shall not be applied to piping, ductwork or equipment until tested, inspected and released for insulation.

C. Where more than one thickness of insulation is required, joints (both longitudinal and transverse) shall be staggered.

D. All insulation shall be continuous through walls, ceiling openings and sleeves. However, insulation shall be broken through fire walls. All covered pipe and ductwork is to be located a sufficient distance from walls, other pipe, ductwork and other obstacles to permit the application of the full thickness of insulation specified. If necessary, extra fittings and pipe are to be used. No noticeable deformation of insulation or discontinuity of vapor seal, where required, will be accepted. Coordinate work with plumbers, pipe fitters, etc. to assure hanger locations agree with location of insulation inserts.

E. Existing and/or new insulation removed and/or damaged during course of construction shall be repaired or replaced by the Contractor at their expense.

F. Vapor barrier jackets shall be applied with a continuous unbroken vapor seal. Do not use staples through the jacket. NO EXCEPTIONS!

G. All insulation shall be installed with joints butted firmly together.

H. The Contractor shall insure that all insulation (piping, equipment, etc.) is completely continuous along all conduits, equipment, connection routes, etc. carrying cold fluids (air, water, other) and that condensation can, in no way, collect in or on the insulation, equipment, conduits, etc. Any such occurrence of condensation collection and/or damage therefrom shall be repaired solely at the expense of the Contractor.

3.3 Piping Systems:

A. Seal insulation and jacket at all points where insulation terminates at unions, flanges, valves, and equipment. This applies to hot water lines only as cold water lines require continuous insulation and vapor barrier.

B. Valves, flanges, and unions shall only be insulated when installed on cold fluid piping whose surface temperature will be at or below the dew point temperature of the ambient air.

C. Insulation shall not extend through fire and smoke walls. Pack sleeve at fire and smoke wall with approved fire retardant packing similar to mineral wool and seal with approved sealant.

D. Metal insulation shields and inserts are required at all pipe hangers where the piping is insulated. Metal shields shall be constructed of galvanized steel, formed to a 180 degree arc. Insulation shields shall be the following size:

Pipe Size	Shield Gauge	Shield Length
2” and less	20	12”
2 ½”- 4”	18	12”
5”- 10”	16	18”
Over 10”	14	24”

E. Insulated pipes 2” in diameter and larger shall be additionally supported with wood inserts of sufficient compressive strength to carry the weight of the pipe and fluid. Inserts shall extend beyond extend beyond the hanger and shall be at least 6” in length.

F. Floor Drain Sanitary Pipes: All floor drains that have condensate spilled to the drain, and the sanitary pipe is not below slab, shall have its respective sanitary pipe insulated with 1” thickness. Insulate the pipe until it connects to a 4’’ main, but a minimum of 20 feet in direction of flow.

G. Provide premolded PVC insulated fitting covers on all pipe fittings, flanges, valves, and pipe terminations. Fittings shall be insulated by applying the proper factory precut insulation insert to the pipe fitting. The ends of the insulation insert shall be tucked snugly into the throat of the fitting and the edges adjacent to the pipe insulation tufted and tucked in, fully insulating the pipe fitting. The proper thickness of insulation must be applied to keep the jacket temperature less than 150°F. An approved vapor retarder mastic compatible with the PVC shall be applied around the edges of the adjoining pipe insulation and on the fitting cover throat overlap seam. The PVC fitting cover shall then be applied and secured with pressure sensitive tape along the circumferential edges. The tape shall extend over the adjacent pipe insulation and have an overlap on itself at least 2" on the downward side. On fittings where the operating temperature is below 50°F, two or more layers of the insulation inserts shall be applied with the first layer being secured with a few wrappings of fiber glass yarn to eliminate voids. One additional insert shall be used for each additional 1" of pipe insulation above 1-1/2". All joints shall be fully sealed.

END OF SECTION 220700

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SECTION 220800 - PLUMBING COMMISSIONING REQUIREMENTS

PART 1 – GENERAL

1.1 DESCRIPTION

A. Commissioning

Commissioning is a systematic process of ensuring that all building systems perform interactively according to the owner's project requirements and operational needs. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment startup, performance testing and training. Commissioning during the construction phase is intended to achieve the following specific objectives:

1. Verify that applicable equipment and systems are installed according to the manufacturer's recommendations and to industry accepted minimum standards and that they receive adequate operational checkout by installing contractors.
2. Verify and document proper functional performance of equipment and systems.
3. Verify that O&M documentation is complete.
4. Verify that the Owner's operating personnel are adequately trained.

1.2 RELATED WORK

A. Section 01 1000 – Summary of Work

B. Section 01 3300 – Submittal Procedures

C. Section 01 7700 – Closeout Procedures

D. Section 01 7823 – Operation and Maintenance Data

E. Section 01 7839 – Project Record Document

F. Section 01 7900 – Demonstration and Training

G. Section 01 9113 – General Commissioning Requirements

1.3 Division 22 – Plumbing ABBREVIATIONS AND DEFINITIONS

A. A/E: Architect, Architect/Engineer, and/or Engineer

B. ASI: Architectural Supplemental Instruction

C. BAS: Building Automation System

D. BoD: Basis of Design. A narrative of how the designer plans to achieve the OPR

E. CxA: Commissioning Authority

F. Controls Contractor

G. CM: Construction Manager

H. Cx: Commissioning

I. Cx Plan: Commissioning Plan

J. Cx RFI: Commissioning Request for Information

K. DDC: Direct Digital Control System

L. Deficiency: A condition in the installation or function of a component, piece of equipment or system that is not in compliance with the Contract Documents and cannot be corrected in five (5) minutes time.

M. EC: Electrical Contractor

N. FBO: Furnished By Others

O. FT: Functional Performance Test

P. IAW: In Accordance With

Q. MC: Mechanical Contractor

R. O&M: Operation and Maintenance

S. OPM: Owner Project Manager

T. OPR: Owner Project Requirement. A dynamic document expressing how the owner expects the building systems to perform upon project completion.

U. PC: Prefunctional Checklist

V. RFI: Request for Information

W. Sub(s): Subcontractors or Prime Contractor

X. TC: Testing Contractor

1.4 TBD: To Be Determined

1.5 PLUMBING SYSTEMS TO BE COMMISSIONED

A. Domestic hot water systems

B. Natural gas supply equipment

C. Sump pumps and sump pump controls

1.6 SUBMITTALS

A. Refer also to Specification Section 01 9113, Subsection 1.6.

B. Provide the CxA a copy of the following items, for the systems to be commissioned:

1. Equipment and System Submittals to include, at minimum, the following:

a. Cut Sheets
b. Performance data

2 Manufacturer's pre-startup checklists
a. Manufacturer's start-up checklists
b. Installation Instructions

2. Shop drawings (including any resubmittals required by the A/E)

3. Test plan
4. Completed field test report, including all completed forms and checklist, and list of all outstanding deficiencies and uncompleted items
5. Operational and maintenance documentation
6. Training plan and training materials
7. As-built documentation

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Refer to Specification Section 01 9113, Subsection 2.1.

B. Instrumentation required to verify readings and test system and equipment performance shall be provided by Contractor and made available to Commissioning Authority. Camera equipment capable of viewing an entire pipe assembly at one time.

2.2 Cx WEB-BASED COMMISSIONING TOOL

A. Refer to Specification Section 01 9113, Subsection 2.1.

PART 3 - EXECUTION

3.1 MEETINGS

A. Refer to Specification Section 01 9113, Subsection 3.3.

3.2 START-UP, PREFUNCTIONAL CHECKLISTS AND INITIAL CHECKOUT

A. The following procedures apply to all equipment to be commissioned, according to Section 1.4 above.

B. General

Contractor shall complete plumbing testing as required in sections 221000, 221010, 221123, 223000,

224000,

C. Testing Plan

1. The subcontractor responsible for providing and installing the equipment completes the testing plan. The test plan will include checklists and procedures with specific boxes or lines for recording and documenting the tests, and a summary statement with a signature block at the end of the plan.
2. The contractor submits the full test plan to the A/E and CxA for review and approval.

D. Execution of Testing Plan

1. Two weeks prior to testing, the Subs and vendors schedule testing with the OPM, CM and CxA. The performance of the tests are directed and executed by the Sub or vendor.
2. The CxA and possibly the A/E will observe the testing procedures for selected pieces of equipment.
3. The Subs and vendors shall execute testing and provide the CM with a signed and dated copy of the completed testing report. The CM reviews for completion and accuracy, then submits to the CxA and A/E.
4. Only individuals that have direct knowledge and witnessed that a line item task on the testing was actually performed shall initial or check that item off. It is not acceptable for witnessing supervisors to fill out these forms.

E. Deficiencies, Non-Conformance and Approval in Checklists and Startup

1. The Sub(s) shall clearly list any outstanding items of the initial testing that were not completed successfully. The testing forms and any outstanding deficiencies shall be provided to the CxA within two days of test completion.
2. The installing Subs or vendors shall correct all areas that are deficient or incomplete in the tests in a timely manner and shall notify the CxA as soon as outstanding items have been corrected.
3. Items left incomplete, which later cause deficiencies or delays during functional performance testing may result in backcharges to the responsible party. Refer to Section 01 9113, 3.7 – Documentation, Non-Conformance, and Approval of Tests.

3.3 FUNCTIONAL PERFORMANCE TESTING, VERIFICATION AND VALIDATION

A. Objectives and Scope

1. The contractor will perform functional performance testing of the water heating equipment and any plumbing automation system integration with the EMS.
2. The objective is to demonstrate that each system is operating according to the owner's project requirements, documented project program, and Contract Documents. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and function of the systems.
3. The CxA develops specific functional test procedures and forms to verify and document proper operation of each piece of equipment and system. The CxA provides a copy of the test procedures to the A/E, OPM and installing Sub who shall review the tests prior to testing. The A/E and Sub(s) shall point out to the CxA any specific problems as related to feasibility, safety, equipment, and warranty protection.
4. Testing proceeds from components to subsystems to systems. When the proper performance of all interacting individual systems has been achieved, the interface or coordinated responses between systems is checked.
5. The contractor shall supply all personnel and equipment for the demonstration, including, but not

limited to, tools, instruments, ladders, lifts, computers, software, cables, etc. Contractor supplied personnel must be competent with and knowledgeable of all project- specific systems. All training documentation, submittals, installation manuals, and O&Ms, shall be at the job site before demonstration testing commences.

B. Coordination and Scheduling

1. The CM shall provide sufficient notice to the CxA regarding the Subs completion schedule for the testing of all equipment and systems. The CxA will schedule demonstration and validation after written notification from the CM and affected Subs. The CxA shall direct, witness and document the demonstration retesting of equipment and systems. The Subs shall execute the tests.
2. In general, functional performance testing shall not be scheduled until all equipment submittals are approved, testing plans are approved, testing has been satisfactorily completed, and testing report has been provided. Scheduling of testing shall be done with a minimum of two weeks notice prior to testing. Testing which occurs outside the presence of the CxA or OPM without written authorization to do so will be required to be re-tested at no expense to the owner.

C. Problem Solving

1. The CxA will recommend solutions to problems found, however the burden of responsibility to solve, correct and retest problems is with the CM, Subs and A/E.

3.4 DOCUMENTATION, NON-CONFORMANCE, AND APPROVAL OF TESTS

A. Refer to Specification Section 01 9113, Subsection 3.7.

3.5 OPERATION AND MAINTENANCE MANUALS

A. In addition to installation manuals, the contractor shall provide one copy of the Operation and Maintenance Manuals to the CxA for the systems to be commissioned. The O&M Manuals shall be provided to the CxA at least 8 weeks prior to the start of Functional Testing. O&M Manuals shall be in electronic form, the file format shall be Adobe Acrobat readable document. The document shall be formatted to include level 1 bookmarks that link to each main section of equipment. Refer to specification section 01 9113, subsection 3.8 for further detail.

3.6 TRAINING OF OWNER PERSONNEL

A. See Specification Section 01 9113, Subsection 3.9.

B. Provide designated Owner personnel with comprehensive training in the understanding of the systems and the operation and maintenance of cabling systems.

C. Training shall start with classroom sessions, if necessary, followed by hands-on training on each piece of equipment.

3.7 DEFERRED TESTING

A. See Specification Section 01 9113, Subsection 3.10.

END OF SECTION 220800

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SECTION 220995 - TESTING, BALANCING, LUBRICATION AND ADJUSTMENTS FOR PLUMBING

PART 1 – GENERAL:

1.1 The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR PLUMBING and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

1.2 SCOPE

A. The Engineer, or authorized representative, shall be notified by the Contractor twenty-four (24) hours in advance of any tests called for in these Specifications or required by others.

B. Only after written approval, signed by the Engineer, shall the Contractor apply insulation or paint or allow the work to be furred in. This written approval, however, does not relieve the Contractor of the responsibilities for any failure during the guarantee period. The expense of all tests shall be borne by the Contractor, along with all temporary equipment, materials, gauges, etc. required for tests.

C. The test and balance of this system shall be by a Contractor who employs only the services of a certified AABC or independent NEBB firm whose sole business is to perform test and balance services.

D. The test and balance contractor shall bid directly to the Mechanical Contractor.

E. Instruments used for testing and balancing of the hydronic systems shall have been calibrated within a period of six months prior to balancing. All final test analysis reports shall include a letter of certification listing instrumentation used and last date of calibration.

PART 2 – PRODUCTS

2.1 The following systems shall be tested and balanced:

A. Domestic pumps total water flow

B. Water Heaters

2.2 Three (3) copies of the complete test reports shall be submitted to the Consulting Engineer prior to final acceptance of the project. Preliminary test reports shall be submitted when requested.

PART 3 – EXECUTION

3.1 Mechanical Contractor shall provide all start-up documents to Test and Balance Contractor prior to any test and balance services.

3.2 The Plumbing Contractor shall test all piping before being insulated or concealed in any manner. Where leaks or defects develop, required corrections shall be made and tests repeated until systems are proven satisfactory. Water piping systems shall be subjected to a hydrostatic test as specified and shall be proven tight after a twenty-four (24) hour test.

3.3 All motors, bearings, etc. shall be checked and lubricated as required during start-up procedures. All automatic, pressure regulating, and control valves shall be adjusted. Excessive noise or vibration shall be eliminated.

3.4 System balancing, where required, shall be performed only by persons skilled in this work. The system shall be balanced as often as necessary to obtain desired system operation and results.

3.5 Testing shall occur after completion of the ceiling systems installation.

3.6 All deficiencies observed by the Test and Balance Contractor shall be reported immediately to the Engineer and Mechanical Contractor.

3.7 Balance domestic hot water return system including all balance valves and record settings and flows.

3.8 Balance the water flow rate of each domestic hot water recirculating pump. Set the flow rate for each balancing valve in the recirculating hot water system. If flow rates are not indicated, contact the engineer for each balance valve GPM.

3.9 The Contractor shall provide and coordinate work to provide sufficient time before final completion date so that tests and balancing can be accomplished and provide immediate labor and tools to make corrections when required without undue delay.

3.10 The Test and Balance Contractor shall be present during the Engineer's final inspection of the building, or a separate project review date. The Engineer may request confirmation of the air balance report by asking for new measurements to be taken at that time. Any information in the test and balance report may be asked to be reconfirmed.

END OF SECTION 220995

SECTION 221000 - PIPE, PIPE FITTINGS AND PIPE SUPPORT FOR PLUMBING

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR PLUMBING and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. Each Contractor's attention is also directed to Specification Section HANGERS, CLAMPS, ATTACHMENTS, ETC.

C. The Contractor's attention is also directed to Specification Section SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS LISTS FOR PLUMBING.

D. The Contractor's attention is directed to Specification Section INSULATION - MECHANICAL.

E. The Contractor's attention is directed to Specification Section PIPE FILLING, CLEANING, FLUSHING, PURGING AND CHEMICAL TREATMENT.

1.2 SCOPE

A. Unless otherwise indicated, all materials shall be new and of the best grade and quality for the type specified. Materials shall comply with the “Buy American Act”.

B. Where piping is not indicated on the plans, but is obviously or apparently required, contact the Engineer prior to submission of the bid.

C. The piping indicated shall be installed complete and shall be of the size indicated. When a pipe size is not indicated, the Contractor shall request the pipe size from the Engineer. Where a section of piping is not indicated but is obviously required for completion of the system, the Contractor shall provide same at no additional cost to the project.

D. Piping materials in each system shall, to the extent practicable, be of the same material. Frequent changes of material (for example, from copper to steel) shall be avoided and in no case shall be accomplished without use of insulating unions and permission of the Engineers.

PART 2 – PRODUCTS

2.1 EXTERIOR APPLICATIONS (SITE WORK):

A. SITE SANITARY SEWER: Refer to the Civil Plans and Specifications.

B. SITE STORM SEWER: Refer to the Civil Plans and Specifications.

C. SITE WATER: Refer to the Civil Plans and Specifications.

D. SITE NATURAL GAS: Refer to the Civil Plans and Specifications.

2.2 PLUMBING PIPING APPLICATIONS:

A. SOIL, WASTE AND VENT PIPING (BELOW SLAB):

1. Sanitary Waste/Vent Piping ASTM C 2665 Schedule 40 PVC with plastic, non-pressure piping, solvent cement joints.
2. Where waste water applications exceed 140 deg F, and all Grease Piping, ASTM A 74, service class, hub and spigot cast iron pipe with ASTM C 564, rubber gasket fittings.
3. Piping below slab shall be a minimum of 2" in size.

B. SOIL, WASTE AND VENT PIPING (ABOVE SLAB):

1. Sanitary Waste/Vent Piping above ground: ASTM C 2665 Schedule 40 PVC plastic, non- pressure piping, solvent-cement joints. Insulate as required when installed in return air plenums.

2.3 ROOF LEADERS AND STORM LINES (BELOW SLAB):

A. Service weight cast iron hub and spigot piping with compression gasket joints.

B. Schedule 40 PVC pipe with drainage pattern fittings and solvent cement joints made in accordance with the Plumbing Code.

2.4 ROOF LEADERS AND STORM LINES (ABOVE SLAB):

A. Storm Piping above ground: ASTM C 2665 Schedule 40 PVC plastic, non- pressure piping, solvent-cement joints. Insulate as required when installed in return air plenums.

2.5 DOMESTIC COLD, HOT AND RECIRCULATING HOT WATER PIPING (ABOVE SLAB):

A. Domestic Water Systems (Above Ground): Domestic water systems shall be one of the following:

1. ASTM B 88 "Type L", water tube, drawn temper copper with soldered joints.
2. ASTM B 88 'Type L", water tube, drawn temper copper with Press-fit joints.
   a. Manufacturers:
      1) Apollo
      2) Pro-Press
      3) Approved equal

B. Domestic Cold Water Systems (Below Ground): Domestic water system shall be the following:

1. ASTM B 88 "Type K", water tube, annealed temper copper with silver-soldered joints.

C. Domestic Hot Water and Hot Water Recirculation Systems (Below Ground): Domestic hot water and domestic hot water recirculation system shall be one of the following:

1. Pre-Insulated Piping: Cased copper carrier piping with polyurethane foam insulation and HOPE jacket rated for up to 250 deg F. Carrier piping shall be Type L copper, ASTM B88, with silver-soldered joints. Insulation shall be closed cell foam with minimum 2- inches thick. Jacket shall be seamless HOPE. Perma-Pipe XTRU-Therm or pre- approved equal.

2.6 UNIONS, FLANGES AND WELDED TEES

A. Screwed unions, soldered unions or bolted flanges shall be provided as required to permit removal of equipment, valves, and piping accessories from the piping system. Keep adequate clearances for coil removal, rodding, tube replacement, motor lubrication, filter replacement, etc. Flanged joints shall be assembled with appropriate flanges, gaskets, and bolting. The clearance between flange faces shall be such that the connections can be gasketed and bolted tight without imposing undue strain on the piping system.

B. Dielectric insulating couplings or though ways shall be used wherever the adjoining materials being connected are of dissimilar metals such as connections between copper and steel pipe.

C. Tee connections for welded pipe shall be assembled with welding fittings. Where the size of the side outlet is such that a different connection technique than on the run is required, a weldolet, sockolet, or threadolet type fitting may be used for the branch in place of reducing tees only where the branch is 2/3 the run size or smaller. Weld-o-let and thread-o-let branch connections are acceptable.

2.7 SPECIFICATIONS STANDARDS:

A. All piping and material shall be new, comply with the "Buy American Act" and shall conform to the following minimum applicable standards:
1. Steel pipe; Schedule 40; ASTM A-53.
2. Copper tube; Type K, L, M; ASTM B88-62; Type DWV ASTM B306-62.
3. Cast iron soil pipe; ASA A-40.l and CS 188-59.
4. Cast iron drainage fittings; ASA B16.12.
5. Cast iron screwed fittings; ASA B16.4.
6. Welding fittings; ASA B16.9.
7. Cast brass and wrought copper fittings; ASA B16.18.
8. Cast brass drainage fittings; ASA B16.23.

A. STEAM AND CONDENSATE RETURN MAINS: One (1) inch in 20 feet in direction of flow.

B. ALL OTHER LINES: Provide ample pitch to a low point to allow 100 percent drainage of the system.

2.8 NATURAL GAS PIPING – INTERIOR:

A. Schedule 40 black steel pipe ASTM A 120, with malleable iron threaded fittings Class 150, for pipe sizes 2" and smaller.

B. Schedule 40 black steel pipe with wrought steel buttwelded fittings for pipe sizes 2½" and larger.

C. Where gas pressure is 2 psi or greater, piping shall be schedule 40 black steel pipe with wrought steel buttwelded fittings.

D. Paint all exterior and mechanical room gas piping with one primer coat and (2) two coats of oil based paint. Gas piping shall be painted yellow.

E. All gas piping shall be tested at a test pressure of 100-psi minimum for a period of not less than (8) eight hours. Test to be conducted using a chart recorder. Chart size to be 8 in., range to be Oto 150-psi with a 24 hour recording time. Pressure measuring elements to be heat-treated to prevent hysteresis-related inaccuracies. Engineer to witness all tests. Contractor to turn over chart in close-out documents to Owner.

2.8.1 WATER HEATER RELIEF LINE: Type "M" copper tubing with sweat fittings and 95/5 solder. Hot water relief valves must be piped to location to minimize danger to personnel or students upon relief. Hot water relief valves should be piped to exterior or to funnel-type floor drains located near the equipment. Provide a union near valve for future valve replacement.

PART 3 – EXECUTION

3.1 Pay particular attention to conflict of piping with other work. Do not install until conflict is resolved. If in doubt, consult Engineer.

3.2 CD/DVD Recording Note: The entire underground sanitary waste piping system shall be videoed and recorded by the Contractor on an audible CD/DVD to ensure that the Owner knows the location of the piping being viewed. The recorded CD/DVD shall be provided to the Engineer of Record and the WCPSS

Project Manager three (3) weeks prior to Substantial Completion inspection. The Substantial Completion inspection cannot occur until the video has been reviewed and all the underground waste piping system has been approved by the Engineer of Record. Designer shall provide the note above on drawings and in specifications.

3.3 Install underground drainage mains with the laser beam alignment system.

3.4 All soil, waste and vent piping shall be smoke tested by the contractor. Test shall be witnessed by WCPSS maintenance personnel.

3.5 Dielectric couplings or through ways shall be provided at all connections of dissimilar materials.

3.6 Nipples shall be of the same material, composition, and weight classification as pipe with which installed.

3.7 Install all gas piping per NFPA54. Union or valves shall not be installed in an air plenum. Piping below slab must be sleeved and vented. Piping installed in contained non-vented areas shall not have mechanical joints.

3.8 The entire sanitary waste and vent piping system within the building shall be air-tight. If any sewer gases are present within the building. It shall be the Contractor's responsibility to locate and correct any leaks and retest as required. Any sewer odor issues that occur during the Warranty Period shall be corrected by the Contractor.

3.9 All piping shall be capped or plugged during erection as required to keep clean and debris and moisture free.

3.10 All piping shall be capped or plugged during erection as required to keep clean and debris and moisture free.

3.11 All piping shall be installed straight and true, parallel, or perpendicular to the building construction. Piping shall be installed so as to allow for expansion without damage to the building finishes, structure, pipe, equipment, etc., use offsets, U-bends or expansion joints as required. No mitered joints or field fabricated pipe bends shall be accepted. Pipe shall clear all windows, doors, louvers, and other building openings.

3.12 All pipes shall be supported in a neat and workmanlike manner and wherever possible, parallel runs of horizontal piping shall be grouped together on hangers. Vertical risers shall be supported at each floor line with approved steel pipe riser clamps. Spacing of pipe supports shall not exceed eight (8) foot intervals for pipes 3" and smaller and ten (10) foot intervals on all other piping. Small vertical pipes (1" and less) shall be bracketed to walls, structural members, etc. at four (4) foot intervals so as to prevent vibration or damage by occupants.

3.13 Insulated piping shall be supported on a rigid insulation block at each hanger so as to prevent crushing of insulation by hangers. Hangers shall pass completely around the insulation jacket and a steel protective saddle shall be applied to prevent compression of the insulation. Refer to Specification Section INSULATION - PLUMBING.

3.14 The use of wire or perforated metal to support pipes will not be permitted. Hanging pipes from other pipes shall not be permitted.

3.15 Where piping rests directly on a hanger, clip, bracket or other means of support, the support element shall be of the same material as the pipe, (e.g., copper to copper, ferrous to ferrous, etc.) or shall be electrically isolated one from the other so as to prevent pipe damage by electrolysis. Pay particular attention and do not allow copper pipe to rest on ferrous structural members, equipment, etc. without electrolytic isolation. This includes temporary support required during Construction.

3.16 In general, piping shall be installed concealed except in mechanical rooms, etc. unless otherwise indicated, and shall be installed underground or beneath concrete slabs only where indicated. All lines at ceilings shall be held as high as possible and shall run so as to avoid conflicts with other trades, and to facilitate the Owner's use and maintenance. Location of pipe in interior partitions shall be carefully coordinated with whoever will construct the partitions after the piping is in place. Where exposed risers occur, they shall be kept as close to walls as possible.

3.17 Pipe shall be cut accurately to measurements established at the building by the Contractor and worked into place without springing or forcing. All pipes shall be reamed to full pipe diameter before joining and before assembling. All lengths of pipe shall be set vertically and tapped with a hammer to remove scale and dust and inspected to ensure that no foreign matter is lodged therein.

3.18 All hot and cold water piping shall be kept a sufficient distance apart so as to prevent heat transfer between them. Cold water piping shall also be kept apart from refrigerant hot gas lines.

3.19 Piping carrying water or other fluids subject to freezing shall not be installed in locations subject to freezing. If in doubt, consult Engineer.

3.20 Apply approved pipe dope for service intended to all male threaded joints. The dope shall be listed for intended use.

3.21 Eccentric reducers shall be used where required to permit proper drainage and venting of pipe lines; bushings shall not be permitted.

3.22 Installation of pipe shall be in such a manner as to provide complete drainage of the system, whether detailed or not on plans. Drain valves shall be provided at all drainage points on pipes. Drain valves shall be ½" size ball valves with 3/4" hose thread end and vacuum breaker. Label each drain valve.

3.23 Plastic piping or any material with a flame and smoke spread rating not approved for plenum use shall not be permitted in supply, return, relief, or exhaust plenums.

3.24 All increases in vent size at roof shall be by means of service weight cast iron increasers.

3.25 Piping for all drainage systems shall be installed to permit flow, trapping, and venting in accord with current codes and best practice.

3.26 The entire domestic hot, cold, and recirculating hot water piping system shall be sterilized in strict accord with requirements of the Department of Health Codes, Rules, and Regulations for the State in which the work is being accomplished.

3.27 PIPE TESTING:

A. All domestic water piping shall be tested per the NC Plumbing Code. Piping shall be tested before being insulated or concealed in any manner. Where leaks or defects develop, required corrections shall be made and tests repeated until systems are proven satisfactory.

B. Water piping systems shall be subjected to a hydrostatic test of 150 psi. The system shall be proven tight after a twenty-four (24) hour test.

C. The house drain line, interior storm sewers, interior rainwater conductors, and all soil, waste and vent piping shall be subjected to a hydrostatic test of not less than a 10-foot head or an air test of not less than 5 psi and shall hold for 15 minutes.

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D. Exterior sewer lines to the termination point outside the building shall be subject to a ten-foot hydrostatic test or an approved smoke test. These lines shall be subjected to a second test after 2 feet of backfill has been properly installed.

E. After fixtures have been installed, the entire plumbing system, exclusive of the house sewer, shall be subjected to an air pressure test equivalent to one inch water column and proven tight. The Contractor responsible shall furnish and install all of the test tees required, including those for isolating any portion of the system for tests.

F. The Contractor shall perform all additional tests that may be required by the Department of Health or other governing agency.

G. Any leaks or imperfections found shall be corrected and a new test run until satisfactory results are obtained. The cost of repair or restoration of surfaces damaged by leaks in any system shall be borne by the Contractor.

H. The natural gas service shall be tested in accordance with requirements and/or recommendations of the local gas company.

I. Natural gas piping downstream of the meter assembly shall be tested per the local gas company requirements or the following (whichever is stricter):
   1. Low Pressure (up to 14” wc) – Test to 10 psi for 24 hours.
   2. Elevated Pressure (up to 2 psi) – Test to 50 psi for 24 hours.
   3. Medium pressure (up to 60 psi) – Test to 100 psi for 24 hours.

3.28 PITCH OF PIPING:

A. All piping systems shall be installed so as to drain to a low point. Certain minimum pitches shall be required for this drainage. For proper flow and/or for proper operation, the following pitches shall be required:

B. INTERIOR SOIL, WASTE AND VENT PIPING: ¼” per foot in direction of flow where possible but in no case less than 1/8" per foot.

C. SITE SANITARY LINES: Not less than one (1) % fall in direction of flow and no greater than indicated.

D. SITE STORM LINES: Not less than one (1) % grade in direction of flow.

E. ROOF LEADERS: 1/8” per foot where possible.

F. CONDENSATE DRAIN LINES FROM COOLING EQUIPMENT: Not less than ¼” per foot in direction of flow.

END OF SECTION 221000

SECTION 221010 – WELDING - PLUMBING

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR PLUMBING and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

1.2 SCOPE

A. All welding accomplished by any Mechanical Contractor shall comply with provision of the latest revision of applicable codes, whether ASME Boiler and Pressure Vessel Code for pressure piping or such State and Local requirements as may supersede these codes.

1.3 WELDING QUALIFICATIONS:

A. Pipe welding shall comply with the provisions of the latest revision of the applicable codes, whether ASME Boiler and Pressure Vessel Code, ASA Code for Pressure Piping, or such state or local requirements as may supersede codes mentioned above.

B. Before any pipe welding is performed, submit to the Owner, a copy of the welding procedure specifications, together with proof of its qualification as outlined and required by the most recent issue of the code having jurisdiction.

C. Before any welder shall perform any pipe welding, submit to the Owner the Operator's qualification record in conformance with the provisions of the code having jurisdiction, showing that the operator was tested under the proven procedure specifications submitted.

D. Standard Procedure Specifications and Welders qualified by the National Certified Pipe Welding Bureau shall be considered as conforming to the requirements of these specifications.

PART 2 - PRODUCTS

A. Welding fittings shall conform to ASA B16.9; of the same materials, thickness, etc., as the pipe being jointed; see ASA B36.10.

PART 3 – MATERIALS:

3.1 Welds shall be of sound metal thoroughly fused to the base metal at all points, free from cracks and reasonably free from oxidation blow holes and non-metallic inclusions. No fins or weld metal shall project within the pipe and should they occur, they shall be removed. All pipe beveling shall be done by machine. The surface of all parts to be welded shall be thoroughly cleaned free from paints, oil, rust or scale at the time of welding, except that a light coat of oil may be used to preserve the beveled surfaces from rust.

3.2 Pipe and fittings shall be carefully aligned with adjacent parts and this alignment must be preserved in a rigid manner during the process of welding.

3.3 Each Contractor shall be responsible for quality of welding done by his organization and shall repair or replace any work not done in accordance with specifications. If required by the Architect/Engineer, the Contractor shall cut out at least five (5) welds during the job for X-raying and testing. These welds shall be selected at random by the Resident Inspector and shall be tested as a part of the Contractor's Contract. Certifications of these tests and X-rays shall be submitted, in triplicate to the Engineer. In case a faulty weld is discovered, the Contractor shall be required to furnish additional tests.

END OF SECTION 221010

SECTION 221123 - PUMPS FOR PLUMBING

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR PLUMBING and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

1.2 SCOPE

A. Electric motors shall be furnished with the pumps and shall be of the size and type scheduled or otherwise specified. All motors shall be UL labeled and shall comply with applicable NEMA standard. Motors to be high efficiency type. Refer to Specification Section – ELECTRIC MOTORS, ETC.

B. Shop drawings shall be submitted as required and shall include complete pump specifications, installation and start-up instructions, current and accurate pump performance curves with the selection points clearly indicated, maintenance data and spare parts lists.

C. Pumps shall be factory tested, cleaned, and painted prior to shipment. Size, type, capacity, and electrical characteristics are listed in the pump schedule.

D. Insofar as possible, all pumps shall be by the same manufacturer.

PART 2 – PRODUCTS

2.1 PERMANENTLY LUBRICATED INLINE PUMPS:

A. Permanently Lubricated Inline Pumps shall be Series PL as manufactured by Bell & Gossett or equal by Taco, Armstrong, Patterson.

B. The pumps shall be of the horizontal permanently lubricated type, specifically designed for quiet operation. Suitable for 225 degrees F operation at 150 PSIG working pressure.

C. The pumps shall have a solid high-strength alloy steel shaft supported by XL11 permanently lubricated sealed precision bearings. Bearings are to be permanently oil lubricated. Pump shaft shall connect to a non-metallic noryl impeller.

D. Pump shall have integral stainless steel face plate and double sided stainless steel neck rings for increased life and seasonal start-up capabilities.

E. Pump volute shall be of cast bronze. The connection style on bronze pumps shall be flanged with isolation valves.

F. The motor shall be isolated from circulating fluid through use of a carbon/silicone seal attached on a stainless steel shaft sleeve.

G. Motors shall be of an Open Drip-Proof design and shall be non-overloading at any point on the pump curve. Motors shall be UL and CSA listed.

H. Pump shall be of a maintenance free design and be capable of operating in variable speed (varying voltage) applications.

2.2 CLOSED COUPLED INLINE PUMPS:

A. Closed Coupled Inline Pump shall be Series 60 as manufactured by Bell & Gossett or equal by Taco, Armstrong, Patterson.

B. The pumps shall be of a vertical or horizontal installation type specifically designed for quiet operation. Suitable for 225° F operation at 175 PSIG working pressure. The pump shall be single stage, vertical split case design, all bronze construction. The pump internals shall be capable of being serviced without disturbing piping connections.

C. The pumps shall have a solid SAE1045 steel shaft that is integral to the motor. A non-ferrous shaft sleeve shall be employed to completely cover the wetted area under the seal.

D. The motor bearings shall support the shaft via heavy-duty grease lubricated ball bearings.

E. Pump shall be equipped with a mechanical seal assembly. Seal assembly shall have a brass housing, BUNA bellows and seat gasket, stainless steel spring, and be of a carbon ceramic design with the carbon face rotating against a stationary ceramic face.

F. Pump shaft shall connect to a brass impeller. Impeller shall be hydraulically and dynamically balanced, keyed to the shaft and secured by a locking capscrew or nut.

G. Pump should be designed to allow for true back pull-out access to the pump's working components for ease of maintenance.

H. Pump volute shall be of cast iron design for heating systems or cast brass for domestic water systems. The connection style on cast iron and bronze pumps shall be flanged. Volute shall include gauge ports at nozzles.

I. Motors shall meet scheduled horsepower, speed, voltage, and enclosure design. Motors shall have heavy-duty grease lubricated ball bearings to offset the additional bearing loads associated with the closed coupled pump design. Motors shall be non-overloading at any point on the pump curve and shall meet NEMA specifications.

J. Pump shall be of a maintainable design and for ease of maintenance should use machine fit parts and not press fit components.

K. Each pump shall be factory tested and name-plated before shipment.

L. Pumps shall conform to ANSI/HI 9.6.3.1 standard for Preferred Operating Region (POR).

PART 3 – EXECUTION (NOT APPLICABLE)

END OF SECTION 221123

SECTION 223000 - PLUMBING EQUIPMENT

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS - MECHANICAL and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractors attention is directed to Specification Section SHOP DRAWINGS, MAINTENANCE MANUALS & PARTS LISTING FOR PLUMBING.

C. The Contractors attention is directed to Specification Section ELECTRICAL MOTORS AND OTHER ELECTRICAL REQUIRMENTS FOR PLUMBING EQUIPMENT.

D. The Contractors attention is directed to Specification Section FACILITY MONITORING SYSTEM.

E. The Contractors attention is directed to Specification Section TESTING, BALANCING, LUBRICATION AND ADJUSTMENTS.

1.2 SCOPE

A. All Contractors and Vendors providing a bid for this project shall review the Plans and Specifications and determine any modifications and/or adjustments necessary relative to the proposed equipment and materials with specific manufacturer’s installation requirements. Include in the bid any necessary installation methods, features, options, accessories, etc. necessary to install the proposed equipment and materials, regardless of whether used as basis of design or being offered as a substitution in accordance with the specific manufacturer’s installation requirements whether specifically detailed or not within the Plans and Specifications.

B. The Contractor shall provide in complete working order the following plumbing equipment located as indicated and installed, connected, and placed in operation in strict accordance with the manufacturer's recommendations. All equipment shall be factory painted and, where applicable, factory insulated and shall, where such standards exist, bear the label of the Underwriters Laboratory.

C. All equipment, material and labor warranties shall be furnished by the equipment supplier/vendor. All warranties begin on the date of Substantial Completion. Refer to Specification Section GENERAL PROVISIONS – MECHANICAL for special warranty requirements.

D. All plumbing equipment shall comply with the latest provisions of ASHRAE Standard 90.1 and all provisions of the International Energy Conservation Code.

PART 2 – PRODUCTS

2.1 HIGH EFFICIENCY WATER HEATERS:

A. ACCEPTABLE MANUFACTURERS: AO Smith, State and Lochinvar.

B. The water heater(s) shall be of the seamless glass lined steel tank construction in which the glass coating is applied to the water side surfaces of the tank after the tank has been assembled and welded. The condensing flue coil shall be coated on the flue gas side with acid resistant glass lining designed for use in condensing heaters. The heater(s) shall be suitable for sealed combustion direct venting using a 4” diameter PVC air intake pipe and 4” diameter PVC exhaust pipe for a total distance of 80’ equivalent feet of vent and 80’ equivalent feet of intake. The heater shall be factory assembled and tested. The power

burner shall be of a design that requires no special calibrations on start up. The heater(s) shall be approved for 0" clearances to combustibles. The control shall be an integrated solid state temperature and ignition control device with integral diagnostics, LED fault display capability and a digital display of temperature settings. The tanks shall be foam insulated and equipped with a ASME rated temperature pressure relief valve. The water heater shall be UL listed and exceed the minimum efficiency requirements of ASHRAE/IES 1999.

C. Install water heaters on rubber/cork isolation pads.

D. Turn over two spare igniters per water heater to Owner.

PART 3 – EXECUTION

3.1 Ensure that the equipment that is proposed to be furnish may be installed, connected, placed in operation, and easily maintained at the location and in the space allocated for it.

3.2 Determine from the Bid Documents the date of completion of this project and ensure that equipment delivery schedules can be met so as to allow this completion date to be met.

3.3 Through coordination with other Contractors, Vendors and Suppliers associated with this Project, this Contractor shall insure a complete, 100% functional, tested, inspected, and approved systems. Claims for additional cost or change orders will immediately be rejected. All equipment shall be furnished for a single point electrical connection unless specifically excluded as a requirement.

3.4 EQUIPMENT START-UP: Prior to utilization of equipment, start-up service shall be performed by factory authorized representative. Utilize startup sheets provided by the manufacturer. Refer to Specification Section GENERAL PROVISIONS – MECHANICAL for additional requirements.

3.5 Provide four (4) hours of onsite training for this system. All training to occur after building completion. System shall function properly, and O&M staff shall be able to operate the system prior to turnover.

END OF SECTION 223000

SECTION 224000 - PLUMBING FIXTURES, FITTINGS AND TRIM

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS - MECHANICAL and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

1.2 SCOPE

A. The Contractor shall provide all fixtures complete with trim required and connect in a manner conforming to the State Plumbing Code.

B. The Contractor shall obtain exact centerline rough-in dimensions between partitions, walls, etc. as required for lay-out of the rough-in work. All work shall be roughed-in so that all exposed piping will be straight and true without bends or offsets.

C. All fixtures and trim shall be new. All fixtures and trim shall be installed as recommended by the manufacturer. All fixtures shall be set level and true and shall be grouted into finished walls, floors, etc. in a neat and workmanlike manner with an approved waterproof non-yellowing grout for such service. All fixtures and trim hall be installed in a neat and workmanlike manner. Unacceptable workmanship shall be removed and replaced at the installing Contractor's cost. Pay particular attention to flush valves and bracket concealed portion to building structure during rough-in. Loose, shaky flush valves, lavatories, etc. shall not be acceptable.

D. Handicapped accessible fixtures shall be mounted as recommended by the Building Code and ADA. Special Note for Handicap Grab Rails: Coordinate top of shower valves, flush valves, flush tank, etc., with location of grab rails as shown on the architectural plans. The Contractor shall install all items to allow for installation, removal, and service without removal of the grab bar.

E. Fixture seats shall be Church model 9500NSSC or VCPSS approved equal, elongated open front less cover institutional grade water closet seat with self-sustaining check hinges.

F. All exposed piping, stops, traps, tailpieces, etc. shall be code approved chrome plated brass unless otherwise indicated or specified. Where acid resistant piping is indicated on the drawing or the specifications, all piping and ancillary components from the sink/lavatory to dilution basin shall be acid resistant as specified and required by code.

G. Water supplies shall connect through walls with stops and chrome plated escutcheons with set screws. In general, furnish drinking fountains, wall-hung lavatories, and hose bibbs with manual loose key stop valves. For all other fixtures, furnish with manual permanent-key stop valves (i.e. sinks in casework, etc.). When in doubt, contact Engineer prior to installation.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS: Subject to compliance with requirement's manufacturers offering plumbing fixtures and trim which may be incorporated in the work include only the following:

A. Plumbing Fixtures: American Standard, Kohler, Sloan, or VCPSS approved equal.

B. Plumbing Trim: American Standard, Chicago Faucet, Kohler, Delta Commercial, T&S Brass, Just, Speakman, Zurn Aqua-Spec, Moen Commercial, Symmons

C. Flush Valves: Sloan, Zurn, or VCPSS approved equal.

D. Stainless Steel Sinks: Elkay, Just, or VCPSS approved equal.

E. Mop Basins and Laundry Tubs: American Standard, Eljer, Fiat, Kohler, Mustee, Acorn, Zurn

F. Water Coolers: Elkay, Oasis, Halsey Taylor

G. Showers: Bradley, Symmons, Chicago Faucets, Speakman Company, Powers, Acorn, Aqua Bath, Florestone, Swanstone, Willoughby, Aquarius

H. Appliance Connection Boxes: Guy Gray, Oatley, Wolverine

I. Wash Fountains: Bradley, Acorn, Willoughby

J. Emergency/Safety Fixtures: Bradley, Acorn, Guardian, Haws

K. Fixture Seats: Bemis, Church, Olsonite

L. Fixture Carriers: Josam, Kohler, Tyler Pipe, Zurn, Wade, Smith, Watts

M. Lavatory, Sink, Mop Basin and Laundry Tub Strainers: American Standard, Elkay, Kohler, McGuire., Sloan, Zurn.

N. P-traps, Tailpieces, chrome plated semi-cast 17 gauge brass p-traps, equal to McGuire Model #8912C and #8902C.

O. Escutcheons: American Standard, Elkay, Kohler, McGuire, Moen Commercial, Sloan, Zurn.

P. P-trap Insulation covering for ADA Fixtures: IPS Corp., McGuire, Plumberex.

Q. Water supplies and stops: American Standard, Elkay, Kohler, McGuire, Moen Commercial, Nibco, Sloan, Watts, Zurn,

2.2 PLUMBING FIXTURE SPECIFICATIONS:

P-1 WATER CLOSET – FLUSH VALVE, FLOOR MOUNTED
American Standard, Madera 2234.001, vitreous china, 15” high siphon jet, elongated bowl, china bolt caps and white open front plastic seat with check hinge. Water closet flush valve shall be as follows:
- Manual flush valve shall be Zurn model Z6000-WS1. Provide with solid ring supports.

P-1A WATER CLOSET – FLUSH VALVE, FLOOR MOUNTED – ADA HEIGHT
American Standard, Madera 3043.001, vitreous china, 18" high, siphon jet, 1-1/2" top spud, elongated bowl, china bolt caps and white open front plastic seat with check hinge. Install flush valve on “open” side of water closet. Water closet flush valve shall be as follows:
- Manual ADA flush valve shall be Zurn model Z6000-WS1. Top of flush valve handle shall be a maximum of 31-1/4" A.F.F. Provide with solid ring supports.

P-2 LAVATORY – WALL-HUNG, STUDENT
American Standard Regalyn – 4869.004, enameled cast iron, 20”x18” lavatory with backsplash, rectangular basin, splash lip, front overflow, and 4” center faucet holes. Provide with concealed arm support and wall carrier. Provide lavatory drain with integral perforated strainer, 3/8" angle rigid supplies with stops and P-trap. Lavatory trim shall be as follows:
- Self-metering faucet shall be Zurn model Z86100-CP4-3M with polished chrome-plated cast brass body, single inlet, 3-3/4” centerline spout, and vandal resistant push-button handle.

Furnish with vandal resistant 0.5 GPM aerator and 4” cover plate. Furnish and install Wilkins model ZW3870 tempering mixing valve.

P-2A LAVATORY – WALL-HUNG - STAFF

Zurn model Z5344, 20”x18” vitreous china lavatory with backsplash, rectangular basin, splash lip, front overflow, and 4” center faucet holes. Provide with concealed arm support and wall carrier. Provide lavatory drain with integral perforated strainer, 3/8" angle rigid supplies with stops and P-trap. Install insulation on the supply lines and P-trap similar to Brocar “Trap Wrap” vinyl plastic covering per ADA Standards. Mounting height to be per ADA. Lavatory trim shall be as follows:

- Single handle faucet shall be Zurn model Z81000-3M with polished chrome-plated cast brass faucet body on 4” centers with single lever control. Furnish with 1.0 GPM vandal-resistant aerator.

P-2B LAVATORY – WALL-HUNG - KITCHEN

Elkay EHS-18X, 18 gauge 304 stainless steel hand sink, 18”x14-1/2” x 11” with gooseneck faucet.

P-3 URINAL - WALL-HUNG – STANDARD HEIGHT

American Standard Washbrook 6590.001, vitreous china, wall-hung, 1.0 GPF urinal with 3/4” top spud and concealed wall hanger brackets. Urinal flush valve shall be as follows:

- Manual flush valve shall be Zurn model Z6003-WS1.

P-3A URINAL – WALL-HUNG – ADA HEIGHT

American Standard Washbrook 6590.001, vitreous china 1.0 GPF urinal with 3/4” top spud and concealed wall hanger brackets. Mounting height shall be per ADA. Urinal flush valve shall be as follows:

- Manual ADA flush valve shall be Zurn model Z6003-WS1. Install per ADA requirements.

P-4 SINGLE COMPARTMENT SINK – CLASSROOM

Elkay DRKAD2220R, ADA compliant, single compartment stainless steel sink, 22" x 20" O.D., 18 gauge with 2-hole, faucet punching. Provide with grid strainer, 3/8" chrome supplies stops, tailpiece, P-trap, drain and escutcheons. Provide with trap wrap insulation on p-trap and water supplies. Sink trim shall be as follows:

- LK208513L Single wing handle faucet with 13’’ high fixed spout, 1.0 gpm, ADA compliant. Provide with LK1141A pushbutton bubbler with flexible guard and ADA compliant. Provide with Powers series 480 thermostatic tempering valve.

P-5A SINGLE COMPARTMENT SINK – 19”X18”

Elkay LR-1918, single compartment stainless steel sink, 19" x 18" O.D., 18 gauge with 3-hole, 8" center faucet punching. Provide with grid strainer, 3/8" chrome supplies stops, tailpiece, P-trap, drain and escutcheons. Sink trim shall be as follows:

- Two-handle faucet shall be Zurn model Z81103-3M with polished chrome-plated cast brass faucet body on 4” centers with quarter turn ceramic disc cartridges and 4” long integral cast spout. Furnish with 1.0 GPM vandal resistant-aerator and 2” color-coded metal dome lever handles.

P-5B SINGLE COMPARTMENT SINK – 19”X18” – ART ROOM

Elkay LR-1918, single compartment stainless steel sink, 19" x 18" O.D., 18 gauge with 3-hole, 8" center faucet punching. Provide with grid strainer, 3/8" chrome supplies stops, tailpiece, P-trap, drain and escutcheons. Sink trim shall be as follows:

- Gooseneck faucet with wrist blade handles shall be Zurn model Z812B4-3F with polished chrome-plated cast brass faucet body on 4" centers with quarter turn ceramic disc cartridges and 5-3/8” swing gooseneck spout. Furnish with 1.0 GPM vandal-resistant aerator and 4” color-coded metal wrist blade handles.
- Plaster trap shall be Zurn Z-1184, Bottom Access solids interceptor.

P-5C ONE COMPARTMENT STAINLESS STEEL SINK – FREE STANDING
Elkay Weldbuilt Stainless Steel 33''x27-1/2''x14'' 18 gauge floor mount single compartment sink. Provide with grid strainer, 3/8" chrome supplies stops, tailpiece, P-trap, drain and escutcheons. Stops shall be Chicago Faucets 1017-CSTABCP with integral check valves. Sink trim shall be as follows:

- Two-handle faucet shall be Zurn Model Z843M1-XL with polished chrome-plated cast brass faucet body on 8" centers with quarter turn ceramic disc cartridges and 6.5" spout with vacuum breaker. Furnish with 2.2 GPM vandal resistant aerator.

P-6 MOP SINK
Florestone Terrazzo 24, 24" x 24" 12" mop service basin. 3" drain, Provide Chicago Faucet model 897-CP faucet, hose and hose bracket, mop hanger. Provide with MSG stainless steel wall guards. Provide check valves on the hot and cold water supplies to the faucet.

P-7 ELECTRIC WATER COOLER – 2 STATION – non-filtered
Elkay EZH20 – VRCGRNTL8C, Wall hung, 2 station with water bottle filling station. UL labeled self-contained two level wheelchair access water cooler with front push button, stainless steel top, stainless steel face mounting panels, steel mounting frame, non-ferrous waterways, built-in pressure regulator; automatically operated permanently lubricated air cooled, hermetically sealed cooling unit having freeze-up protection, adjustable temperature control; electric rating 115 VAC, minimum cooling capacity 8 GPH (80 deg F entering to 50 deg F drinking at 90 deg F ambient).

P-7A ELECTRIC WATER COOLER – 2 STATION – With Bottle Filler – non-filtered
Elkay EZH20 – VRCTLR8WSK, Wall hung, 2 station with water bottle filling station. UL labeled self-contained two level wheelchair access water cooler with front push button, stainless steel top, stainless steel face mounting panels, steel mounting frame, non-ferrous waterways, built-in pressure regulator; automatically operated permanently lubricated air cooled, hermetically sealed cooling unit having freeze-up protection, adjustable temperature control; electric rating 115 VAC, minimum cooling capacity 8 GPH (80 deg F entering to 50 deg F drinking at 90 deg F ambient).

P-8 WASHING MACHINE CONNECTION BOX
Guy Gray Model #WB200HA, 2" drain outlet, 16 gauge steel with epoxy finish and integral water hammer arrestors. Field paint exposed portions of box to match adjacent wall surfaces.

P-8A ICE MAKER CONNECTION BOX
IPS Corporation Water-Tite mini round ice maker outlet box with integral water hammer arrestor and preloaded nails. Connect cold water supply line to water supply at adjacent sink. Field paint exposed portions of box to match adjacent wall surfaces.

PART 3 - EXECUTION

3.1 Coordinate all stainless steel sinks with architectural casework shop drawings for appropriate fit. Do not order sinks until this has been coordinated. Change Orders will be immediately rejected for lack of coordination during construction.

3.2 Test for appropriate operation at least twice, ALL fixtures and trim including hands-free trim. Open all faucets and allow to run for fifteen (15) minutes, then remove all faucet aerators and thoroughly clean until smooth flow is obtained. Test by operation at least twice, adequate flow of water at flush valves including appropriate adjustment of hands-free devices, faucets including appropriate adjustment of hands-free devices, hose bibbs, fixture drains, shower heads, etc.

3.3 Remove all stick-on labels, dirt, grease, other removable stampings, lettering, etc. from plumbing fixtures and thoroughly clean same.

END OF SECTION 224000

SECTION 224005- PLUMBING SPECIALTIES

PART 1 – GENERAL:

1.1 RELATED DOCUTMENTS

A. The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS - MECHANICAL and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

1.2 SCOPE

A. The Contractor shall provide all equipment and specialties complete with trim required and connect in a manner conforming to the State Plumbing Code.

B. All equipment and specialties shall be new. All equipment and specialties shall be installed as recommended by the manufacturer.

PART 2 – PRODUCTS

2.1 CLEANOUTS:

A. Access panels for cleanouts shall be of the Zurn 1460 series or equivalent by Josam or Wade. Where they are not to receive paint, they shall be polished bronze unless otherwise indicated where they are to receive paint or other finishes.

B. Zurn Z-1400-HD cleanout with tractor cover for exterior locations.

2.2 Cleanouts shall be as manufactured by Zurn, Josam, Wade, Ancon, Jay R. Smith, similar to the following:
1. Zurn Z-1440 or Z-1445 cleanout tee at base of exposed stack and at change in direction of exposed lines.
2. Zurn Z-1440 cleanout or Z-1445-1 cleanout tee where stacks are concealed in finished walls.
3. Zurn ZN-1400-T cleanout with scoriated top in finished concrete and masonry tile floors.
4. Zurn ZN-1400-Tx cleanout with square recessed top for VCT and linoleum finished floors.
5. Zurn ZN-1400-Z cleanout with round recessed top for poured floors.
6. Mueller D-731 or D-714, Nibco, Flage or equivalent for cleanouts in copper waste with cover plates and/or access panels listed for other cleanouts.
7. Threaded hex head type cleanouts of same materials as pipe for piping 2" and smaller.
8. No Cleanouts to be installed in the gym floor or in carpeted areas.

2.3 All floor drains shall have deep seal traps. The floor drains shall be Zurn, Josam, Smith, Wade, Watts Drainage, Ancon, similar to the following:
1. FD-1 - Zurn, ZN-415 floor drain with 6"dia. nickel bronze strainer, Type "B", dura-coated cast iron body with bottom 3" outlet. For areas with tile floors, Provide Type “S” strainer 6”x6” square top for all floor areas which are tile. Provide with SURE-SEAL trap guard. Refer to architectural plans.
2. FD-2 - Zurn, ZN-511 floor drain with 9"dia. nickel bronze strainer, dura-coated cast iron deep sump with 4" bottom outlet, seepage pan and sediment bucket. Provide with Trap Primer connection.
3. FD-3 - Zurn, ZN-415 floor drain with 6"dia. nickel bronze strainer, Type "B", dura-coated cast iron body with bottom 4" outlet. For areas with tile floors, Provide Type “S” strainer 6”x6” square top for all floor areas which are tile. Provide with SURE-SEAL trap guard. Refer to architectural plans.
4. FD-4 - Zurn, ZN-415 floor drain with 6"dia. nickel bronze strainer, Type "B", dura-coated cast iron body and funnel, with bottom 3” outlet. Provide with SURE-SEAL trap guard
5. FS-1 – JR Smith, 300 series floor sink, 345-Y04, cast iron body with white acid resisting porcelain enamel interior nickel bronze strainer, half-grate, anti-splash interior bottom dome strainer, 12”x12”x10" depth and 4" outlet. Provide with SURE-SEAL trap guard.

2.4 EXTERIOR AREA DRAINS (AD-1): Zurn Z508 area drain, 9" diameter top drain, dura-coated cast iron body, 4" bottom outlet and sediment bucket.

A. The roof drains shall be Zurn, Josam, Smith, Wade, Watts Drainage, Ancon, similar to the following:
1. RD-1 - Zurn ZC-100-DP 4” outlet roof drain, sump receiver, deck plate, cast iron dome strainer.
2. RD-1A - Zurn, ZC-100-AW-C 4” outlet with aluminum dome, adjustable water level regulator, under deck clamp, cast iron body.
3. RD-2 - Zurn ZC-100-DP 6” outlet roof drain, sump receiver, deck plate, cast iron dome strainer.
4. RD-2A - Zurn, ZC-100-AW-C 6” outlet with aluminum dome, adjustable water level regulator, under deck clamp, cast iron body.
5. RD-3 - Zurn ZC-100-DP 3” outlet roof drain, sump receiver, deck plate, cast iron dome strainer.
6. RD-3A - Zurn, ZC-100-AW-C 3” outlet with aluminum dome, adjustable water level regulator, under deck clamp, cast iron body.
7. RD-3A - Zurn, ZC-100-AW-C with aluminum dome, adjustable water level regulator, under deck clamp, cast iron body with accessories as required for roof construction, 3" outlet.
8. OSD-1 – Zurn, ZARB-199-SS 6” outlet downspout nozzle. All rough bronze body, threaded inlet and decorative face of wall flange and outlet nozzle, with removable stainless steel screen.
9. OSD-2 – Zurn, ZARB-199-SS 8” outlet downspout nozzle. All rough bronze body, threaded inlet and decorative face of wall flange and outlet nozzle, with removable stainless steel screen.
10. OSD-3 – Zurn, Z ZARB-199-SS 12” outlet downspout nozzle. All rough bronze body, threaded inlet and decorative face of wall flange and outlet nozzle, with removable stainless steel screen.

2.5 Wall hydrants shall be Zurn 1320 or equivalent, 3/4", with half-turn ceramic cartridge, encased, flush, non-freeze, anti-siphon, automatic draining wall hydrant with key lock and combination backflow preventer/vacuum breaker.

2.6 INTERIOR HOSE BIBBS AND DRAIN VALVES:

A. HOSE BIBBS (HB): Provide code approved hose bibbs with vacuum breakers and male threaded spouts at each location indicated (toilet rooms, mechanical rooms, etc.). The hose bibbs shall be Woodford Model 24 (or equal) with loose key handle polished chrome finish, brass construction. Hose bibbs shall be mounted at eighteen (18) inches above finished floor. Do not install hose bibbs in spaces which do not have floor drains. Install hose bibbs in a key operated chrome plated box, cover flush with wall.

2.7 Install 3/4 inch bronze body drains, similar and equivalent to Nibco, No. 72 or 73

2.8 Water hammer arrestors shall be Zurn, Z-1700, Shoktrol, Smith, Josam, Wade or equivalent. Water hammer arrestors shall be stainless steel, bellows type. Field fabricated capped cylinders shall not be acceptable. Provide insulating unions where arrestors are of dissimilar material from the piping served (unless piping is non-conducting, such as ABS or PVC).

2.9 MULTIPLE FIXTURES – BRANCH LINE LESS THAN 20’ LONG: The preferred location for a Zurn Shoktrol is at the end of the branch line between the last two fixtures served when the branch lines do not exceed 20’ in length, from the start of the horizontal branch line to the last fixture supply on this line.

2.10 MULTIPLE FIXTURES – BRANCH LINE MORE THAN 20’ LONG: On branch lines over 20’ in length, use two Shoktrols whose capacities total the requirement of the branch. Locate one unit between the last and next to last fixture and the other unit approximately midway between the fixtures.

PART 3 – EXECUTION

3.1 The Contractor shall obtain exact centerline rough-in dimensions between partitions, walls, etc. as required for lay-out of the rough-in work. All work shall be roughed-in so that all exposed piping will be straight and true without bends or offsets.

3.2 Prior to final inspection, test by operation at least twice, all equipment. Also, remove all stick-on labels, dirt, grease, other removable stampings, lettering, etc. from equipment and specialties and thoroughly clean same.

3.3 All equipment and specialties shall be installed in a neat and workmanlike manner. Unacceptable workmanship shall be removed and replaced at the installing Contractor's cost.

3.4 Provide all drainage specialties indicated, specified and/or required to provide complete and acceptable removal of all storm, sanitary, waste, laboratory waste, etc. from the building and into approved receptors. Drainage specialties shall be on non-electrolytic conduction to the material to which they are connected. Drainage specialties shall be installed in a manner so as to ensure no leakage of toxic or odorous gases or liquids and shall have traps and/or backflow preventers where required. Nor shall they allow backflow into other or existing systems.

3.5 CLEANOUTS:

A. In addition to cleanouts indicated on the drawings, provide cleanouts in soil and waste piping and storm drainage at the following minimum locations:
   1. At base of each stack.
   2. At fifty (50) foot maximum intervals in horizontal lines.
   3. At each change of direction of a horizontal line.
   4. As required to permit rodding of entire system.
   5. As required by current State Plumbing/Building Codes.

B. Water closets, mop sinks/basins and other fixtures with fixed traps shall not be accepted as cleanouts.

C. Cleanouts and/or test tees concealed in inaccessible pipe spaces, walls and other locations shall have an eight (8) inch by eight (8) inch (minimum) access panel or cover plates shall be set flush with finished floors and walls and shall be key or screw driver operable.

D. Cleanouts and access panels shall be sized so as to permit the entry of a full sized rodding head capable of one hundred percent circumferential coverage of the line served.

E. Provide a non-hardening mixture of graphite and grease on threads of all screwed cleanouts during installation.

F. Do not install cleanouts against walls, partitions, etc. where rodding will be difficult or impossible. Extend past the obstruction.

G. In finished walls, floors, etc., ensure that cleanouts are installed flush with finished surfaces and, where required, grout or otherwise finish in a neat and workmanlike manner.

3.7 EXTERIOR CLEANOUTS (ECO): Provide exterior cleanouts where indicated for all sanitary and storm lines leaving the building within 5’-0” of building perimeter. Permanently locate all exterior cleanouts with 12”x12”x12” solid finished concrete marker slightly above grade in grass areas or flush in concrete or pavement areas. Label "CO". Zurn Z-1400-HD cleanout with tractor cover for exterior locations. Provide concrete supporting pad crowned to shed water.

3.8 FLOOR DRAINS:

A. Provide floor drains at locations indicated and/or as required by State Plumbing/Building Codes. Install in a neat and workmanlike manner. Install floor drains in strict accordance with manufacturer's recommendations and the State Plumbing and Building Codes. Coordinate locations with General Contractor to ensure floor pitch to drain where required.

B. Insure by coordination with the General Contractor that spaces served with floor drains on all floors above the lowest level have a water seal extending at least three (3) inches from the floor. Also, for these locations, provide a 36”x36”, four (4) pound sheet lead flashing sheet and clamping collar or a 30 mil chlorinated polyethylene shower pan liner. Lead pans shall be given a heavy coat of asphaltum on bottom and sides before installation and a heavy coat on any exposed surfaces. After installation, provide one ply of fifteen (15) pound roofing felt beneath each pan.

3.9 ROOF DRAINS:

A. Provide roof drains at locations indicated within the Contract Documents. Install in a neat and workmanlike manner. Install roof drains in strict accordance with manufacturer's recommendations and the State Plumbing and Building Codes. Coordinate locations with General Contractor to ensure pitch to drain.

B. Provide roof drains with accessories as required to match roof construction. Provide water tight seal at the connection of the body to the dome, to prevent roof water from entering into the body.

C. Adjust all water level regulators for overflow roof drains in the field.

D. Locate downspout nozzles in locations as directed by the Architect.

3.10 FREEZEPROOF WALL HYDRANTS:

A. Provide code approved wall hydrants at each location indicated in a neat and workmanlike manner. Woodford Model B65, or Josam, Zurn or WCPSS approved equal. Key operated box type automatic draining non-freeze wall hydrant. Affix tight to walls and ensure that the feed piping is on the heated side of the building insulation blanket. Provide all water supply specialties indicated, specified and/or required for the complete installation. Install in accordance with the manufacturer's recommendations and the Building Code. Where required by the State Plumbing Code, install code approved vacuum breakers in each water supply specialty.

B. Mount all wall hydrants at least twenty (20) inches above finished exterior grade. Where this is not possible or practical, contact Engineer for direction.

C. Turn over for each hydrant, an operator key in an envelope labeled "Exterior Wall Hydrants" to Owner upon completion of the project. Where hydrants have lockable boxes, turn over an operator key for each in an envelope labeled "Exterior Wall Hydrant Locks” to Owner upon completion of project.

3.11 INTERIOR HOSE BIBBS AND DRAIN VALVES:

A. Provide code approved hose bibbs and drain valves at each location indicated in a neat and workmanlike manner. Affix hose bibs tight to walls. Provide all water supply specialties indicated, specified and/or required for the complete installation. Install in accordance with the manufacturer's recommendations and the Building Code. Where required by the State Plumbing Code, install code approved vacuum breakers in each water supply specialty.

B. HOSE BIBBS (HB): Provide code approved hose bibbs with vacuum breakers and male threaded spouts at each location indicated (toilet rooms, mechanical rooms, etc.). The hose bibbs shall be Woodford Model 24 (or equal) with loose key handle polished chrome finish, brass construction. Hose bibbs shall be mounted at eighteen (18) inches above finished floor. Do not install hose bibbs in spaces which do not have floor drains. Do not install hose bibbs in ADA accessible toilet stalls.

C. DRAIN VALVES: Install 3/4 inch bronze body drains, similar and equivalent to Nibco, No. 72 or 73, as indicated and at the following locations:
   1. At the low point and isolatable section of the plumbing system.
   2. At each low point and isolatable section of the hydronic system.

3. At each isolatable pipe section.
4. At each water heater.
5. At each storage tank.
6. At each boiler.
7. At each heat pump.
8. At each water-to-water unit.
9. At each chiller.
10. At each pump suction.
11. Install a code approved vacuum breaker where installation on to domestic water system.

3.12 WATER HAMMER ARRESTORS (WHA): Water Hammer Arrestors shall be JR Smith series 5000, maintenance-free. Provide water hammer arrestors at each location indicated and/or as required to eliminate hydrostatic on the domestic water system. Install in an accessible location and in a neat and workmanlike manner. Provide all water supply specialties indicated, specified and/or required for the complete installation. Install in accordance with the manufacturer's recommendations and the Building Code. Where required by the State Plumbing Code, install code approved vacuum breakers in each water supply specialty.

3.13 Provide at least one water hammer arrestor at all quick acting valve locations including:

- Clothes Washers
- Ice maker
- Commercial Dishwashers
- Solenoid operated equipment
- Mop Basins, downstream of check valves
- Flush valve fixtures

3.14 VACUUM BREAKERS AND BACK FLOW PREVENTERS: Where required by the Building Code, whether indicated or not, provide approved vacuum breakers or backflow preventers at the following locations.

- Where domestic water system connects to a limited area fire protection system.
- Where domestic water system connects to hydronic system.
- At any threaded hose tap on the domestic water system.
- At all mop basins, provide check valves to the hot and cold water supply upstream of the faucet.

3.15 ROOF FLASHINGS: All plumbing vents or other plumbing passing thru the roof shall be flashed as approved by the State Plumbing and Building Codes and as recommended by the roofing manufacturer and/or Contractor.

3.16 LINT INTERCEPTOR: Provide steel fabricated lint interceptor with acid resistant coating on interior and exterior with non-skid cover and removable lift handle. An aluminum primary and secondary screen assembly shall be provided with straining baffle with a 3/8” diameter perforated holes. Provide stainless steel tamper resistant securing hardware. Provide an extension collar for invert elevation of the inlet piping to maintain a minimum of 12” below finished floor. Field verify.

END OF SECTION 224005

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SECTION 230500 – COMMON WORK RESULTS FOR HVAC

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

1.2 SCOPE

A. The Advertisement for Bid, Instructions to Bidders, Bidding Requirements, General, Special and Supplementary Conditions, and all other Contract Documents shall apply to the Contractor's work as well as to each of their Sub-Contractor's work.

B. All manufacturers, suppliers, fabricators, contractors, etc. submitting proposals for any part of the work, services, materials, or equipment to be used on or applied to this project are hereby directed to familiarize themselves with the Contract Documents. In case of conflict between these General Provisions and the General and/or Special Conditions, the Contractor shall contact the Engineer for clarification and final determination prior to the Bid.

C. The work included in this Division consists of the furnishing of all labor, equipment, transportation, excavation, backfill, supplies, material, appurtenances, and services necessary for the satisfactory installation of the complete and operating Mechanical Systems indicated or specified in the Contract Documents.

D. Any materials, labor, equipment, or services not mentioned specifically herein which may be necessary to complete any part of the Mechanical Systems in a substantial manner, in compliance with the requirements stated, implied, or intended in the Plans and/or Specifications, shall be included in the Bid as part of this Contract.

E. It is not the intent of this Section of the Specifications to make any Contractor, other than the Construction Manager responsible to the Owner. All transactions such as submittal of shop drawings, claims for extra costs, requests for equipment or materials substitution, shall be routed through the Construction Manager to the Architect, then to the Engineer. Also, this Section of the Specifications shall not be construed as an attempt to arbitrarily assign responsibility of work, material, equipment or services to a particular trade or Contractor. Unless stated otherwise, the subdivision and assignment of work under the various sections shall be optional.

F. The Architect and Engineer do not define the scope of individual trades, subcontractors, material suppliers and vendors. Any sheet numbering system or specification numbering system used which identifies disciplines is solely for the Architect and Engineer’s convenience and is not intended to define a subcontractor’s scope of work. Information regarding individual trades, subcontractors, material suppliers and vendors may be detailed, described, and indicated at different locations throughout the Contract Documents. No consideration will be given to requests for change orders for failure to obtain and review the complete set of Contract Documents when preparing Bids, prices, and quotations. Unless stated otherwise, the subdivision and assignment of work under the various sections shall be the responsibility of the Contractor holding the prime contract.

G. It is the intent of the Contract Documents to deliver to the Owner a new, complete, and operational project once the work is complete. Although Plans and Specifications are complete to the extent possible, it shall be the responsibility of the Contractors involved to remove and/or relocate or re-attach any existing or new systems which interfere with new equipment or materials required for the complete installation without additional cost to the Owner.

H. In general, all work shall be accomplished without interruption of existing facilities operations. The Contractor shall advise the Owner at least seven (7) days prior to the interruption of any services (gas, domestic water, heating, etc.). The Owner shall be advised of the exact time that interruption will occur and the length of time the interruption will last. Failure to comply with this requirement may result in complete work stoppage for the Contractors involved until a complete schedule of interruptions can be developed.

I. Whenever utilities are interrupted, either deliberately or accidentally, the Contractor shall work continuously to restore said service. The Contractor shall provide tools, materials, skilled journeymen of Bidder/Proposer's own and other trades as necessary, premium time as needed and coordination with all applicable utilities, including payment of utility company charges (if any), all without requests for extra compensation from the Owner.

J. Each Bidder/Proposer shall also be governed by any unit prices and Addenda insofar as they may affect part of their work or services.

1.3 DEFINITIONS AND ABBREVIATIONS:

A. Contractor - Any Contractor whether bidding, proposing, or working independently or under the supervision of a Construction Manager and who installs any type of Mechanical Work as specified in the Contract Documents or, the Construction Manager.

B. Engineer - The Consulting Mechanical-Electrical Engineer either consulting to the Owner, Architect, or Other, etc. In this case: CMTA, Inc., Consulting Engineers.

C. Architect - The Architect of Record for the project.

D. Contract Documents - All documents pertinent to the quality and quantity of work to be performed on this project. Includes, but not limited to: Plans, Specifications, Instructions to Bidders, General and Special Conditions, Addenda, Alternates, Lists of Materials, Lists of Sub-Contractors, Unit Prices, Shop Drawings, Field Orders, Change Orders, Cost Breakdowns, Schedules of Value, Periodical Payment Requests, Construction Contract with Owner, etc.

E. Bidder/Proposer - Any person, agency or entity submitting a proposal to any person, agency, or entity for any part of the work required under this contract.

F. The Project - All of the work required under this Contract.

G. Furnish - Deliver to the site in good condition and turn over to the Contractor who is to install.

H. Provide - Furnish and install complete, tested and ready for operation.

I. Install - Receive and place in satisfactory operation.

J. Indicated - Listed in the Specifications, shown on the Plans or Addenda thereto.

K. Typical or Typ.- Where indicated repeat this work, method or means each time the same or similar condition occurs whether indicated or not.

L. ADA - Americans with Disabilities Act.

M. AGA - American Gas Association.

N. ANSI - American National Standards Institute.

O. ASHRAE - American Society of Heating, Refrigeration and Air Conditioning Engineers.

P. ASME - American Society of Mechanical Engineers.

Q. IBC - International Building Code.

R. NEC - National Electrical Code.

S. NEMA - National Electrical Manufacturers Association.

T. NFPA - National Fire Protection Association.

U. OHSA - Office of Safety and Health Administration.

V. SMACNA - Sheet Metal and Air Conditioning Contractors National Association.

W. UL - Underwriters Laboratories.

1.4 INTENT AND INTERPRETATION:

A. It is the intention of the Contract Documents to call for a complete and operational system, including all components, accessories, finish work, etc as necessary for trouble free operation, tested and ready for operation. Anything that may be required, implied, or inferred by the Contract Documents shall be provided and included as part of the Bid.

B. All Contractors and Vendors providing a bid for this project shall review the Plans and Specifications and determine any modifications and/or adjustments necessary relative to the proposed equipment and materials with specific manufacturer's installation requirements. Include in the bid any necessary installation methods, features, options, accessories, etc. necessary to install the proposed equipment and materials, regardless of whether used as basis of design or being offered as a substitution in accordance with the specific manufacturer's installation requirements whether specifically detailed or not within the Plans and Specifications.

C. Details not usually shown or specified, but necessary for the proper installation and operation of systems, equipment, materials, etc., shall be included in the work, the same as if herein specified or indicated.

D. The Bidder/Proposer shall completely review the Contract Documents. Any interpretation as to design intent or scope shall be provided by the Engineer / Architect. Should an interpretation be required, the Bidder/Proposer shall request a clarification not less than ten (10) days prior to the submission of the proposal so that the condition may be clarified by Addendum. In the event of any conflict, discrepancy, or inconsistency develops; the interpretation of the Engineer shall be final.

E. The Contractor shall give written notice of any materials or apparatus believed inadequate or unsuitable; in violation of laws, ordinances, rules, or regulations of authorities having jurisdiction; and any necessary items of work omitted a minimum of ten (10) days prior to bid. In the absence of such written notice and by the act of submitting a bid, it shall be understood that the Contractor has included the cost of all required items in the bid, and that will be responsible for the approved satisfactory functioning of the entire system without extra compensations.

1.5 INDEMNIFICATION: The Contractor shall hold harmless and indemnify the Engineer, employees, officers, agents and consultants from all claims, loss, damage, actions, causes of actions, expense and/or liability resulting from, brought for, or on account of any personal injury or property damage received or sustained by any person, persons, (including third parties), or any property growing out of, occurring, or attributable to any work performed under or related to this contract, resulting in whole or in part from the negligence of the Contractor, any subcontractor, any employee, agent or representative.

1.6 PLANS AND SPECIFICATIONS:

A. The Plans are diagrammatic only and indicate the general arrangement of the systems and are to be followed. If deviations from the layouts are necessitated by field conditions, detailed layouts of the proposed departures shall be submitted to the Engineer for approval before proceeding with the work. The Plans are not intended to show every item which may be necessary to complete the systems. All Bidder/Proposers shall anticipate that additional items may be required and submit their Bid accordingly.

B. The Plans and Specifications are intended to supplement each other. No Bidder/Proposer shall take advantage of conflict between them, or between parts of either. Should this condition exist, the Bidder/Proposer shall request a clarification not less than ten (10) days prior to the submission of the proposal so that the condition may be clarified by Addendum. In the event that such a condition arises after work is started, the interpretation of the Engineer shall be final.

C. The Plans and Specifications shall be considered to be cooperative and anything appearing in the Specifications which may not be indicated on the Plans or conversely, shall be considered as part of the Contract and must be executed the same as though indicated by both.

D. Contractor shall make all of their own measurements in the field and shall be responsible for correct fitting. The work shall be coordinated with all other branches of work in such a manner as to cause a minimum of conflict or delay.

E. The Engineer shall reserve the right to make adjustments in location of piping, ductwork, equipment, etc. where such adjustments are in the interest of improving the project.

F. Should conflict, overlap or duplication of work between the various trades become evident, this shall be called to the attention of the Engineer. In such event neither trade shall assume to be relieved of the work which is specified under their branch until instructions in writing are received from the Engineer.

G. Unless dimensioned, the Plans only indicate approximate locations of equipment, piping, ductwork, etc. Dimensions given in figures on the Plans shall take precedence over scaled dimensions and all dimensions, whether given in figures or scaled, shall be verified in the field to insure no conflict with other work.

H. Each Bidder/Proposer shall review all Plans in the Contract Documents to ensure that the work they intend to provide does not create a conflict with or affect the work of others in any way. Where such effect does occur, it shall be the Bidder/Proposer's responsibility to satisfactorily eliminate any such conflict or effect prior to the submission of their proposal. Each Bidder/Proposer shall in particular ensure that there is adequate space to install their equipment and materials. Failure to do so shall result in the correction of such encroachment conflict or effect of any work awarded the Bidder/Proposer and shall be accomplished fully without expense to others and that they are reasonably accessible for maintenance. Check closely all mechanical and electrical closets, chases, ceiling voids, wall voids, crawl spaces, etc., to insure adequate spaces.

I. Where on the Plans a portion of the work is drawn out and the remainder is indicated in outline, or not indicated at all, the parts drawn out shall apply to all other like portions of the work. Where ornamentation or other detail is indicated by starting only, such detail shall be continued throughout the courses or parts in which it occurs and shall also apply to all other similar parts of the work, unless otherwise indicated.

J. Details not usually shown or specified, but necessary for the proper installation and operation of systems, equipment, materials, etc., shall be included in the work, the same as if herein specified or indicated.

K. Where within the Contract Documents the word “typical” or “typ.” is used, it shall mean that the work method or means indicated as typical shall be repeated in and each time it occurs whether indicated or not.

L. Each Contractor shall evaluate ceiling heights specified on Architectural Plans. Where the location of equipment or systems may interfere with ceiling heights or maintenance and access of equipment or systems, the Contractor shall call this to the attention of the Engineer in writing prior to making the installation. Do not install equipment or systems in the affected area until the conflict is resolved. Any such changes shall be anticipated and requested sufficiently in advance so as to not cause extra work or cost incurred on the part of the Contractor or unduly delay the work.

1.7 EQUIPMENT AND MATERIALS SUBSTITUTIONS OR DEVIATIONS:

A. When any Contractor requests approval of materials and/or equipment of different physical size, weight, capacity, function, color, access, that the design allows for it shall be understood that such substitution, if approved, will be made without additional cost to anyone other than the Contractor requesting the change regardless of changes in connections, space requirements, electrical characteristics, etc. from that indicated, electrical service, etc. In all cases where substitutions affect other trades, the Contractor requesting such substitutions shall advise all such Contractors of the change and shall compensate them for all necessary changes in their work. Any Plans, Specifications, Diagrams, etc., required to describe and coordinate such substitutions or deviations shall be professionally prepared at the responsible Contractor's expense. Review of Shop Drawings by the Engineer does not in any way absolve the Contractor of this responsibility.

B. Notwithstanding any reference in the Specifications to any article, device, product, material, fixture, form, or type of construction by name, make or catalog number, such reference shall be interpreted as establishing a standard of quality and shall not be construed as limiting competition; any devices, products, materials, fixtures, forms, or types of construction which, in the judgment of the Engineer, are equivalent to those specified are acceptable, provided the provisions of this Part are met. Requested substitutions shall be submitted to the Engineer a minimum of ten (10) days prior to Bid. If this procedure is not followed, the substitution will be rejected. If prevailing laws of cities, towns, states, or countries are more stringent than these specifications regarding such substitutions, then those laws shall prevail over these requirements.

C. Wherever any equipment and material is specified exclusively only such items shall be used unless substitution is accepted in writing by the Engineer.

D. Each Bidder/Proposer shall furnish along with their proposal a list of specified equipment and materials which is to be provided. Where several makes are mentioned in the Specifications and the Contractor fails to state which, they propose to furnish, the Engineer shall choose any of the makes mentioned without change in price. Inclusion in this list shall not ensure that the Engineer will approve shop drawings unless the equipment, materials, etc., submitted in shop drawings are satisfactorily comparable to the items specified and/or indicated.

E. Coordinate kitchen equipment selection by the Construction Manager prior to Bid. Any deviations and/or conflicts for any kitchen equipment shall be the Contractor’s responsibility.

1.8 QUALIFICATIONS OF CONTRACTOR/WORKERS:

A. All Mechanical Contractors and their subcontractors bidding this project must have been a licensed company for a minimum of three (3) years to qualify to Bid this project. Individual employee experience does not supersede this requirement.

B. All mechanical subcontractors bidding the mechanical work must have completed one project of 70% this subcontract cost size and two projects of 50% this subcontract cost size.

C. All mechanical work shall be accomplished by qualified workers competent in the area of work for which they are responsible. Untrained and incompetent workers, as evidenced by their workmanship, shall be summarily relieved of their responsibilities in areas of incompetency. The Engineer shall reserve the right to determine the quality of workmanship of any workers and unqualified or incompetent workers shall

refrain from work in areas not deemed satisfactory. Requests for relief of workers shall be made through the normal channels of Architect, Contractor, etc.

D. The Contractor shall hold all required licenses in the State which the work is to be performed.

E. The installation of all Heating, Ventilating and Air-Conditioning Systems (HVAC) by any Contractor, whether in existing or new building construction shall be performed by a Licensed Master HVAC Contractor. This includes any Contractor installing HVAC systems, piping, and ductwork.

F. All sheet metal, insulation and pipe fitting work shall be installed by workers normally engaged in this type work.

G. All automatic control systems shall be installed by workers normally engaged or employed in this type work, except in the case of minor control requirements (residential type furnaces, packaged HVAC equipment with integral controls, etc.) in which case, if a competent worker is the employee of this Contractor, the worker may be utilized subject to review of their qualifications by the Engineer and after written approval from same.

H. All electrical work shall be accomplished by Licensed Journeymen electricians under the direct supervision of a licensed Electrician. All applicable codes, utility company regulations, laws and permitting authority of the locality shall be fully complied with by the Contractor.

1.9 HAZARDOUS MATERIALS:

A. The Contractor is hereby advised that it is possible that asbestos and/or other hazardous materials are or were present in this building or site.

B. Any worker, occupant, visitor, inspector, etc., who encounters any material of whose content they are not certain shall promptly report the existence and location of that material to the Contractor and/or Owner. The Contractor shall, as a part of their work, ensure that their workers are aware of this potential and what they are to do in the event of suspicion. The Contractor shall also keep uninformed persons from the premises during construction. Furthermore, the Contractor shall insure that no one comes near to or in contact with any such material or fumes therefrom until its content can be ascertained to be non-hazardous.

C. CMTA, Inc., Consulting Engineers, have no expertise in the determination of the presence of hazardous materials. Therefore, no attempt has been made by them to identify the existence or location of any such material. Furthermore, CMTA nor any affiliate thereof will neither offer nor make any recommendations relative to the removal, handling, or disposal of such material.

D. If the work interfaces, connects or relates in any way with or to existing components which contain or bear any hazardous material, asbestos being one, then, it shall be the Contractor's sole responsibility to contact the Owner and so advise them immediately.

E. The Contractor by execution of the contract for any work and/or by the accomplishment of any work thereby agrees to bring no claim relative to hazardous materials for negligence, breach of contract, indemnity, or any other such item against CMTA, its principals, employees, agents, or consultants. Also, the Contractor further agrees to defend, indemnify, and hold CMTA, its principals, employees, agents, and consultants, harmless from any such related claims which may be brought by any subcontractors, suppliers or any other third parties.

F. No asbestos or mercury containing materials shall be installed in this project.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 – EXECUTION

3.1 EXAMINATION OF SITE CONDITIONS

A. Each Bidder/Proposer shall inform themselves of all of the conditions under which the work is to be performed, the site of the work, the structure of the ground, above and below grade, the obstacles that may be encountered, the availability and location of necessary facilities and all relevant matters concerning the work.

B. Each Bidder/Proposer shall also fully acquaint themselves with all existing conditions as to ingress and egress, distance of haul from supply points, routes for transportation of materials, facilities and services, availability of utilities, etc. A proposal shall cover all expenses or disbursements in connection with such matters and conditions. No allowance will be made for lack of knowledge concerning such conditions after Bids are accepted.

3.2 CODES, RULES, PERMITS, FEES, INSPECTIONS, REGULATIONS, ETC.:

A. The Contractor shall give all necessary notices, obtain, and pay for all permits, government sales taxes, fees, inspections, and other costs, including all utility connections, meters, meter settings, taps, tap fees, extensions, etc. in connection with their work. They shall also file all necessary plans, prepare all documents, and obtain all necessary approvals of all governmental departments and/or the appropriate municipality or utility company having jurisdiction, whether indicated or specified or not. They shall also obtain all required certificates of inspection for their work and deliver same to the Engineer before request for acceptance and final payment for the work.

B. Ignorance of Codes, Rules, regulations, utility company requirements, laws, etc., shall not diminish or absolve Contractor's responsibilities to provide and complete all work in compliance with such.

C. The Contractor shall include in their work, without extra cost, any labor, materials, services, apparatus, and Plans in order to comply with all applicable laws, ordinances, rules, and regulations, whether or not indicated or specified.

D. All materials furnished and all work installed shall comply with the National Fire Codes of the National Fire Protection Association, with the requirements of local utility companies, or municipalities and with the requirements of all governmental agencies having jurisdiction.

E. All materials and equipment so indicated and all equipment and materials for the electrical portion of the mechanical systems shall bear the approval label of or shall be listed by the Underwriters' Laboratories (UL), Incorporated. Each packaged assembly shall be approved as a package. Approval of components of a package shall not be acceptable.

F. All Heating, Ventilation and Air Conditioning work shall be accomplished in accordance with the Building Code and amendments thereto, the latest standards recognized by the American Society of Heating, Refrigerating and Air Conditioning and the National Fire Protection Association.

G. The Contractor shall furnish three (3) copies of all Final Inspection Certificates obtained to the Engineer when work is complete. Final payment for work will be contingent upon compliance with this requirement.

H. Where minimum code requirements are exceeded in the Design, the Design shall govern.

I. The Contractor shall insure that their work is accomplished in accord with the OHSA Standards and that they conduct their work and the work of their personnel in accord with same.

J. All work relating to the handicapped shall be in accord with regulations currently enforced by the Authority Having Jurisdiction and the American Disabilities Act.

K. All pressure vessel installations shall comply with the State, and/or Federal Code applicable. A Certificate of Final Boiler Inspection shall be required.

L. Work in elevators, elevator shafts and elevator equipment rooms shall comply with the Elevator Code enforced by the Authority Having Jurisdiction.

M. All work in conjunction with a natural gas installation shall, in addition to all other Codes, Rules, Regulations, Standards, etc., comply with the requirements of the local gas supplier and/or standards and recommendations of the American Gas Association.

N. Discharge of any toxic, odorous, or otherwise noxious materials into the atmosphere or any system shall be subject to regulations of the Environmental Protection Agency (EPA) and/or the air pollution control commission. If in doubt, contact the State Department for Environmental Protection.

O. Where conflict arises between any code and the Plans and/or Specifications, the code shall apply except in the instance where the Plans and Specifications exceed the requirements of the code. Any changes required as a result of these conflicts shall be brought to the attention of the Engineer at least ten (10) days prior to bid date, otherwise the Contractor shall make the required changes at their own expense.

3.3 SUPERVISION OF WORK:

A. The Contractor shall personally supervise the work for which they are responsible or have a competent superintendent, approved by the Engineer, on the work at all times during progress with full authority to act on behalf of the Contractor.

3.4 CONDUCT OF WORKERS:

A. The Contractor shall be responsible for the conduct of all workers under their supervision. Misconduct on the part of any worker to the extent of creating a safety hazard, or endangering the lives and property of others, shall result in the prompt removal of that worker. The consumption of alcoholic beverages or other intoxicants, narcotics, barbiturates, hallucinogens or dehabilitating drugs on the job site is strictly forbidden.

3.5 COOPERATION AND COORDINATION WITH OTHER TRADES:

A. The Contractor shall give full cooperation to all other trades and shall furnish in writing with copies to the Engineer, any information necessary to permit the work of other trades to be installed satisfactorily and with the least possible interference or delay.

B. Where any work is to be installed in close proximity to, or will interfere with work of other trades, each shall cooperate in working out space conditions to make a satisfactory adjustment. If so, directed by the Engineer, the Contractor shall prepare composite working drawings and sections at a suitable scale not less than ¼" = 1'-0", clearly indicating how their work is to be installed in relation to the work of other trades, or so as not to cause any interference with work of other trades. Make the necessary changes in the work to correct the condition without extra charge.

C. The Contractor shall furnish to other trades, as required, all necessary templates, patterns, setting plans, and shop details for the proper installation of work and for the purpose of coordinating adjacent work.

3.6 GUARANTEES AND WARRANTIES:

A. The Contractor shall guarantee all equipment, apparatus, materials, and workmanship entering into their Contract to the best of its respective kind and shall replace all parts at their own expense, which are proven defective within the time frame outlined in the General Conditions of the Contract. The effective date of completion of the work shall be the date of the Project's Statement of Substantial Completion. Items of

equipment which have longer guarantees, as called for in these Specifications, shall have warranties and guarantees completed in order, and shall be in effect at the time of final acceptance of the work by the Engineer. The Contractor shall present the Engineer with such warranties and guarantees at the time of final acceptance of the work. The Engineer shall then submit these warranties, etc. to the Owner. The Owner reserves the right to use equipment installed by the Contractor prior to date of final acceptance. Such use of equipment shall not invalidate the guarantee except that the Owner shall be liable for any damage to equipment during this period, due to negligence of their operator or other employees. Refer to other sections for any special or extra warranty requirements.

B. All gas fired heat exchangers shall have 15 year warranty.

C. All compressors shall have five year warranty. (1st year parts and labor, 2nd thru 5th year compressor parts only).

D. All VFD's shall have a two year warranty. (Parts and Labor).

E. Provide all warranty certificates to Owner. All warranties begin starting at the substantial completion date, submit warranty certificates accordingly.

3.7 COST BREAKDOWNS (SCHEDULE OF VALUES):

A. Within thirty (30) days after acceptance of the Contract, the Contractor shall furnish to the Engineer, one copy of a detailed cost breakdown on each respective area of work. These cost breakdowns shall be made in a format approved by the Engineer. Payments will not be made until satisfactory cost breakdowns are submitted.

B. The breakdown shall be minimally as follows. Material and labor shall be listed separately. Pay special attention to required withholding percentages for startup, testing, documentation, acceptance, owner training, etc.:
- Mechanical Shop Drawings
- Motor Load Coordination with other subcontractors
- Mechanical Record Drawings & Acceptance
- Mechanical O&M Manuals & Acceptance
- Mechanical Owner Training & Acceptance
- Spare Parts
- Coordination Drawings
- Mechanical Identification Materials & Labor
- HVAC Piping Materials & Labor
- HVAC Piping Testing, Cleaning, Documentation, Acceptance, etc.
- HVAC Piping Purging, Flushing, Cleaning
- Insulation (Piping) Materials & Labor
- Insulation (Ductwork) Materials & Labor
- Sheetmetal Equipment
- Sheetmetal Materials & Labor
- Sheetmetal Shop Fabrication
- Ductwork Air Leakage Testing, Documentation, Acceptance, etc.
- Air Handling Unit Equipment & Labor
- Air Handling Unit Startup, Testing, Documentation, Training, Acceptance, etc.
- Split System Equipment & Labor
- Split System Startup, Testing Equipment Room A/C Equipment & Labor
- Other HVAC Equipment & Labor
- Other HVAC Equipment Startup, Testing, Documentation, Training, Acceptance, etc.
- Chemical Treatment Materials & Labor
- Chemical Treatment Pre-Testing

- Chemical Treatment Startup, Testing, Documentation, Training, Acceptance, etc.
- Controls Front-end Interface
- Controls Commissioning Plan
- Controls Shop Drawings
- Controls Materials & Labor
- Controls Graphics
- Controls Record Drawings
- Controls Startup, Commissioning, Testing, Documentation, etc.
- Controls Training and Acceptance
- Test and Balance Materials & Labor
- Test and Balance Pre-Testing
- Test and Balance Initial Report, Final Report and Acceptance

3.8 CHANGES IN MECHANICAL WORK:

A. REFER TO GENERAL AND SPECIAL CONDITIONS.

3.9 CLAIMS FOR EXTRA COST:

A. REFER TO GENERAL AND SPECIAL CONDITIONS.

3.10 MATERIALS AND WORKMANSHIP:

A. All equipment, materials and articles incorporated in the work shall be new and of comparable quality to that specified. Each Bidder/Proposer shall determine that the materials and/or equipment they propose to furnish can be brought into the building(s) and installed within the space available. In certain cases, it may be necessary to remove and replace walls, floors and/or ceilings and/or disassemble/reassemble the materials and equipment and this work shall be the responsibility of the Contractor, whether specifically initiated or not.

B. All equipment shall be installed so that all parts are readily accessible for inspection, maintenance, replacement of fans, motors, coils, filters, etc. Extra compensation will not be allowed for relocation of equipment for accessibility or for dismantling equipment to obtain entrance into the building(s). Insure, through coordination that no other Contractor seals off access to space required for equipment materials, etc.

C. Materials and equipment shall bear Underwriters' Laboratories label where such a standard has been established, where applicable.

D. All equipment shall bear the manufacturer's name and address. All electrically operated equipment shall bear a name plate indicating required horsepower, voltage, phase, and ampacity. Pumps and fans shall have a data plate indicating horsepower, pressure, and flow rate.

3.11 TEMPORARY SERVICES:

A. The Contractor shall arrange any temporary water, electrical and other services which may be required to accomplish the work. Refer also to General and Special Conditions.

B. All temporary services shall be removed by Contractor prior to completion of work.

3.12 SURVEY, MEASUREMENTS AND GRADE:

A. The Contractor shall lay out their work and be responsible for all necessary lines, levels, inverts, elevations, and measurements. The Contractor must verify the figures shown on the Plans before laying out the work and will be held responsible for any error resulting from failure to do so.

B. The Contractor shall base all measurements, both horizontal and vertical from established bench marks. All work shall agree with these established lines and levels. Verify all measurements at the site and check the correctness of same as related to the work.

C. Should the Contractor discover any discrepancy between actual measurements and those indicated which prevents following good practice or the intent of the contract documents, the Contractor shall promptly notify the Engineer and shall not proceed with this work until the Contractor has received instructions from the Engineer on the disposition of the work.

3.13 PROTECTION OF EQUIPMENT:

A. The Contractor shall be entirely responsible for all material and equipment they furnish in connection with their work and special care shall be taken to properly protect all parts thereof from damage during the construction period. Such protection shall be by a means acceptable to the Engineer. All piping, etc., shall be properly plugged or capped during construction in a manner approved by the Engineer. Equipment damaged, stolen, or vandalized while stored on site, either before or after installation, shall be repaired or replaced by the Contractor at their expense. All ductwork with open ends shall be covered with plastic during construction.

3.14 REQUIRED CLEARANCES FOR ELECTRICAL EQUIPMENT:

A. The NEC has specific required clearances above, in front, and around electrical gear, panels etc. The Contractor shall not install any piping, ductwork, etc., in the required clearance. If any appurtenance is located in the NEC required clearance, it shall be relocated at no additional cost. Coordinate with the Electrical Contractor prior to any work.

3.15 EQUIPMENT SUPPORT:

A. Each piece of equipment, apparatus, piping, or conduit suspended from the ceiling or mounted above the floor level shall be provided with suitable structural support, pipe stand, platform, or carrier in accordance with the best recognized practice. Such supporting or mounting means shall be provided by the Contractor for all equipment and piping. Exercise extreme care that structural members of building are not overloaded by such equipment. Provide any required additional bracing, cross members, angles, support, etc. Do not support items from roof/floor deck or bridging.

3.16 DUCT AND PIPE MOUNTING HEIGHTS:

A. All exposed or concealed ductwork, piping, etc., shall be held as high as possible unless otherwise noted and coordinated with all other trades. Exposed piping and ductwork shall, insofar as possible, run perpendicular or parallel to the building structure. Refer to Plans for minimum heights of ducts and piping. Minimum height above ceilings shall be 6” clear including insulation, unless otherwise noted.

3.17 BROKEN LINES AND PROTECTION AGAINST FREEZING:

A. No conduits, piping, etc. carrying water or any other fluid subject to freezing shall be installed in any part of the building where danger of freezing may exist without adequate protection being given by the Contractor whether or not insulation is specified or indicated on the particular piping. All damages resulting from broken and/or leaking lines shall be replaced or repaired at the Contractor's own expense. Do not install piping across or near openings to the outside whether or not they are carrying static or moving fluids. Insulation on piping does not necessarily ensure that freezing will not occur. If in doubt, contact the Engineer.

3.18 WEATHERPROOFING:

A. Where any work pierces waterproofing including waterproof concrete, the method of installation shall be as specified and approved by the Architect and Engineer before work is performed. The Contractor shall furnish all necessary sleeves, caulking and flashing required to make openings permanently watertight.

B. Wherever work penetrates roofing, it shall be done in a manner that will not diminish or void the roofing guarantee or warranty in any way. Coordinate all such work with the roofing installer.

3.19 FINAL CONNECTIONS TO EQUIPMENT:

A. The Contractor shall finally connect mechanical services (water, sanitary, gas, air, etc.), to any terminal equipment, appliances, kitchen equipment, etc., provided under this and/or other divisions of the work. Various equipment connections indicated are based upon “basis of design” equipment selections. Should alternate equipment be purchased by the Construction Manager, then this Contractor shall make the necessary provisions in the Bid for any and all differences. Change Orders shall not be considered for any differences due to alternate equipment purchase. Such connections shall be made in strict accord with current codes, safety regulations and the equipment manufacturer’s recommendations. If in doubt, contact the Engineer prior to installation.

3.20 ACCESSIBILITY:

A. The Contractor shall be responsible for the sufficiency of the size of shafts and chases, the adequate clearance in double partitions and ceilings for the proper installation of their work. They shall cooperate with all others whose work is in the same space. Such spaces and clearances shall, however, be kept to the minimum size required.

B. The Contractor shall locate and install all equipment so that it may be serviced and maintained as recommended by the manufacturer. Allow ready access and removal of the entire unit and/or parts such as valves, filters, fan belts, motors, prime shafts, controls, coils, etc.

C. Whether shown on the Plans or not, the Contractor shall provide in the Bid access panels for each concealed shut-off valve, motorized control damper, manual air damper or other device requiring service as shown on Engineer's Plans or as required. Locations of these panels shall be identified in sufficient time to be installed in the normal course of work. Change orders for access panels will not be accepted.

3.21 SCAFFOLDING, RIGGING AND HOISTING:

A. The Contractor shall furnish all scaffolding, rigging, hoisting and services necessary for erection and delivery onto the premises of any equipment and apparatus furnished. All such temporary appurtenances shall be set up in strict accord with OHSA Standards and Requirements. Remove same from premises when no longer required.

3.22 CONCRETE WORK:

A. The Contractor shall be responsible for the provisions of all concrete work required for the installation of any of their systems or equipment. The Contractor may, at their option, arrange with the others to provide the work. This option, however, will not relieve the Contractor of their responsibilities relative to dimensions, quality of workmanship, locations, etc.

B. In the absence of other concrete Specifications, all concrete related to Mechanical work shall be 3500 psi minimum compression strength at 28 days curing, slump: 4” ± 1”, air entrainment 4.5% water to cement ratio 0.5 and shall conform to the standards of the American Concrete Institute Publication AC1-318. Heavy equipment shall not be installed on pads for at least seven (7) days after pour. Insert 6-inch steel dowel rods into new and existing floors to anchor pads.

C. All concrete pads shall be complete with all pipe sleeves, anchor bolts, reinforcing steel, concrete, etc. as required. Pads larger than 18" in width shall be reinforced with ½" deformed round bars on 6" centers both ways. Bars shall be approximately 2" above the bottom of the pad. All parts of pads and foundations shall be properly rodded or vibrated. If exposed parts of the pads and foundations are rough or show honeycomb after removing forms, all surfaces shall be rubbed to a smooth surface. Chamfer all vertical edges ¾" and tool horizontal edges with ¾" radius.

D. In general, unless otherwise noted, concrete pads for equipment shall be 4" thick, extend six (6) inches beyond the equipment's base dimensions. Where necessary, extend pads 30 inches beyond base or overall dimensions to allow walking and servicing space.

E. Exterior concrete pads shall be 8" thick with four (4) inches minimum above grade and four (4) inches below grade on a compacted four (4) inch dense grade rock base unless otherwise indicated or specified. Surfaces of all foundations and bases shall have a smooth finish with one-half (½) inch chamfer on exposed edges. Turn down edges 18" below grade.

3.23 RESTORATION OF NEW OR EXISTING LANDSCAPING, PAVING, SURFACES, ETC.:

A. The Contractor shall at their expense restore to their original conditions all paving, curbing, surfaces, drainage ditches, structures, fences, landscaping, existing or new building surfaces and appurtenances, and any other items damaged or removed by their operations. Replacement and repairs shall be in accordance with good construction practice; by qualified tradesman and shall match materials employed in the original construction of the item and shall be to the satisfaction of the Owner and/or Engineer.

3.24 MAINTENANCE OF EXISTING UTILITIES AND LINES:

A. The locations of all piping, conduits, cables, utilities, and manholes existing, or otherwise, that comes within the contract construction site, shall be subject to continuous uninterrupted service with no other exception than the Owner of the utilities permission to interrupt same temporarily. Provide a seven (7) day written notice to Engineer, Architect and Owner prior to interrupting any utility service or line.

B. Known utilities and lines as available to the Engineer are shown on the Plans. However, it is additionally required that, prior to any excavation being performed, each Contractor ascertain and mark all utilities or lines that would be endangered by the excavation. Hand dig if required to locate. Contractor shall bear costs of repairing damaged utilities.

C. If utilities or lines occur in the earth within the construction site, the Contractor shall probe and locate the lines prior to machine excavation in the respective area. Hand dig if required to locate.

D. Cutting into existing utilities and services shall be performed in coordination with and as designated by the Owner of the utility. The Contractor shall work continuously to restore service(s) upon deliberate or accidental interruption, providing premium time and materials as needed without extra claim to the Owner.

E. The Contractor shall repair to the satisfaction of the Owner and Engineer, any surfaces or subsurface improvements damaged during the course of the work, unless such improvement is shown to be abandoned or removed.

F. Machine excavation shall not be permitted with ten feet of gas lines, fuel lines, electrical lines or lines carrying combustible and/or explosive materials. Hand excavate only in accord with utility company, agency or other applicable laws, standards or regulations.

G. Protect all new or existing lines from damage by traffic, etc. during construction. Repairs or replacement of such damage shall be at the sole expense of the party responsible.

H. Protect existing trees, indicated to remain with fencing or other approved method. Hold all new subsurface lines outside the drip line of trees, offsetting as necessary to protect root structures. Refer to planting or landscaping plans, or in their absence, consult with the Architect.

3.25 CLEANING:

A. The Contractor shall, at all times, keep the area of their work presentable to the public and clear from rubbish and debris caused by their operations; and at the completion of the work, they shall remove all rubbish, debris, all of their tools, equipment, temporary work, and surplus materials from and about the premises, and shall leave the area clean and ready for use. If the Contractor does not attend to such cleaning upon request, the Engineer may cause cleaning to be done by others and charge the cost of same to the Contractor. The Contractor shall be responsible for all damage from fire which originates in, or is propagated by, accumulations of their rubbish or debris.

B. After completion of all work and before final acceptance of the work, the Contractor shall thoroughly clean all equipment and materials and shall remove all foreign matter such as grease, dirt, plaster, labels, stickers, etc., from the exterior of piping, equipment, fixtures and all other associated or adjacent fabrication.

C. Ductwork and piping shall be kept clean at all times. Ductwork stored on the job site shall be placed a minimum of 4" above the floor and shall be completely covered in plastic. Installed ductwork shall be protected with plastic. Do not install the ductwork or insulation (pipe or duct) if the building is not "dried-in". If this is required, the entire lengths of duct shall be covered in plastic to protect. The Owner/Engineer shall periodically inspect that these procedures are followed. If deemed unacceptable, the Contractor shall be required to clean the duct system utilizing a NADCA certified Contractor.

3.26 TEMPORARY USE OF EQUIPMENT:

A. The permanent heating when installed, may be used for temporary services, with the consent of the Engineer. Should the permanent systems be used for this purpose the Contractors shall make all temporary connections required at their expense. They shall also make any replacement required due to damage wear and tear, etc., leaving the same in "as new" condition.

B. Permission to use the permanent equipment does not relieve the Contractors from the responsibility for any damages to the building construction and/or equipment which might result because of its use.

C. Warranties shall begin at substantial completion regardless of temporary use of equipment or not.

D. A pre-start-up conference shall be held in accordance with EQUIPMENT/CONTROLS START-UP AND VERIFICATION in this section.

E. For Air Handling Units during all phases of construction:
   1. At a minimum, four complete sets of filter media are required for each unit. In each unit, install two sets of filter media during construction (more shall be required if construction activities dictate more frequent changes). In each unit, install one set of filter media at substantial completion. Leave one set of filter media in boxes in appropriate mechanical room as a spare set for the Owner. All other filters shall be used by the Contractor during construction. Dispose of all construction filter media.
   2. On the outside of all return air openings install a minimum of two sets of fiberglass filter media, such as cheesecloth, to be utilized as pre-filters for the "construction" filters. Install first set upon start-up and then install second set when first set is dirty. Dispose of all dirty construction filters. Change filters as often as necessary to keep units from becoming dirty at no additional cost.
   3. At substantial completion of the project the entire unit shall be cleaned to present a like "new" unit for the Owner and all filters shall be replaced with new.

3.27 NOISE, VIBRATION OR OSCILLATION:

A. All work shall operate under all conditions of load without any sound or vibration which is objectionable in the opinion of the Engineer. In case of moving machinery, sound, or vibration noticeable outside of room in which it is installed, or annoyingly noticeable inside its own room, will be considered objectionable. Sound or vibration conditions considered objectionable by the Engineer shall be corrected in an approved manner by the Contractor at their expense.

B. All equipment subject to vibration and/or oscillation shall be mounted on vibration supports whether indicated or not suitable for the purpose of minimizing noise and vibration transmission and shall be isolated from external connections such as piping, ducts, etc. by means of flexible connectors, vibration absorbers, or other approved means.

C. Unitary equipment, such as room units, exhaust fans, etc., shall be rigidly braced and mounted to wall, floor or ceiling as required and tightly gasketed and sealed to mounting surface to prevent air leakage and to obtain quiet operation. Flush and surface mounted equipment such as diffusers, grilles, etc., shall be gasketed and affixed tightly to their mounting surface.

D. The Contractor shall provide supports for all equipment they furnish. Supports shall be liberally sized and adequate to carry the load of the equipment and the loads of attached equipment, piping, etc. All equipment shall be securely fastened to the structure either directly or indirectly through supporting members by means of bolts or equally effective means. If strength of supporting structural members is questionable, contact Engineer.

3.28 EQUIPMENT/CONTROLS STARTUP & VERIFICATION:

A. The Contractor and their Subcontractors shall include in the bid to provide equipment and controls startup and verification for ALL Mechanical Systems specified for this project.

B. A pre-start-up conference shall be held with the Architect, Engineer, Owner, Construction Manager, Mechanical Contractor, Electrical Contractor, Controls Contractor, Test and Balance Contractor, and the Manufacturer’s providing startup services. The purpose of this meeting will be to discuss the goals, procedures, etc. for start-up.

C. Specific line-items shall be included on the schedule of values by each Trade for “equipment and controls startup”. These line-item values shall be approved by the Engineer. The Engineer, Owner and the Engineer’s Field Inspector(s) shall closely monitor progress and quality of the equipment and controls startup and may withhold pay requests as deemed appropriate until satisfactorily completed.

D. Specific startup/verification specifications are included throughout the Mechanical Specifications. In general, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians, not third party contractors, and shall complete and submit start-up reports/checklists. The Contractor shall have appropriate trades on site to correct all deficiencies noted by the factory representative. For each deficiency noted, documentation of corrective action (including date and time) shall be submitted to the Engineer and Owner. Where factory start-up is not specified for a particular piece of equipment or system, the Contractor shall be responsible to perform start-up. All information shall be completed by the Contractor and submitted to the Owner/Engineer prior to acceptance of the equipment.

E. The Contractor shall be responsible for completion of System Verification Checklists/Manufacturer’s Checklists. Factory startup is required for all HVAC equipment noted. Unless noted otherwise, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians and shall complete and submit start-up reports/checklists. This shall include the following:
   1. Air Handling Units
   2. Variable Frequency Drives

3. Water Flow Meters/BTUH Meters
4. Split Systems
5. Hot Water Boilers
6. Water Chillers
7. Kitchen Rangehood and Exhaust Fans

F. Except for the specific equipment specified in this Specification Section, the manufacturer's recommended startup procedures and checklists will be acceptable for use in the project. Where "manufacturer" startup is not specified, then this Contractor shall perform startup services in strict accordance with manufacturer's instructions. All startup/verification process shall be thoroughly documented by the Contractor and shall include the time and date when performed.

G. The Contractor shall "zip-tie" a start-up report to each piece of equipment in a clear plastic cover. Once start-up completion is verified by the Engineer the Contractor shall remove all reports and consolidate them into close-out documentation. The Contractor shall be responsible for completion of System Verification Checklist (SVC) / Manufacturer's Checklists.

3.29 INSPECTION, APPROVALS AND TESTS:

A. Before requesting a final review of the installation from the Architect and/or Engineer, each Contractor shall thoroughly inspect their installations to assure that the work is complete in every detail and that all requirements of the Contract Documents have been fulfilled. Failure to accomplish this may result in charges from the Architect and/or Engineer for unnecessary and undue work on their part.

B. The Contractor shall provide as a part of this Contract any required Agency inspection, licensed and qualified to provide such services. All costs incidental to the provisions of inspections shall be borne by the Contractor.

C. The Contractor shall advise each Inspecting Agency in writing, with an informational copy of the correspondence to the Architect and/or Engineer, when they anticipate commencing the work. Inspections shall be scheduled for rough-in as well as finished work. The rough-in inspections shall be divided into as many inspections as may be necessary to cover all rough-in without fail. Failure of the Inspecting Agency to inspect the work in a timely manner and submit the related reports may result in the Contractor having to expose concealed work not so inspected. Such exposure will be at the expense of the responsible Contractor.

D. Approval by an Agency Inspector does not relieve the Contractor from the responsibilities of furnishing equipment having a quality of performance equivalent to the requirements set forth in these Plans and Specifications. All work under this contract is subject to the review of the Architect and/or Engineer, whose decision is binding.

E. Before final acceptance, the Contractor shall furnish the original and three (3) copies of the certificates of final approval by the Agency Inspector to the Engineer with one copy of each to the appropriate government agencies, as applicable. Final payment for the work shall be contingent upon completion of this requirement.

3.30 ABOVE CEILING AND FINAL PUNCH LISTS:

A. The Contractor shall review each area and prepare and complete their own punch list for each of the subcontractors as required for the Project Schedule.

B. Seven (7) days notice shall be given to the Engineer for review of above ceiling work that will be concealed by tile or other materials. Seven (7) days notice shall be given to the Engineer for review of below ceiling work and final inspection.

C. When all work from the Contractor's punch list is complete at each of the major Project Stages and prior to completing ceiling installations (or at the final punch list stage), the Contractor shall request that the Engineer develop a punch list. This request is to be made in writing seven (7) days prior to the proposed date. After all corrections have been made from the Engineer's punch list, the Contractor shall review and initial off on each item. This signed-off punch list shall be submitted to the Engineer. The Engineer shall return to the site once to review each punch list and all work prior to the ceilings being installed and at the final punch list review. The Contractor's representative may be requested at the inspections.

D. If additional visits are required by the Engineer to review work not completed by this review, the Engineer shall be reimbursed directly by the Contractor by check or money order (due net 10 days from date of each additional visit) at a rate of $125.00 per hour plus travel expense for extra trips required to complete either of the above ceiling, below ceiling or final punch lists.

3.31 OPERATING INSTRUCTIONS:

A. Upon completion of all work and all tests, each Contractor shall furnish the necessary skilled labor and helpers for operating the systems and equipment for a period of three (3) days of eight (8) hours each, or as otherwise specified. Refer to Section HVAC EQUIPMENT for additional requirements. During this period, instruct the Owner or their representatives fully in the operations, adjustment, and maintenance of all equipment furnished. Give at least seven (7) days written notice to the Owner, Architect and Engineer in advance of this training period. The Engineer may attend any such training sessions or operational demonstrations. The Contractor shall certify in writing to the Engineer that such demonstrations have taken place, noting the date, time and names of the Owner's representatives that were present.

B. Each Contractor shall furnish three complete bound sets for approval to the Engineer instructions for operating and maintaining all systems and equipment included in this contract. All instructions shall be submitted in draft form, for approval, prior to final issue. Manufacturer's advertising literature or catalogs will not be acceptable for operating and maintenance instructions. Refer to Specification Section SHOP DRAWINGS for additional detail.

C. Each Contractor, in the above mentioned instructions, shall include the maintenance schedule for the principal items of equipment furnished under this contract and a detailed, easy to read parts list and the name and address of the nearest source of supply.

3.32 RECORD DRAWINGS:

A. The Contractor shall insure that any deviations from the Design are as they occur recorded in red, erasable pencil on record drawings kept at the jobsite. The Engineer shall review the record documents from time to time to ensure compliance with this specification. Compliance shall be a contingency of final payment. Pay particular attention to the location of under floor sanitary and water lines, shut-off valves, cleanouts, and other appurtenances important to the maintenance and operation of Mechanical Systems. Also, pay particular attention to Deviations in the Control Systems and all exterior utilities. Keep information in a set of drawings set aside at the job site especially for this purpose and deliver to the Engineer upon completion of the work.

B. All underground utilities/piping installed as part of this project shall be surveyed by a land surveyor licensed in the State in which the project is being constructed. The survey shall include actual pipe depths to top of pipe every 100 feet in length. The survey shall also include benchmarks dimensions relative to above grade, fixed structures. The survey shall be furnished on a compact disc in AutoCad ".dwg" format and ".pdf" format. The survey information shall be included in the closeout documentation.

3.33 COMMISSIONING: CONTRACTOR RESPONSIBILITIES:

A. Contractor shall assign representatives with expertise and authority to act on its behalf and shall schedule them to participate in and perform commissioning process activities including, but not limited to, the following:
   1. Evaluate performance deficiencies identified in test reports and, in collaboration with entity responsible for system and equipment installation, recommend corrective action.
   2. Cooperate with the CxA for resolution of issues recorded in the Issues Log.
   3. Attend commissioning team meetings.
   4. Integrate and coordinate commissioning process activities with construction schedule.
   5. Complete electronic construction checklists as Work is completed and provide to the Commissioning Authority.
   6. Review and accept commissioning process test procedures provided by the Commissioning Authority.
   7. Complete commissioning process test procedures.

3.34 BUILDING PRESSURE TESTING: CONTRACTOR RESPONSIBILITIES:

A. Contractor shall assign representatives with expertise and authority to act on its behalf and shall schedule them to participate in and perform building pressure testing process activities including, but not limited to, the following:
   1. Provide a plan for sealing the mechanical systems to allow proper testing of the envelope system.
   2. Sealing of all mechanical system envelope penetrations (ducts, louvers, etc.).
   3. Cooperate with the CxA for monitoring the process.
   4. Attend building pressure testing coordination meetings.

3.35 COORDINATION DRAWINGS:

A. Detailed electronic coordination drawings shall be required for this project. A specific line-item shall be included on the schedule of values by each Trade for “preparation of coordination drawings”. This line-item value shall be approved by the Engineer. The Engineer and the Engineer’s Field Inspector shall closely monitor progress and quality of the preparation of the electronic coordination drawings and may withhold pay requests as deemed appropriate.

B. Coordination Drawings shall be provided on this project by each Trade. Drawings shall be 30x42 sheet size and shall be at ¼” scale and shall match the drawing setup as included in the Architectural Drawings. Drawings shall be prepared in electronic format utilizing Revit or AutoCad software. The Architect and Engineer will supply electronic drawings files of the Contract Documents upon the Contractor’s request and release.

C. The basis for the Coordination Drawings shall be the sheet metal ductwork fabrication shop drawings, all electrical feeder conduits, and other conduits 2” and larger, and pneumatic tube system piping and components in ceiling spaces. The Coordination Drawings shall be prepared by the Mechanical Contractor. The Coordination Drawings shall indicate (1) systems above ceilings in finished areas, (2) systems supported from the structure in finished areas without ceilings, (3) systems in the mechanical rooms, and (4) all wall, roof, floor penetrations. These drawings shall indicate all ductwork as double lined with bottom elevations noted.

D. The sheet metal fabrication shop drawings shall be completed in a timely manner so as not to conflict with construction schedule and phasing plan. At the Prime Contractor’s discretion, these drawings shall be completed in phases to correspond with the project construction work sequencing. The Mechanical Contractor shall furnish an electronic copy of these ductwork shop drawings to all other Trades, specifically the Fire Protection and Electrical and other Contractors as requested by the Prime Contractor for the purpose of including other trades work on the Coordination Drawings.

E. Pre-Coordination Meetings with all necessary trades shall occur. During these meetings, the Contractors shall discuss locations/elevations where piping, conduits, cable path, etc will be installed with respect to the sheetmetal fabrication drawings and other trades. The sheetmetal ductwork and gravity piping systems shall be given the first priority. Each Trade shall provide the Mechanical Contractor electronic drawings of all of their systems (with elevation noted), coordinated with the ductwork and other trades for them to incorporate into the Coordination Drawings. Coordination Meetings shall then occur so that all conflicts can be resolved between Trades. All conflicts shall be resolved between all Trades at these Coordination Meetings and the Mechanical Contractor shall then amend the Drawings to include the Final Coordinated Work.

F. It is realized that not all systems can be completely detailed. The coordination drawings shall include the following at a minimum:
   1. All supply/return/exhaust ductwork.
   2. All above slab sanitary and roof drainage piping.
   3. HVAC, fire protection and domestic water piping which are 2” in size and greater, excluding insulation.
   4. Electrical conduits which are 1.5” in size and greater.
   5. Cable tray and bridal ring paths.
   6. Multiple smaller piping/conduits hung on a common trapeze hanger.
   7. All wall, roof, floor penetrations.

G. After completion of the Final Coordination Drawings, a Final Review with the all Trades shall occur to provide any final comments and approval by all Trades. Other interim coordination meetings will be required to insure successful coordination drawings. Any additional coordination items will be updated by the Mechanical Contractor. The Final Approved Coordination Drawings shall be distributed electronically (on CD) to each Trade by the Mechanical Contractor. The Mechanical Contractor shall also furnish a complete 30x42 paper set of drawings to the jobsite main office and shall utilize them for updates of field conditions/deviations that occur during construction. Final Approved Coordination Drawings shall also be distributed to the Prime Contractor, Owner, Architect and Engineer for their Records. This process shall be completed prior to starting any work.

H. Each Contractor shall insure that any deviations from the Coordination Drawings are recorded as they occur, in red erasable pencil on Coordination Drawings kept at the jobsite. Upon completion of a particular phase, the Mechanical Contractor shall incorporate all field deviations into the Coordination Drawings to be utilized as Record Drawings. The Engineer shall review the Record Documents from time to time to ensure compliance with this specification. Compliance shall be a contingency of final payment. Pay particular attention to the location of under floor sanitary and water lines, shut-off valves, cleanouts, and other appurtenances important to the maintenance and operation of Mechanical Systems. Also, pay particular attention to Deviations in the Control Systems and all exterior utilities. Keep information in a set of drawings set aside at the job site especially for this purpose. The Record Drawings shall be distributed electronically (on CD) to the Prime Contractor, Owner, Architect and Engineer for their Records.

I. The mechanical contractor is responsible to the Construction Manager for the shop drawing layout of the following rooms and details:
   1. Concrete pads and foundations
   2. Equipment room layouts with actual equipment
   3. Roof layouts
   4. Trench locations and sizes
   5. Dimensioned floor drain locations
   6. Congested areas above ceilings adjacent to mechanical and electrical room
   7. Dimensioned ductwork shop drawings

J. The electrical contractor is responsible to the Construction Manager for the shop drawing layout of the following rooms and details:
   1. Concrete pads and foundations

2. Equipment room layouts with actual equipment
3. Routes of feeders conduits and all other conduits 1.5” and larger
4. Bridle ring cabling paths
5. Trench locations and size
6. Congested areas above ceilings adjacent to mechanical and electrical rooms

END OF SECTION 230500

SECTION 230501 - SCOPE OF THE HVAC WORK

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

1.2 SCOPE

A. The Mechanical work for this Contract shall include all labor, materials, equipment, fixtures, excavation, backfill and related items required to completely install, test, place in service and deliver to the Owner the complete mechanical systems in accordance with the accompanying plans and all provisions of these specifications. This work shall primarily include but is not necessarily limited to the following paragraphs.

B. Installation of all equipment per the manufacturer’s instruction, whether specifically detailed or not.

C. Provide all required motor starters, etc. not provided under the electrical sections.

D. Thorough instruction of the Owner’s maintenance personnel in the operation and maintenance of all mechanical equipment.

E. Thorough coordination of the installation of all piping, ductwork, equipment, and any other material with other trades to insure no conflict in installation.

F. Approved supervision of the mechanical work.

G. Procurement of all required inspections, including fees for all inspection services and submission of final certificates of inspection to the Engineers.

H. Excavation, backfilling, cutting, patching, sleeving, concrete work, etc., required to construct the HVAC systems.

I. Equipment and controls start-up, verification and documentation as specified.

J. Record drawings, final inspection certificates, test results, O & M documentation, warranty certification, spare parts, and other specified closeout documentation.

K. Required schedule of values breakdown.

L. Pipe, duct, and equipment identifications.

M. Preinstallation meetings and equipment mockups.

N. Complete heating, ventilation, and air conditioning systems.

O. All mechanical exhaust systems.

P. All insulation associated with mechanical systems.

Q. Condensate drainage systems.

R. All required pressure testing, flushing, purging, pressure and flow testing requirements.

S. Final coordination and connection of all mechanical equipment furnished by others (e.g., kitchen equipment).

T. All required controls, including self checkout and commissioning.

END OF SECTION 230501

SECTION 230502 - SHOP DRAWINGS, MAINTENANCE MANUALS AND PARTS LISTS FOR HVAC

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractor’s attention is directed to Specification Section DUCT INSULATION.

C. The Contractor’s attention is directed to Specification Section HVAC EQUIPMENT INSULATION.

D. The Contractor’s attention is directed to Specification Section HVAC PIPING INSULATION.

E. The Contractor’s attention is directed to Specification Section INSTRUMENTATION AND CONTROL FOR HVAC.

F. The Contractor’s attention is directed to Specification Section FACILITY MONITORING SYSTEMS.

G. The Contractor’s attention is directed to Specification Section HYDRONIC PUMPS.

H. The Contractor’s attention is directed to Specification Section CENTRIFUGAL HVAC FANS.

I. The Contractor’s attention is directed to Specification Section DIFFUSER, REGISTERS AND GRILLES.

J. The Contractor’s attention is directed to Specification Section MODULAR INDOOR CENTRAL-STATION AIR-HANDLING UNITS.

1.2 SCOPE

A. The Contractor shall prepare and submit to the Engineer, through the Prime Contractor and the Architect within thirty (30) days after the date of the Contract, required copies of all shop drawings, certified equipment drawings, installation, operating and maintenance instructions, samples, wiring diagrams, etc. on all items of equipment specified hereinafter. Refer to Division 1 requirements for shop drawing submittal requirements.

B. The Engineer’s review of shop drawings, schedules or other required submittal data shall not relieve the Contractor from responsibility for adaptability of the item to the project; compliance with applicable codes, rules, regulations, and information that pertains to fabrication and installation; dimensions. weight and quantities; electrical characteristics; and coordination of the work with all other trades involved in this project.

PART 2 – PRODUCTS:

2.1 SHOP DRAWINGS

A. Shop Drawings, descriptive literature, technical data and required schedules shall be submitted on the following:

Access Doors
Air Filtration & Components
Air Handling Units
Boilers (2.2.E)

Cabinet Heaters
Chemical Treatment and Test Reports
Diffusers, Register, and Grilles (2.3)
Double Wall Ductwork
Ductwork Accessories/Volume Dampers
Exhaust Fans
Heat Tracing Systems
High Velocity Ductwork & Fittings
Insulation
Kitchen Rangehood and Exhaust Air System (2.2.D)
Louvers
Pumps and Hydronic Specialties (2.4)
Split Systems
System Verification Check Lists
Facility Management System (2.2.B; 2.2.C)
Instrumentation and Control for HVAC (2.2.B; 2.2.C)
Valves
Variable Frequency Drives
VAV Air Terminals
Water Chillers

(Refer to the corresponding Special Notes.)

2.2 SPECIAL NOTES

A. For all items above, upon substantial completion of the project, the Contractor shall deliver to the Engineer (in addition to the required Shop Drawings) three (3) complete copies of operation and maintenance instructions and parts lists for each item above. Where available, documents shall include at least:
   1. Detailed operating instructions.
   2. Detailed maintenance instructions including preventive maintenance schedules.
   3. Addresses and phone numbers indicating where parts may be purchased.
   4. Expanded parts drawings, parts lists, service manuals, schematics, wiring diagrams.
   5. Master air filter list including equipment identification, filter size, filter quantity, and supplier contact information.
   6. Start-up reports, service records and test reports.

B. Shop drawings for the Facility Monitoring System & Instrumentation and Control for HVAC, shall include detailed, scaled plans and schematic diagrams indicating the function and operation of the system.
   1. The TCC shall not start the project installation until the shop drawing submittals have been reviewed by the Engineer.
   2. Submittals shall include hardware, end devices, ancillary control components, a written operating sequence, unitary control wiring, building floor plans showing communication cabling and labels as well as logic flow diagrams. All submittals shall be provided on paper and electronically in PDF format.
   3. Submittals shall contain one control drawing per specified system and equipment. Drawing shall include point descriptors (DI, DO, AI, AO), addressing, and point names. Each point names shall be unique (within a system and between systems). For example, the point named for the mixed air temperature for AHU #1, AHU #2, and AHU #3 shall not be MAT but should be named AHU#1MAT, AHU#2MAT, and AHU#3MAT. The point names should be logical and consistent between systems and AHU's. The abbreviation or shorthand notation (e.g., MAT) shall be clearly defined in writing by the TCC.
   4. Control diagrams shall identify: System being controlled (attach abbreviated control logic text, all digital points, analog points, virtual points, all functions (logic, math, and control) within control loop, legend for graphical icons or symbols, definition of variables or point names and detailed electric connections to all control devices and sensors.
   5. Points list shall include all physical input/output. Points list shall be provided in both hard copy and

in electronic format and shall include Name, address, engineering units, high and low alarm values and alarm differentials for return to normal condition, default value to be used when the normal controlling value is not reporting, message and alarm reporting as specified, identification of all adjustable points and description of all points.

6. Submittals shall contain floor plans depicting DDC control devices (control units, network devices, LAN interface devices, and power transformers as well as static pressure sensor in duct and temperature sensors in rooms) in relation to mechanical rooms, HVAC equipment, and building footprint.
7. Submittals shall contain DDC system architecture diagram indicating schematic location of all control units, workstations, LAN Interface devices, gateways, etc. Indicate address and type for each control unit, Indicate protocol, baud rate, and type of LAN per control unit.
8. Electrical wiring diagrams shall include motor start, control, and safety circuits and detailed digital interface panel control point termination diagrams with all wire numbers and terminal block numbers identified. Indicate all required electrical wiring. Provide panel termination drawings on separate drawings. Clearly differentiate between portions of wiring that are existing, factory-installed and portions to be field-installed.
9. Show all electric connections of the controls system to equipment furnished by others complete to terminal points identified with manufacturer's terminal recommendations.
10. TCC shall provide one complete drawing that shows the control-wiring interface with equipment provided by others.
11. Submittals shall include project specific graphic screens for each system including a picture of the screen with a list of the variables to be placed on the screen.
12. Submittals shall include TCC's hardware checkout sheets and test reports.
13. Submittals shall include the agenda for approval by the engineer and owner of the specified training periods. See training section for requirements.
14. Provide complete panel drawings that are:
    - Clearly labeled and schematic or drawn to scale.
    - Show the internal and external component arrangement so that the operators can identify the components by their position if the labels come off.
    - Wiring access routes shall also be identified so that Class 1 wiring is separated from Class 2 and 3 and so high voltage wiring is segregated from low voltage wiring.
    - Complete identification of all control devices (manufacturer's type, number, and function).
    - Provide details for labeling all wiring, control devices, and controllers.
    - Material and equipment descriptive material such as catalog cuts, diagrams, performance curves, and other data to demonstrate conformance with specifications shall be provided.
15. Include room schedule including a separate line for each terminal unit, heat pump, etc. indicating location and address.
16. Include control valve schedules including a separate line for each valve provided under this section and a column for each of the valve attributes: code number, configuration, fail position, pipe size, valve size, body configuration, close-off pressure, capacity, valve Cv, design pressure, and actuator type.
17. Include control damper schedule including a separate line for each damper provided under this section and a column for each of the damper attributes, including: code number, fail position, damper type, damper operator, duct size, damper size, mounting, and actuator type.

C. O&M manuals and closeout documents for facility monitoring systems and control for HVAC and variable frequency motor control.
   1. Refer to Mechanical Specification Section – REQUIRED SHOP DRAWINGS, ETC. for additional requirements.
   2. Operating instructions, maintenance procedures, parts and repair manuals shall be supplied. Repair manuals shall include detailed instructions in the setup, calibration, repair and maintenance of all equipment furnished. Also supplied with these manuals will be a complete parts listing of all devices supplied which is to include part numbers and model numbers of all parts and component parts along with exploded views of devices.

3. All as built drawings (wiring diagrams, flowcharts, floor plans, etc.) shall also be supplied to the owner electronically in PDF format.
4. System specific wiring, control diagrams, sequence of operation and points lists shall be as installed in each control panel. This means as-built drawings, not design (submittal) drawings.
5. Supply all software necessary for configuration of, modification, editing or communicating to any of the unitary devices. Software shall be capable of uploading and downloading the entire unitary data base or any part of the automated system for backup or archiving.
6. Supply one copy of the software programming manual (hard copy and PDF format). The manual shall describe all furnished software. The manual shall be oriented to programmers and shall describe calling requirements, data exchange requirements, data file requirements, and other information necessary to enable proper integration, loading, testing, and program execution.
7. Provide a Bill of Materials with each schematic drawing. List all devices/equipment and match to schematic and actual field labeling. Provide quantity, manufacturer, actual product ordering number, description, size, accuracy, operating ranges (voltage, temperature, pressure, etc.), input/output parameters, etc.
8. Maintenance manual shall include copies of signed-off acceptance test forms, commissioning reports, start-up reports, etc.
9. The TCC shall turn over to owner two (2) sets of computerized back-ups of the complete temperature control system.

D. The Contractor shall submit shop drawings for the kitchen range hood system(s) along with all required supporting documentation agency and review fees to the authority having jurisdiction and receive approval prior to submittal to the Engineer. Refer to Specification Section – HVAC EQUIPMENT and Specification Section SHEETMETAL for additional requirements.

E. The Contractor shall submit shop drawings for the boilers along with all required supporting documentation and agency review fees to the authority having jurisdiction and receive approval prior to submittal to the Engineers.

2.3 Shop drawings for Diffuser, Registers and Grilles, shall include a room-by-room schedule indicating devices installed. Also note ceiling and installation.

2.4 Shop drawings shall be submitted as required and shall include complete pump specifications, installation and start-up instructions, current and accurate pump performance curves with the selection points clearly indicated, maintenance data and spare parts lists.

2.5 The Contractor shall submit project specific UL listed firestopping installation drawings to the authority having jurisdiction where required for their approval as required.

PART 3 – EXECUTION:

3.1 Provide all shops in electronic/PDF format. The Engineer’s comments will be returned in electronic format.

3.2 Each shop drawing and/or manufacturers descriptive literature shall have the proper notation indicated on it selecting equipment, accessories and features and shall be clearly referenced to the specifications, schedules, fixture numbers, etc., so that the Engineer may readily determine what the Contractor proposes to furnish. All data and information schedules indicated or specified shall be noted on each copy of each submittal.

3.3 Submittal data shall include specification data including metal gauges, finishes, accessories, etc. Also, the submittal data shall include certified performance data, wiring diagrams, dimensional data, and a spare parts list. Submittal data shall be reviewed by the Engineer before any equipment or materials is ordered or any work is begun in the area requiring the equipment.

3.4 All submittal data shall have the stamp of approval of the Contractor submitting the data as well as the Prime Contractor and the Architect to show that the drawings have been reviewed by the Contractor. Any drawings submitted without these stamps of approval may not be considered and will be returned for proper resubmission.

3.5 The Contractor shall make any corrections or changes required by the Engineer and shall re-submit for final review as outlined above.

3.6 It shall be noted that review of shop drawings by the Engineer applies only to conformance with the design concept of the project and general compliance with the information given in the Contract Documents. In all cases, the Contractor alone shall be responsible for furnishing the proper quantity of equipment and/or materials required, for seeing that all equipment fits the available space in a satisfactory manner and that piping, electrical and all other connections are suitably located. The Contractor shall also coordinate piping side connections.

3.7 Prior to ordering any materials or rough-in of any kind, the HVAC Contractor shall be responsible for final coordination of all electrical requirements (i.e., voltage, phase, circuit breaker, wire sizing, etc.) with the Electrical Contractor. There will be no change in the Contract Amount for any discrepancies. A final coordination meeting shall be held with the Architect, Owner, Engineer, Construction Manager, Mechanical Contractor, Electrical Contractor, and their sub-contractors.

3.8 Equipment shall not be ordered and no final rough-in connections, etc., shall be accomplished until reviewed equipment shop drawings are in the hands of the Contractor. It shall be the Contractor's responsibility to obtain reviewed shop drawings and to make all connections, etc. in the neatest and most workmanlike manner possible. The Contractor shall coordinate with all the other trades having any connections, roughing-in, etc. to the equipment.

3.9 If the Contractor fails to comply with the requirements set forth above, the Engineer shall have the option of selecting any or all items listed in the Specifications or on the Drawings; and the Contractor shall be required to furnish all materials in accordance with this list.

3.10 Colors for equipment in other than mechanical spaces shall be selected from the Manufacturer's standard and factory optional colors unless noted otherwise on the Plans. Color samples shall be furnished with the shop drawing submission for such equipment.

3.11 All submittals for HVAC equipment shall include all information specified and scheduled. This shall include air and water pressure drops, RPM, noise data, face velocities, horsepower, voltage motor type, steel or aluminum construction, and all accessories clearly marked.

3.12 All items listed in the schedules shall be submitted for review in a tabular form similar to the equipment schedule. All items submitted shall be designated with the same identifying tag as specified on each sheet.

3.13 Any submittals received in an unorganized manner without options to be provided specifically noted and with incomplete data will be returned for resubmittal.

END OF SECTION 230502

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SECTION 230513 – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractor’s attention is directed to Specification Section HYDRONIC PUMPS.

C. The Contractor’s attention is directed to Specification Section CENTRIFUGAL HVAC FANS.

D. The Contractor’s attention is directed to Specification Section MODULAR INDOOR CENTRAL STATION AIR HANDLING UNIT.

E. The Contractor’s attention is directed to Specification Section FACILITIES MONITORING SYSTEM.

F. The Contractor’s attention is directed to Specification Section VARIABLE FREQUENCY MOTOR CONTROLLER.

1.2 SCOPE

A. Through coordination with other Contractors, Vendors and Suppliers associated with this Project, this Contractor shall insure a complete, 100% functional, tested, inspected, and approved systems. Claims for additional cost or change orders will immediately be rejected. All equipment shall be furnished for a single point electrical connection unless specifically excluded as a requirement.

B. Prior to ordering any materials or rough-in of any kind, the Mechanical Contractor shall be responsible for final coordination of all electrical requirements (i.e., voltage, phase, circuit breaker, wire sizing, etc.) with the Electrical Contractor. There will be no change in the Contract Amount for any discrepancies. A final coordination meeting shall be held with the Architect, Owner, Engineer, General Contractor, Mechanical Contractor, Electrical Contractor, and their sub-contractors.

PART 2 – PRODUCTS:

2.1 MOTORS

A. The following are basic requirements for simple or common motors. For special motors, more detailed and specific requirements are specified in the individual equipment specifications and drawing schedules.

B. Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads.

C. Motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range.

D. Motors shall be capable of frequency of starts as indicated by automatic control system and not less than five (5) evenly time spaced starts per hour for manually controlled motors.

E. Motors shall have a 1.15 service factor for poly-phase motors and 1.35 service factor for single phase motors.

F. Motors shall have a temperature rating for 40 deg C ambient environment with maximum 90 deg C temperature rise for continuous duty at full load with 1.15 service factor and Class B insulation.

G. Unless otherwise noted or required by application, motors shall confirm to NEMA Standard MG 1 (Table 12-10) for general purpose, continuous duty, horizontal, T-frame, single speed, design “A” or “B”. Utilize design "C" motors where required for high starting torque.

H. Motor frames shall be NEMA Standard No. 48 or 56. Use driven equipment (fans, pumps, etc.) manufacturer's standards to suit specific application.

I. Provide inverter rated motors where variable frequency drives are utilized. Motor shall be premium efficiency type with Class F insulation and shall conform to NEMA MG 1 parts 30 and 31. Inverter duty rated motors shall have a temperature rating for 40 deg C ambient environment with maximum of 105 deg C temperature rise.

J. Motor bearings shall be ball or roller bearings with inner and outer shaft seals. Bearings shall be re-greaseable, except permanently sealed where motor is normally inaccessible for regular maintenance. Bearings shall be designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor.

K. Motor enclosure type shall be open drip-proof motors for indoor use where satisfactorily housed or remotely located during operation. Enclosures shall be guarded drip-proof type motors where exposed to contact by employees or building occupants. Enclosure shall be weather protected Type I for outdoor use or Type II where not housed.

L. Provide built-in thermal overload protection and, where required, internal sensing device suitable for signaling and stopping motor at starter.

M. Provide energy efficient motors with a minimum EPACT efficiency in accordance with NEMA MG 1, Table 12-10 for 1800 rpm, enclosed motors. If efficiency not specified, motors shall have a minimum efficiency as listed below:

1 hp - 82.5%	7.5 hp – 89.5%	30 hp – 92.4%
1.5 hp – 84.0%	10 hp – 89.5%	40 hp – 93%
2 hp – 84%	15 hp – 91%	50 hp – 93%
3 hp – 87.5%	20 hp – 91%	60 hp – 93.6%
5 hp – 87.5%	25 hp – 92.4%	75 hp – 94.1%

N. On the motor nameplate, indicate the full identification of manufacturer, ratings, characteristics, construction, special features and similar information.

2.2 MOTOR STARTERS

A. Provide motor starters where indicated on the mechanical equipment schedules or elsewhere in the Contract Documents.

B. Motor starters shall be NEMA style. Their sizing and installation shall be coordinated with the equipment manufacturer's requirements and in accordance with the National Electrical Code.

C. All starters shall be size 0 minimum. They shall be constructed and tested in accord with latest edition of NEMA standards. All starters shall be across-the-line magnetic type, unless indicated otherwise. On motors of 20 H.P. or greater rating, the supplier shall provide starters capable of limiting inrush currents. These shall be the reduced voltage open-transition type. Do not utilize closed transition starters unless specifically indicated.

D. Magnetic starters shall be furnished with the following characteristics and accessories as a minimum. See remaining paragraphs of the Part and mechanical schedules for further requirements.

E. Contacts shall be silver-alloy, double-break type except NEMA size 8 and 9 shall be single-break type. Contacts shall be replaceable without removal of wiring or removal of starter from enclosure. Number of contacts shall be as required for service indicated. Contacts shall be gravity dropout type, positive operation.

F. Coil voltage shall be 120 volts, A.C., 60 HZ or less, as required to suit control systems available voltages. Coils shall be of molded construction, except for size 8 and 9 which shall be hand wound. Provide coil clearing contact as required.

G. Provide control transformer of adequate K.V.A. as required on all starters with line-to-line voltages higher than 120 volts A.C. Provide fuse block and slow-blow fuse to protect control transformer per NEMA, N.E.C. and U.L.

H. Provide hand-off-auto selector switch in face of starter, wired into hand and off switch positions. Auto position (if needed) to be field wired as indicated for automatic control.

I. Provide NEMA Class 20 resetable overload relays, accurately sized to the motor nameplate rating of the motor served and the temperature differential between motor and controller. Overloads shall be easily replaceable, and resetable without opening enclosure, via a push button or similar means. Class 10 or Class 30 overloads may be used depending on type of motor duty encountered.

J. Provide at least one N.O. auxiliary contact (field-convertible to N.C. operation) with each starter. All starters shall have space for two additional single-pole contacts.

K. All starters shall be thru-wiring type.

L. Provide phase failure sensing relay to open starter coil circuit (on loss of one or more phases) on all three-phase starters controlling motors of 7½ H.P. or larger.

2.3 ELECTRICAL REQUIREMENTS FOR HVAC EQUIPMENT

A. All mechanical equipment shall be provided for single point electrical connection unless noted otherwise.

B. The equipment manufacturer shall provide internally mounted fuses with the equipment, as required, to comply with the U.L. listing on the equipment name plate. (i.e., hermetically sealed compressors or equipment with name plate data that recommends or requires fuse protection.) See also, National Electrical Code, Article 440, Part C, and other applicable sections of the N.E.C.

C. It shall be the Contractor's responsibility to assure that all mechanical equipment requiring electrical connections be provided with all required proper wiring, electrical protective devices, disconnecting means and electro-mechanical starting units to properly match the mechanical equipment requirement.

D. Each separate contractor engaged for the project shall coordinate with all other trades to ensure all necessary equipment and labor is included for fully functioning mechanical systems, installed per Code and Project requirements.

E. Refrigeration condensing units with internal compressors shall be furnished with integral starter.

F. All interlock or other control wiring, unless specifically noted otherwise, is the responsibility of this Contractor.

G. All equipment shall be suitably enclosed. All enclosures for equipment shall be rated and approved for the environment in which it operates. (i.e., NEMA 1, NEMA 3R, NEMA 7, NEMA 12, etc.) Verify the requirement with the installation condition if not indicated on the plans.

H. Observe the following standards for manufacture of equipment and in selection of components: (1) Starters, control devices and assemblies - NEMA (I.E.C. style not acceptable), (2) Enclosures for electrical equipment – NEMA, (3) Enclosed switches – NEMA, (4) All electrical work, generally NFPA 70, (5) All electrical work in industrial occupancies - J.I.C. standards, (6) All electrical components and materials - U.L. listing required.

I. Where scheduled on the drawings, provide disconnect switches and contactors. Disconnect switches shall be fusible type or circuit breaker type.

2.4 REQUIREMENTS FOR HVAC EQUIPMENT 3/4 H.P. OR LESS

A. This section describes requirements for small mechanical equipment such as (but not limited to) package terminal heating/cooling units, VAV boxes, unit heaters, unit ventilators, exhaust fans, fans, fan coil units, cabinet heaters, DDC temperature control panels, etc.

B. Small equipment with motor(s) of 3/4 H.P., single phase or less are generally not required to be furnished with starter(s), unless otherwise noted. For such equipment, provide integral contactor or horsepower-rated relay where controlled by thermostat or other type of switch. Contactors or relays shall be as recommended by the manufacturer of the equipment.

C. Provide transformer within unit as required to provide low voltage A.C. for thermostat control.

D. Provide internal fusing for unit motor and other loads in fuse block or in-line fuseholder.

E. Where externally mounted disconnecting means is required and would be impractical, unsightly or inappropriate in the judgment of the Engineer, disconnects shall be located within the unit. These disconnects may be fusible H.P.-rated snap switches or manual starters with overload elements, as required. Locate this and other electrical equipment within enclosure where easily accessible behind access panel or door on unit, and as acceptable to the electrical inspector or local authority having jurisdiction.

PART 3 – EXECUTION: (NOT APPLICABLE)

END OF SECTION 230513

SECTION 230517 – SLEEVING AND SLEEVE SEALS FOR HVAC PIPING

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

1.2 SCOPE

A. The Contractor shall be responsible for all openings, sleeves, trenches, etc., that may be required in floors, roofs, ceilings, walls, etc., and shall coordinate all such work with the General Contractor and all other trades. Coordinate with the General Contractor, any openings which they are to provide before submitting a bid proposal in order to avoid conflict and disagreement during construction. Improperly located openings shall be reworked at the expense of the Contractor.

B. All work improperly performed or not performed as required in this section, shall be corrected by the General Contractor at the responsible Contractor’s expense.

PART 2 – PRODUCTS:

2.1 SLEEVES

A. Cast iron or Schedule 40 steel sleeves shall be installed through all walls where pipe enters the building below grade. Sleeves shall be flush with each face of the wall and shall be sufficiently larger than the entering pipe to permit thorough caulking between pipe and sleeve for water proofing. Horizontal sleeves passing through exterior walls or where there is a possibility of water leakage and damage shall be caulked watertight. Utilize “Link-Seal” at these locations.

B. In all cases, sleeves shall be at least two pipe sizes larger than nominal pipe diameter plus insulation. Sleeves through walls and floors shall be cut off flush with inside surface unless otherwise indicated.

C. Vertical sleeves in roofs shall be flashed and counterflashed with lead (4 lb.) or 16 oz. copper and welded or soldered to piping, lapped over sleeve and properly weather sealed. Where sleeves pass through roof construction, sleeves shall extend minimum of 12" above the roof.

2.2 FIRESTOPPING

A. Firestopping materials include (but are not limited to) wraps, strips, caulks, moldable putties, restricting collars with steel hose clamps, damming materials, composite sheets, fire dam caulks, steel sleeves, etc.

B. The following indicates the 3M penetration details for uninsulated pipe penetration of various wall and floor construction types (the list is not inclusive):
   1. One, two or three hour fire rated concrete floor - 3M #5300-MPC8.
   2. One, two or three hour fire rated solid or block concrete wall - 3M #5300-MPC16 or 3M #5300-MPC26.
   3. One hour fire rated gypsum wallboard - 3M #5300-MPC7.
   4. Two hour fire rated gypsum wallboard - 3M #5300-MPC7.

C. The following indicates the 3M penetration details for insulated pipe penetrations of various wall and floor construction types (the list is not inclusive):
   1. One, two and three hour fire rated concrete floor - 3M #5300-IMP2.
   2. One, two and three hour concrete block wall - 3M #5300-IMP2.

3. One hour fire rated gypsum wallboard - 3M #5300-IMP4.
4. Two hour fire rated gypsum wallboard - 3M #IMP7.

D. HVAC ducts penetrating a one or two hour fire rated wall or floor shall be firestopped per 3M #5300-HVD1.

PART 3 – EXECUTION:

3.1 The Contractor shall plan their work ahead and shall place sleeves, frames or forms through all walls, floors and ceilings during the initial construction, where it is necessary for piping, ductwork, conduit, etc., to route through; however, when this is not coordinated, the Contractor shall then do all cutting and patching required for the installation of their work, or pay other trades for doing this work when so directed by the Engineer. Any damage caused to the building by this Contractor shall be corrected or rectified at their expense.

3.2 The Contractor shall notify other trades in due time where they will require openings or chases in new concrete, masonry, etc. Set all concrete inserts and sleeves for their work. Failing to coordinate, Contractor shall cut openings for the work and patch same as required at their expense with qualified tradesman.

3.3 The Contractor shall be responsible for properly shoring, bracing, supporting, etc., any existing and/or new construction to guard against cracking, settling, collapsing, displacing, or weakening while openings are being made. Any damage occurring to the existing and/or new structures, due to failure to exercise proper precautions or due to action of the elements shall be promptly and properly corrected to the satisfaction of the Engineer.

3.4 CUTTING

A. All openings in plaster, gypsum board or similar materials, shall be framed by means of plaster frames, casing beads, or angle members as required. The intent of this requirement is to provide smooth, even termination of wall, floor and ceiling finishes as well as to provide a fastening means for devices, etc.

B. The Mechanical Contractor shall coordinate all openings in masonry walls with the General Contractor; and, unless otherwise indicated in the Contract Documents, shall provide lintels for all openings required for the mechanical work such as louvers, exhaust fans, etc. Prime paint all lintels. Lintels shall be sized as follows:

C. New Openings under 48" in width: Provide one 3½"x3½"x3/8" steel angle for each 4" of masonry width. Lintel shall have 8" bearing on each end.

D. New Openings over 48" in width: Consult with Structural Engineer.

E. No cutting shall be performed at location that will weaken the structure and unnecessary cutting must be avoided. If in doubt, contact the Engineer.

F. Pipe openings in slabs and walls shall be cut with core drill. Hammer devices will not be permitted. Edges of trenches and large openings shall be scribe-cut with a masonry saw.

3.5 PATCHING, REPAIRING AND FINISHING

A. Patching and repairing made necessary by work performed under this Division shall be included as a part of the work and shall be done by skilled workers of the trade. The work shall be performed in strict accordance with the provisions herein before specified to match adjacent surfaces and in a manner acceptable to the Engineer.

B. Where portions of existing sites, lawns, shrubs, paving, etc. are disturbed for installation of work of this Division, such items shall be repaired and/or replaced back to original or better condition to the satisfaction of the Engineer.

C. Piping and ductwork passing through floors, ceilings and walls in finished areas shall be fitted with chrome plated brass escutcheon trim pieces of sufficient outside diameter to amply cover the sleeved openings and an inside diameter to closely fit the pipe/duct around which it is installed.

D. Flanged metal collars shall be provided around all ducts, flues, pipes, etc. at all wall penetrations, both sides. Penetrations through any wall will require the installation of flanged collars. Openings shall not be any larger than 2" in any direction than the piping/duct passing through the wall. Openings larger than this requirement shall also be infilled to match adjacent construction. Fill void with insulation for sound reduction.

3.6 FIRESTOPPING

A. Provide shop drawings indicating penetration detail for each type of wall and floor construction. Shop drawings must be specific for each individual type of penetration (one hour fire rated gypsum wall board with insulated metal pipe penetration, etc.) Provide copies to the authority having jurisdiction if required.

B. All mechanical pipes and ducts penetrating fire rated floors and walls shall be firestopped by this Contractor. All firestopping products and assemblies installed shall be UL listed.

C. Where the installation of conduit, ducts, piping, etc. requires the penetration of fire or smoke rated walls, ceilings or floors, the space around such conduit, duct, pipe, etc., shall be tightly filled with an approved non-combustible fire insulating material and properly sealed to maintain the rating integrity of the wall, floor or ceilings affected.

D. Where the installation of ductwork requires the penetration of non-rated floors, the space around the duct or pipe shall be tightly filled with an approved non-combustible material.

E. The manufacturer of the firestopping materials shall provide on site training for the installing Contractor. The training session shall demonstrate to the Contractor the proper installation techniques for all the firestopping materials.

F. Multiple pipes penetrating fire rated floors and walls may be firestopped as a group. Submit details for specific applications if this method of firestopping is chosen.

END OF SECTION 230517

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SECTION 230519 – METERS AND GAGES FOR HVAC PIPING

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. Each Contractor's attention is also directed to Specification Section SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC, and provide all documentation called for therein.

1.2 SCOPE

A. The Contractor shall include all meters, thermometers, pressure gauges and/or compound gauges at the locations indicated. All pressure gauges and/or compound gauges shall be provided with ¼ turn ball valves to allow the gauge to be removed and replaced without shutting down system.

PART 2 – PRODUCTS:

2.1 THERMOMETERS AND PRESSURE GAUGES:

A. TEMPERATURE SENSOR AND TRANSMITTER FOR METERING APPLICATIONS (Chilled Water,): **Rosemount 214C Temperature Sensor** RTD thin-film PT100=0.00385, -50 to 450C with Sensor Sheath Material 321 SST with Class B sensor accuracy per IEC 60751. Include 4-wire sensor configuration with English Units. Coordinate sensor insertion length with manufacturer based on pipe diameter. Spring loaded adapter for sensor mounting style and US Explosion Proof product certification. Process ready assembly of sensor and thermowell. Calibration Certification with A, B, C and Calendar-Van Dusen constants, 0 deg c to 100 deg C. **Rosemount 3144P Temperature Transmitter**. Field mounted dual compartment aluminum housing with 4-20mAwith digital signal based on HART protocol. The sensor trim has transmitter-sensor matching – Trim to PT100 RTD Calibration schedule. Dual-Input Pre-configuration PV set to differential temperature. Utilize the dual sensor measurement configuration with LCD display and 5-point calibration with calibration certification. **Rosemount 114C Thermowell**, threaded with tapered stem and process connection ¾-14 ANPT. Include process ready assembly of a sensor and thermowell. Material 316/ 316L Dual Rated. Coordinate head length with manufacturer and owner.

B. Gauges and thermometers shall be Miljoco, Marsh, Trerice, or Weksler.

C. Digital thermometers shall be solar powered industrial thermometer. The range shall be -50°F/300°F with an accuracy of 1% or 1°, whichever is greater. The display shall be a 3/8" LCD digit. Use where specifically indicated on the drawings.

D. Water thermometers shall be blue-reading spirit liquid-in-glass type with 9" scale, powder coated cast aluminum case and stem socket of length as required by system. Accuracy to be plus or minus 1 scale division. Lens to be plastic. Hot water thermometer shall have a 30°F to 240°F range and chilled water thermometer shall have a 0°F to 120°F range.

E. Pressure gauges shall be Bourdon Type, circular, 4-1/2" face, black letters on white face graduated in 2 PSI or less and shall be manufactured for service intended. Provide with pig tail connectors and gauge cocks. Accuracy to be plus or minus 1%. Water pressure gauges shall have 0 to 100 PSI range.

2.2 METERS

A. CHILLED WATER FLOW METER: **Rosemount 8705** Process Sensor with factory mounted integral 8732 transmitter. Polyurethane Lining, 316L Stainless Steel electrode material with 2 measurement electrodes. Includes flanged connections, slip on, raised-face carbon steel with flange rating of ASMEB16.5, Class 150. Coil housing sealed welded housing with field replaceable terminal block/ Socket Module. The **8732E Magnetic Flow Meter Transmitter** shall have transmitter class Rev 4 Electronics with AC Power supply (90 to 250VAC, 50-60Hz). Outputs to the control system of 4-20mA, Digital HART and Scalable Pulse with ½"-14 NPT conduit entry. Safety Approvals from FM Class 1 Div 2 for flammable and non-flammable fluids. Advanced diagnostics Suite 1 (process diagnostics) and Suite 2 (Smart Meter). Local operator interface display option. Install flow meter with sufficient pipe diameters as recommended by manufacturer. Provide factory authorized start-up verification of operation and calibration. Include high accuracy calibration option with base reference accuracy of 0.15% and calibration certificate per ISO 10474.3.1B/ EN 10204 3.1.

B. HOT WATER METER: **Yokogawa Magnetic Meter AXF___C-E1AL1L-BA11-21B/FF1**, Rosemount or Krohne equal, Magnetic Flow Meter, Integral digital indicator w/ HART 5/7 protocol, 4-20mA output, 150 lb. ANSI Flanged, 120V power, SS316L electrode material and grounding ring, PFA lining, FM Explosion Proof hazardous area certification. Install flow meter with sufficient pipe diameters as recommended by manufacturer. Provide factory authorized start-up verification of operation and calibration.

C. SYSTEM FILL WATER FLOW METER: **Onicon Model F-1330/F-1130** series dual turbine insertion flow meter suitable for potable water applications. 50:1 turn down with 2% accuracy with 0.4 to 20 fps range. Install flow meter with sufficient pipe diameters as recommended by manufacturer. Provide factory authorized start-up verification of operation and calibration. Provide with remote display where indicated.

PART 3 – EXECUTION:

3.1 INSTALLATION

A. All thermometers, meters and pressure gauges shall be readable from a standing position on the floor. Mount thermometers in approved wells. Do not make direct contact of base with fluid in pipe. Pressure gauges and thermometers subject to vibration shall be mounted remotely away from vibrating pipe surface, etc. with flexible tubing.

B. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.

C. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

D. Install thermowells with extension on insulated piping.

E. Fill thermowells with heat-transfer medium.

F. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

G. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.

H. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.

I. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

J. Install remote-mounted pressure gages on panel.

K. Install valve and snubber in piping for each pressure gage for fluids (except steam).

L. Install valve and syphon fitting in piping for each pressure gage for steam.

M. Install test plugs in piping tees.

N. Install flow indicators in piping systems in accessible positions for easy viewing.

O. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.

P. Install flowmeter elements in accessible positions in piping systems.

Q. Install flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.

R. Install permanent indicators on walls or brackets in accessible and readable positions.

S. Install connection fittings in accessible locations for attachment to portable indicators.

T. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.

U. Install thermometers in the following locations:

V. Install test plugs in the following locations:

3.2 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

B. Connect flowmeter-system elements to meters.

C. Connect flowmeter transmitters to meters.

3.3 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

B. Adjust faces of meters and gages to proper angle for best visibility.

END OF SECTION 230519

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SECTION 230523 – GENERAL DUTY VALVES FOR HVAC PIPING

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. Review the Specification Section – REQUIRED SHOP DRAWINGS, ETC., and provide all documentations called for therein.

1.2 SCOPE

A. Each Contractor shall provide all valves required to control, maintain, and direct flow of all fluid systems indicated or specified. This shall include but may not be limited to all valves of all types including balancing valves, air vents, drain valves, check valves, special valves for special systems, etc., for all Mechanical Systems.

B. ACCEPTABLE MANUFACTURERS: Lunkenheimer, Powell, Nibco, Crane, Jenkins, T & S Brass, Walworth, Milwaukee, DeZurik, Consolidated Valve Industries, Inc., Bell & Gossett, Apollo.

C. The following type valves shall not be acceptable: Zinc, plastic, fiber or non-metallic.

D. Each type of valve shall be of one manufacturer, i.e., ball valves, one manufacturer, butterfly valves, one manufacturer, check valves, one manufacturer, etc.

E. All valves shall comply with current Federal, State and Local Codes. All valves shall be new and of first quality. All valves shall be designed and rated for the service to which they are applied. Zinc, plastic, fiber, or non-metallic valves shall not be acceptable.

F. Contractor shall provide colored tape on ceiling tile where valves are located above ceiling. Provide access panels where valves are located above hard ceiling.

PART 2 – PRODUCTS:

2.1 HVAC APPLICATIONS:

A. GATE VALVE (2" AND UNDER): Use ball valves as specified.

B. GATE VALVE (2" AND SMALLER): Gate valve shall have bronze body, union bonnet, non-rising stem solid wedge and handwheel. Gate valve shall be rated for 200 psi working pressure. Gate valve shall be Nibco T-136 for threaded ends and Nibco S-136 for solder ends.

C. GATE VALVE (2½" AND LARGER): Gate valve shall have cast iron body with cast iron bolted bonnet, non-rising stem, solid cast iron wedge and handwheel. Gate valve shall be rated for 200 psi working pressure. Gate valve shall be Nibco F-619 for flanged ends and Nibco T-619 for threaded ends. Threaded end valve allowed for sizes 3" or less only.

D. OS&Y GATE VALVES: OS&Y gate valve shall have cast iron body with cast iron bolted bonnet, bronze rising stem, solid cast iron wedge and handwheel. From viewing stem, valve position shall be capable of being determined. Valve shall be rated for 200 psi service. OS&Y gate valve shall be Nibco F-617-0 with flanged ends.

E. GLOBE VALVE (2" AND UNDER): Globe valve shall have bronze body, bonnet, and disc holder. Globe valve shall have union bonnet, integral seat, teflon or stainless steel renewable disc and be rated for 200 psi working pressure. Globe valve shall be Nibco T-235 for threaded ends or Nibco S-235 for solder ends.

F. GLOBE VALVES (2½" AND OVER): Globe valve shall have cast iron body, bolted bonnet, bronze disc, renewable seat and have outside screw and yoke. Handwheel to be cast iron. Globe vale to be rated for 200 psi working pressure. Globe valve shall be Nibco F-718 for flanged ends of Nibco T-718 for threaded ends. Threaded ends valve allowed for sizes 3" and less only.

G. CHECK VALVES (2" AND LESS): Check valve shall have bronze body, disc, and hinge. Check valve shall be Y-pattern type horizontal swing, renewable disc and rated for 200 psi working pressure. Check valve shall be Nibco T-413 for threaded ends or Nibco S-413 for solder ends.

H. CHECK VALVES (2½" AND LARGER): Check valve shall have cast iron body and cast iron bolted bonnet the disc and seat ring shall be bronze. Check valve shall be horizontal swing with renewable seat and disc. Valve shall be rated for 200 psi working pressure. Check valve shall be Nibco F-918 for flanged ends and Nibco T-918 for threaded ends. Threaded ends valve allowed for sizes 3" and less only. Victaulic 716/W716 are acceptable with grooved piping systems.

I. THREE PIECE BALL VALVES (2" AND UNDER): Ball valve shall have bronze body, ball and reinforced, watertight seat. Valve shall be three piece, swing-out, construction to facilitate inspections and repair. Valve shall be "full port" type. Valve handle shall only require quarter turn to go from full open to full close. The handle shall be removable with vinyl grip. Valve shall be rated for 250 degrees F water temperature and 200 psi working pressure. Ball valve shall be Nibco T-595 for threaded ends and Nibco S-595 for solder ends. Provide extended handles for all ball valves installed in a chilled water system or dual temperature hot/chilled water system.

J. BALL VALVES (2½"-3"): Ball valve shall have bronze body, ball, and reinforced, watertight seat. Valve handle shall only require quarter turn to go from full open to full close. The handle shall be removable with vinyl grip. Valve shall be rated for 250 degrees F water temperature and 200 psi working pressure. Ball valve shall be Nibco T-580 for threaded ends and Nibco S-580 for solder ends. Provide extended handles for all ball valves installed in chilled water piping systems.

K. BALL VALVE (2-1/2" TO 6"): Ball valve shall have a cast iron body, with Teflon fused solid ball, blow-out proof stainless steel stem, and reinforced Teflon seats. Valve shall be "full port" type and the handle shall only require a quarter turn to go from full open to full close. The handle shall be removable with a vinyl grip. Valve shall be rated for a 200 psi working pressure and 350°F temperature. Ball valve shall be American Model 4000 or approved equal. Valves installed in chilled or dual temperature hydronic systems shall be insulated up to the handle to eliminate condensation. Extend the handle as required.

L. BUTTERFLY VALVE (4" AND LARGER): Valve to be rated for 285 psi working and have positive shut-off equal to Nibco G1L-C55R. Butterfly valve shall have carbon steel body with stainless steel disc and stem. Valve to have extended neck to allow for insulation and be "lug" type configuration. Interior liner shall be made of EPDM. Provide manual gear operator and on valves mounted higher than 7 ft, mechanical rooms, provide chain wheels and chains. Victaulic Vic-300/W761 rated to 300 PSI is an acceptable alternate when used in conjunction with grooved piping system. Valve shall be bidirectional, incorporate offset disc and have a 360 degree bubble-tight seal rated for dead end service. Gasket shall be grade "EHP" EPDM rated for 250 deg F and have extended neck for insulation. Provide stainless steel disc and trim.

M. STRAINERS (2" AND UNDER): Watts 77S Series "Y" type strainer with cast iron body and threaded ends. Screen shall be 20 mesh stainless steel. Strainer shall be provided with cleanout plug and be rated for 200 psi working pressure.

N. STRAINERS (2½" AND LARGER): Watts 77F Series "Y" type strainer with semi-steel body and flanged ends. Screen shall be 20 mesh stainless steel. Strainer shall be provided with bolted cleanout and be rated for 200 psi working pressure.

O. BALANCING VALVE (4" AND LESS): Balancing valve shall have bronze or cast iron body. Valves to have differential pressure readout ports across valve seat area with integral check valves. Valve shall be equipped with memory stop. Valves to have threaded ends for sizes 3" and less, flanged ends for larger sizes. Valve to be provided with performed molded insulation casing. Design working pressure and temperature to be 200 psi at 250 degrees F balancing valve shall be similar to Bell & Gossett Model CB. Provide with balancing valves, one (1) water gpm readout kit to be turned over to Owner which shall include a differential pressure meter with full scale overrange protection, hoses, readout probes, filters, carry and calculator.

P. TRIPLE DUTY VALVE: Triple duty valve shall be straight pattern type with flange ends and be constructed of cast iron. Valve to be designed to perform as a non-slam check valve, calibrated balancing valve and shut-off valve. Valve to be provided with two (2) brass readout ports with integral check valve to obtain flow measurement. Triple duty valve shall be rated for 175 psi working pressure and 250 degrees F. Valve to be similar to Bell & Gossett Model 3DS. Locate a triple duty valve at the discharge of each base mounted pump per the manufacturer's recommendations.

Q. FLEXIBLE CONNECTION: Pumpsaver SMP or equal braided stainless steel pump connector(s). Construction to be of annular corrugated stainless steel close-pitch hose with stainless steel overbraid. The corrugated metal hose, braid(s), and a stainless steel ring-ferrule/band (material gauge not less than .048") must be integrally seal-welded using a 100% circumferential, full-penetration TIG weld. End fittings shall be flat-face plate steel flanges with 150# ANSI drilling and outside diameter. Fittings must be attached using a 100% circumferential TIG weld. Braided stainless steel pump connector(s) must be suitable for operating temperatures up to 850 degrees F. The rated working pressure of the braided metal hose must have a minimum 4:1 safety factor. Each braided stainless steel pump connector shall be individually leak tested by the manufacturer using air-under-water or hydrostatic pressure. Flanged pump connectors shall be prepared for shipment using cut-to-length spacers, securely positioned between the flanges to prevent axial compression damage and maintain the manufactured length. Spacers must be removed prior to system start up.

R. AUTOMATIC AIR VENT: Bell & Gossett Model 107A high-capacity float actuated automatic air vent with cast iron body and bonnet. Vent to be rated for 150 psi working pressure and 240 degrees F working temperature. Pipe discharge to nearest floor drain unless noted otherwise.

S. MANUAL AIR VENT: Bell & Gossett Model 78 manual air vent with cast brass body and built-in check valve. Vent to be rated for 150 psi working pressure and 240 degrees F working temperature. Install with 12" length of 1/4" soft copper discharge piping unless noted otherwise.

PART 3 – EXECUTION:

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install chainwheels on operators for butterfly and gate valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

F. Install check valves for proper direction of flow

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

END OF SECTION 230523

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractor directed to Specification Section HYDRONIC PIPING.

C. The Contractor directed to Specification Section HVAC PIPING INSULATION.

D. The Contractor directed to Specification Section REFRIGERANT PIPING.

1.2 SCOPE

A. This section includes, but is not limited to, furnishing, and installing supports, anchors, and accessories for piping, ductwork, equipment, etc. Furnishing and installing shall be by each trade for the completion of their work as directed in this Section.

PART 2 – PRODUCTS:

2.1 HANGERS, CLAMPS, ATTACHMENTS SCHEDULE:

A. ACCEPTABLE MANUFACTURERS: Grinnell, Elcen, Fee & Mason.
B. All hangers, clamps and attachments shall be manufactured products.
C. Pipe Rings (2” pipe and smaller) – adjustable swivel split ring or split pipe ring.
D. Pipe Clevis (2.5” pipe and larger) – adjustable wrought clevis type.
E. Pipe Clevis (All pipe sizes) – steel clevis for insulated pipe.
F. Riser Clamps (All pipe sizes) – extension pipe or riser clamp.
G. Beam Clamps (All pipe sizes) – malleable beam clamp with extension piece.
H. Brackets (All pipe sizes) – medium weight steel brackets.
I. Concrete Inserts (All pipe sizes) – wrought or wedge type inserts.
J. Concrete Fasteners (All pipe sizes) – self-drilling concrete inserts.
K. Rod Attachments (All pipe sizes) – extension piece, rod coupling, forged steel turnbuckle
L. U-bolts (All pipe sizes) – standard u-bolt.
M. Welded Pipe Saddles (All pipe sizes) – pipe covering protection saddle sized for thickness of insulation.
N. Pipe Roll (All pipe sizes) – adjustable swivel pipe roll.
O. Protection Saddle (All pipe sizes) – 180 degree coverage, sheet metal pipe protection saddle.
P. Hanger Rods (All pipe sizes) – Steel, diameter of hanger threading.
Q. Concrete Channel Inserts (All pipe sizes) – continuous heavy duty slot inserts unistrut.
R. Adjustable Spot Inserts (All pipe sizes) – continuous heavy duty spot insert unistrut.
S. Miscellaneous steel such as steel angles, rods, bars, channels, etc used in framing for supports, fabricated brackets, anchors, etc. shall confirm to ASTM-A-7.

PART 3 – EXECUTION:

3.1 Supporting and hanging shall be done so that excessive load will not be placed on any one hanger so as to allow for proper pitch and expansion of piping.

3.2 Hangers and supports shall be placed as near as possible to joints, turns, and branches.

3.3 For concrete construction, utilize adjustable concrete inserts for fasteners. Expansion anchors and power driven devices may be used when approved in writing by the Architect/Engineer.

3.4 Utilize beam clamps for fastening to steel joists and beams. Expansion anchors in masonry construction. Do not support piping or ductwork from bridging or metal decking.

3.5 When piping is routed in joists, piping shall be top mounted on trapeze type hangers with each pipe individually clamped to trapeze hanger. Do not support piping or ductwork from bridging angles.

3.6 Trapeze hangers are not allowed, unless specifically approved by the Engineer.

3.7 Install all miscellaneous steel other than designed building structural members as required to provide means of securing hangers, supports, etc., where piping does not pass directly below or cross structural elements.

3.8 Piping shall not be supported by the equipment to which it is connected. Support all piping so as to remove any load or stress from the equipment.

3.9 Where piping, etc., is routed vertically, approved riser clamps, brackets or other means shall be utilized at approximately 10'-0" center to center minimum. An approved adjustable base stand or fitting on concrete support base shall be utilized at the base of the vertical run.

3.10 Where piping is routed along walls, knee braced angle frames, etc. pipe brackets with saddles, clamps, and rollers mounted on structural brackets fastened to walls or columns shall be used.

3.11 Support all ceiling hung equipment with approved vibration isolators.

3.12 Where copper tubing is specified, hangers shall be of copper clad type when piping is uninsulated.

3.13 Uninsulated piping hung from above shall be supported with ring and clevis type pipe hangers. Uninsulated piping mounted on trapeze (when allowed) and wall bracket type support shall be held in place with U-bolts. U-bolts shall allow for axial movement in the piping.

3.14 All insulated piping shall be supported with clevis type and pipe roll hangers. Hangers shall be sized to allow the pipe insulation to pass through the hangers. Install insulation protection saddles at all hanger locations. Welded pipe saddles shall be installed at all hangers on piping 5" and larger. The pipe saddles shall be sized for the thickness of insulation used. Hangers shall fit snugly around outside of insulation saddles.

3.15 Under no conditions will perforated band iron or steel wire driven hangers be permitted.

3.16 Support steel and copper piping at a minimum of eight (8) foot intervals for piping 3" and smaller and ten (10) foot intervals for larger piping. Provide additional support at end of the branches and change of direction.

3.17 Support plastic pipe at intervals not to exceed four (4) feet and at the end of the branches and at the change of direction and shall be installed as to permit freedom of movement. Vertical piping shall be supported at their bases and all upward movement shall not be restricted. Hangers shall be at least one (1) inch wide and shall not compress, distort, cut, or abrade the piping to allow free movement at all times.

3.18 Where fireproofing is dislodged/damaged from the building structure due to Contractor’s installation of hangers, clamps, etc., it shall be the Contractor’s responsibility to repair all dislodged/damaged fireproofing to original fireproofing rating. This shall also include all work performed by their contractors’ sub-contractors.

3.19 Ensure that all bolts and nuts are tightened.

END OF SECTION 230529

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SECTION 230533 – HEAT TRACING FOR HVAC PIPING

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractor directed to Specification Section HYDRONIC PIPING.

C. The Contractor directed to Specification Section HVAC PIPING INSULATION.

D. The Contractor directed to Specification Section UNDERGROUND HVAC PIPING.

1.2 SCOPE

A. This section includes, but is not limited to, furnishing, and installing supports, anchors, and accessories for piping, ductwork, equipment, etc. Furnishing and installing shall be by each trade for the completion of their work as directed in this Section.

PART 2 – PRODUCTS:

2.1 ACCEPTABLE MANUFACTURERS: Chromalox, Tyco, Thermon, Heat Trace Products.

2.2 Provide complete heat-tracing system with ambient air sensing thermostat. The heat tape shall have a cross-linked polymer core with copper bus wire so that the heater output increases as the jacket temperature drops. Heat output shall be 5.0 watts per foot at 50 degrees F surface temperature. The heat tape shall be installed as recommended by the manufacturer along the entire length of all exterior piping subject to freezing and where indicated on the drawings. All valves shall be wrapped additionally two (2) feet of heat tape. Provide one complete tracing on each pipe, fitting, etc with power supplied from electrical circuits. Heat tape electrical characteristics shall be as indicated on the electrical plans. Provide with power connection kits and end caps. Heat tape shall be placed in operation at the electrical circuit breaker. Heat trace shall activate when the outside air temperature is less than 40 deg F.

2.3 Provide heat trace with control panel with integral 30 mA GFPE protection as required per NEC 426/427. Provide with input voltage as indicated on electrical drawings. Provide in NEMA-3R enclosure outdoors and NEMA-1 enclosure indoors. Panel shall be Delta-Therm #GFPE-4-277-30-4X Series or equal. Heat trace to be 277V/ 1 Phase.

PART 3 – EXECUTION:

3.1 Install heat trace after piping has been tested but before insulation is installed or the piping is concealed in any way.

3.2 Each subcontractor shall be responsible for their own completion of System Verification Checklists/Manufacturer’s Checklists. Factory startup is required for all HVAC equipment. In general, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians and shall complete and submit start-up reports/checklists.

3.3 Ensure that the equipment that is proposed to be furnish may be installed, connected, placed in operation, and easily maintained at the location and in the space allocated for it.

3.4 EQUIPMENT START-UP: Prior to utilization of equipment, start-up service shall be performed by factory authorized representative. Utilize startup sheets included in the Specification Section COMMON WORK RESULTS FOR HVAC. Refer to Specification Section COMMON WORK RESULTS FOR HVAC for additional requirements.

3.4.1 The system shall be inspected, tested, and start-up performed before insulation is installed or the piping is concealed in any way.

3.5 Install heat trace in accordance with manufacturer's instructions and according to IEEE 515.1.

3.6 Install heat trace in accordance with the Electrical Specifications and in accordance with NFPA 70.

END OF SECTION 230533

SECTION 230553 – IDENTIFICATIONS FOR HVAC PIPING AND EQUIPMENT

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

PART 2 – PRODUCTS:

2.1 Provide and install on each valve 1” in size or greater for all mechanical systems a 1.5" diameter circular bronze or baked phenolic tag fitted to each valve so that it cannot be removed. Each tag shall be embossed consecutively with sequential number identifiers. Number identifiers shall be determined by the Contractor sequentially.

2.2 Provide typewritten valve charts indicating each valve identifier, the valves service, normal position, and its location. Also furnish one electronic copy on CD in “*.xls” format. One (1) copy of this chart shall be mounted in suitable frame(s) with clear plastic covers in a conspicuous location in each of the major mechanical rooms. Repeat only main valves which are to be operated in conjunction with operations of more than single mechanical room.

2.3 All emergency shutoff valves shall be identified with a permanent engraved tag hung from the valve with 1-inch high lettering. Emergency shutoff valves shall be identified as any valve whose closure could create an emergency condition in the facility (i.e. main HVAC valves, etc.).

2.4 Label all control panels and disconnect switches with service and equipment served.

PART 3 – EXECUTION:

3.1 PIPING AND DUCTWORK IDENTIFICATION:

A. All piping and ductwork installed shall be identified according to the charts hereinafter specified. Provide stenciled markers and arrows indicating direction of flow on all piping and ductwork installed under this contract. Markers and arrows shall be painted on the piping and ductwork using machine cut stencils. All letters shall be sprayed using fast drying lacquer paint. All markers and arrows shall be properly oriented so that descriptive name may be easily read from the floor. Piping and ductwork shall be identified on twelve (12) foot centers. All piping and ductwork shall be minimally identified once above all room ceilings and where it passes thru walls or floors. At the Contractor's option, Setmark or equivalent manufactured marking system may be substituted for field marking.

B. The following table describes the size of the color field and size of the identification letters which shall be used for pipes of different outside pipe diameters.

Outside Diameter	Label Length	Letter Size
¾” – 1 ¼”	8”	½”
1 ½” – 2”	8”	¾”
2 ½” – 6”	12”	1 ¼”
8” – 10”	24”	2 ½”
Over 10”	24”	3 ½”

C. The following chart describes the pipe service and label identification which shall be used for various pipes.

PIPE	ABBREVIATION
Chilled Water Supply	C.H.W.S.
Chilled Water Return	C.H.W.R.
Hot Water Supply	H.W.S.
Hot Water Return	H.W.R.
Refrigerant Piping	R.F.

3.2 EQUIPMENT IDENTIFICATION

A. Unless otherwise specified, all equipment shall be identified. The titles shall be short and concise, and abbreviations may be used as long as the meaning is clear. In finished rooms and mechanical rooms, equipment shall be identified neatly and conspicuously with engraved black lamacoid plates (or equivalent) with 1" high white letters on the front of each piece of equipment.

B. All mechanical equipment and associated starters/disconnects shall have the electrical panel number and circuit number identified on a lamacoid plate. Coordinate with the Electrical Contractor.

3.3 DUCTWORK:

A. All ductwork shall be identified as to the service of the duct and direction of flow. Include equipment designator on SA & RA ductwork. The letters shall be at least two inches high, and the flow arrow shall be at least six inches long. The letters and flow arrow shall be made by precut stencils and black oil base paint with aerosol can. Concealed ducts also need to be identified.

B.

DUCTWORK	ABBREVIATION
Supply Air Ductwork	SA + Equipment Identifier
Return Air Ductwork	RA + Equipment Identifier
Exhaust Air Ductwork	EA + Equipment Identifier
Outside Air Ductwork	OA + Equipment Identifier

3.4 ACCESS THROUGH LAY-IN CEILINGS: Mark each lay-in ceiling panel which is nearest access to equipment, valves, dampers, filters, duct heaters, etc., with colored tape labels located on the ceiling grid.

END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractor’s attention is directed to Specification Section SHOP DRAWING HVAC.

C. The Contractor’s attention is directed to Specification Section FACILITY MONITORING SYSTEM.

1.2 SCOPE

A. The Engineer, or authorized representative, shall be notified by the Contractor twenty-four (24) hours in advance of any tests called for in these Specifications or required by others.

B. Only after written approval, signed by the Engineer, shall the Contractor apply insulation or paint or allow the work to be furred in. This written approval, however, does not relieve the Contractor of the responsibilities for any failure during the guarantee period. The expense of all tests shall be borne by the Contractor, along with all temporary equipment, materials, gauges, etc. required for tests.

C. The test and balance of this system shall be by a Contractor who employs only the services of a certified AABC or independent NEBB firm whose sole business is to perform test and balance services.

D. The test and balance contractor shall bid directly to the HVAC Contractor or Construction Manager or Owner.

E. For the purpose of placing the Heating, Ventilating and Air Conditioning systems in operation according to design conditions and certifying same, final testing and balancing shall be performed in complete accordance with AABC Standards for Total System Balance, Volume Six (2002), for air and hydronic systems as published by the Associated Air Balance Council.

F. The Test and Balance Contractor shall provide a Test and Balance Plan and Schedule according to AABC guidelines. Submit for review by the Owner, Engineer, and Commissioning Agent as applicable.

G. Instruments used for testing and balancing of air and hydronic systems shall have been calibrated within a period of six months prior to balancing. All final test analysis reports shall include a letter of certification listing instrumentation used and last date of calibration.

PART 2 – PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.1 THE FOLLOWING SYSTEMS SHALL BE TESTED AND BALANCED:

A. The supply, return and outside air duct systems associated with all AHUs. Provide static pressure profiles thru each system. Static pressure profiles shall include all sections from the return duct inlet and supply duct outlet of the air handling unit. Show accurate representation of return, relief, outdoor and economizer damper locations. On units equipped with return air fans; show location and profile of the return fan.

B. Verify that the temperature control systems supply and return VFD's on all VAV AHUs are calibrated to maintain the minimum OA setting. Test at 50%, 60%, 70%, 80%, 90% and 100% flow rated.

C. Measure and verify the minimum outside air flow at the minimum OA damper. Measure the resulting differential pressure across the damper and record it on the placard located on the unit.

D. Each AHU shall have supply and return duct air leakage testing per Specification Section SHEET METAL.

E. Each EF shall have exhaust duct air leakage testing per Specification Section SHEET METAL.

F. Verify calibrations of the duct static pressure sensors for all VAV AHUs.

G. The chilled water pumps and chilled water coils.

H. The hot water pumps and hot water coils.

I. Set the minimum and maximum air flow rates for each VAV box.

J. Balance all supply, return and exhaust air grille to within 10% of design air flow rate.

K. Balance all exhaust air fans and record inlet static pressure.

L. Balance the kitchen rangehood exhaust air system.

3.2 Three (3) copies of the complete test reports shall be submitted to the Consulting Engineer prior to final acceptance of the project. Preliminary test reports shall be submitted when requested.

3.3 HVAC Contractor shall provide all start-up documents to Test and Balance Contractor prior to any test and balance services.

3.4 The HVAC Contractor shall test all piping before being insulated or concealed in any manner. Where leaks or defects develop, required corrections shall be made and tests repeated until systems are proven satisfactory. Water piping systems shall be subjected to a hydrostatic test as specified and shall be proven tight after a twenty-four (24) hour test.

3.5 All motors, bearings, etc. shall be checked and lubricated as required during start-up procedures. All automatic, pressure regulating, and control valves shall be adjusted. Excessive noise or vibration shall be eliminated.

3.6 System balancing, where required, shall be performed only by persons skilled in this work. The system shall be balanced as often as necessary to obtain desired system operation and results.

3.7 All fan belts shall be adjusted for proper operation of fans.

3.8 Testing shall occur after completion of the ceiling systems installation.

3.9 All deficiencies observed by the Test and Balance Contractor shall be reported immediately to the Engineer and Mechanical Contractor.

3.10 Provide a complete preliminary test report to the Engineer immediately after the system is air balanced, or any initial phases are balanced. This report may be hand written. Any systems that are not found to operate within the design tolerances by the Test and Balance Contractor shall immediately be reported to the Engineer via telephone call to attempt to determine a resolution while the Test and Balance Contractor is still on site. Additional compensation will not be accepted for additional trips.

3.11 Anticipate visiting the site again after the Engineer has reviewed the report. The Engineer may request up to two (2) additional site visits for onsite troubleshooting where additional measurements may be required.

3.12 Balance all units rated for 2,000 cfm unit such that the total air volume delivered does not exceed 2,000 cfm, otherwise the Contractor shall furnish and install a code compliant duct smoke detection system integrated into the building's system.

3.13 Test and Balance agency shall provide sizing of fan or motor sheaves required for proper balance. The Mechanical Contractor shall purchase and install all sheaves and belts as required. This includes new and existing equipment.

3.14 The Contractor shall provide and coordinate work to provide sufficient time before final completion date so that tests and balancing can be accomplished and provide immediate labor and tools to make corrections when required without undue delay.

3.15 The Contractor shall put all heating, ventilating and air conditioning systems and equipment and rangehood system into full operation and shall continue the operation of same during each working day of testing and balancing.

3.16 The Test and Balance Contractor shall be present during the Engineer's final inspection of the building, or a separate project review date. The Engineer may request confirmation of the air balance report by asking for new measurements to be taken at that time. Any information in the test and balance report may be asked to be reconfirmed.

END OF SECTION 230593

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SECTION 230713 – DUCT INSULATION

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractor directed to Specification Section SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC.

C. The Contractor directed to Specification Section METAL DUCTS.

1.2 SCOPE

A. Work under this section shall include all labor, equipment, accessories, materials, and services required to furnish and install all insulation, fittings and finishes for all mechanical systems specified herein and/or as indicated.

B. Application of insulation materials shall be performed in accordance with manufacturer's written recommendations. Where thickness of insulation is not specified, use applicable thickness recommended by manufacturer for specific use.

C. Insulation thicknesses shall comply with the latest version of ASHRAE 90.1 and IECC at a minimum.

D. All insulation materials shall be installed per the latest edition of the National Commercial and Industrial Insulation Standards.

E. Insulation shall be installed by a company regularly engaged in the application of insulation and any work deemed unacceptable by the Engineer shall be removed and properly installed at the expense of the Contractor.

F. “Concealed", where used herein, shall mean hidden from sight as in trenches, chases, furred spaces, or above hung finished ceilings. "Exposed" shall mean that piping or equipment is not "concealed" as defined above. Ductwork in service tunnels, mechanical equipment rooms, storage areas, or unfinished rooms is to be considered "exposed".

G. The Contractor shall photograph any installations prior to concealment. This includes duct risers in chases and at rooftop equipment.

1.3 FIRE RATINGS AND STANDARDS:

A. Insulations, jackets, facings, adhesives, mastics, tapes, fitting materials, etc. shall have composite fire and smoke hazard ratings as tested by ASTM E-84, NFPA 255 and UL 723 procedures not exceeding Flame Spread 25, Smoke Developed 50, and Fuel Contributed 50.

B. All products and their packaging shall bear a label indicating above requirements are not exceeded.

C. Fiber glass duct wrap shall meet the requirements of Scientific Certification Systems Certification or Greenguard Validation of Formaldehyde Free.

D. Fiber glass mechanical board shall meet the requirement of the Greenguard Standards for Low-Emitting Products.

E. Fiber glass pipe insulation shall meet the requirement of the Greenguard Gold level standard.

PART 2 – PRODUCTS:

2.1 ACCEPTABLE MANUFACTURERS: Johns Manville, Knauf, Owens-Corning.

2.2 Unless otherwise specified or allowed, closed cell type insulation shall not be acceptable.

2.3 EXTERNAL INSULATION FOR SUPPLY AIR DUCTWORK: Knauf "Friendly Feel" faced, Duct Wrap, 0.75 PCF density, 2.2" thick or approved equivalent. Wrap shall be factory laminated to a reinforced foil kraft vapor barrier facing (FRK) with a 2" stapling flange at one edge. The installed R value shall be a minimum of 6.0. Flame spread 25, smoke developed 50, vapor barrier performance 0.02 perms per inch.

2.4 EXPOSED EXTERNAL INSULATION SUPPLY AIR DUCTWORK IN THE MECHANICAL ROOMS: Knauf "Insulation Board" or approved equivalent industrial insulation. Use 1½" rigid fiberglass industrial board with foil scrim kraft vapor barrier facing, 6.0 PCF density, K=0.22 Btu in/hr. ft² °F @ 75°F. Use 1/2" thick, 1.6 PCF insulation board for round ducts. The installed R-value shall be a minimum of 5.0. Flame spread 25, smoke developed 50, vapor barrier performance 0.02 perms per inch. Provide 6oz. canvas jacket with fire retardant lagging and provide a metal corner bead at all duct corners (on the exterior of the insulation) for protection. The corner bead shall be taped in place with foil scrim tape.

PART 3 – EXECUTION:

3.1 The Contractor shall photograph any installations prior to concealment. This includes duct risers in chases and at rooftop equipment.

3.2 Insulation shall be applied on clean, dry surfaces in a neat and workmanlike manner reflecting the best current practices in the trade. Insulation shall not be applied to ductwork until tested, inspected, and released for insulation.

3.3 Where more than one thickness of insulation is required, joints (both longitudinal and transverse) shall be staggered.

3.4 Duct insulation shall extend completely to all registers, grilles, diffusers, and louver outlets, etc., to insure no condensation drip or collection.

3.5 All insulation shall be continuous through walls, ceiling openings and sleeves. However, insulation shall be broken through fire walls. All covered ductwork is to be located a sufficient distance from walls, other pipe, ductwork, and other obstacles to permit the application of the full thickness of insulation specified. If necessary, extra fittings and pipe are to be used. No noticeable deformation of insulation or discontinuity of vapor seal, where required, will be accepted. Coordinate work with plumbers, pipe fitters, etc. to assure hanger locations agree with location of insulation inserts.

3.6 Existing and/or new insulation removed and/or damaged during course of construction shall be repaired or replaced by the Contractor at their expense.

3.7 Vapor barrier jackets shall be applied with a continuous unbroken vapor seal. Do not use staples through the jacket. NO EXCEPTIONS!

3.8 All insulation shall be installed with joints butted firmly together.

3.9 The Contractor shall insure that all duct insulation is completely continuous along all conduits, equipment, connection routes, etc. carrying cold (air) and that condensation can, in no way, collect in or on the insulation, equipment, conduits, etc. Any such occurrence of condensation collection and/or damage therefrom shall be repaired solely at the expense of the Contractor.

3.10 DUCTWORK SYSTEMS

A. Duct sizes indicated are the net free area inside clear dimensions; where ducts are internally lined, overall dimensions shall be increased accordingly.

END OF SECTION 230713

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SECTION 230716 – HVAC EQUIPMENT INSULATION

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractor directed to Specification Section SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC.

1.2 SCOPE

A. Work under this section shall include all labor, equipment, accessories, materials, and services required to furnish and install all insulation, fittings and finishes for all mechanical systems specified herein and/or as indicated.

B. Application of insulation materials shall be performed in accordance with manufacturer's written recommendations. Where thickness of insulation is not specified, use applicable thickness recommended by manufacturer for specific use.

C. Insulation thicknesses shall comply with the latest version of ASHRAE 90.1 and IECC at a minimum.

D. All insulation materials shall be installed per the latest edition of the National Commercial and Industrial Insulation Standards.

E. Insulation shall be installed by a company regularly engaged in the application of insulation and any work deemed unacceptable by the Engineer shall be removed and properly installed at the expense of the Contractor.

F. The Contractor shall photograph any installations prior to concealment. This includes risers in chases and at rooftop equipment.

1.3 FIRE RATINGS AND STANDARDS:

A. Insulations, jackets, facings, adhesives, mastics, tapes, fitting materials, etc. shall have composite fire and smoke hazard ratings as tested by ASTM E-84, NFPA 255 and UL 723 procedures not exceeding Flame Spread 25, Smoke Developed 50, and Fuel Contributed 50.

B. All products and their packaging shall bear a label indicating above requirements are not exceeded.

C. Fiber glass duct wrap shall meet the requirements of Scientific Certification Systems Certification or Greenguard Validation of Formaldehyde Free.

D. Fiber glass mechanical board shall meet the requirement of the Greenguard Standards for Low-Emitting Products.

E. Fiber glass pipe insulation shall meet the requirement of the Greenguard Gold level standard.

PART 2 – PRODUCTS:

2.1 ACCEPTABLE MANUFACTURERS: Johns Manville, Knauf, Owens-Corning.

2.2 Unless otherwise specified or allowed, closed cell type insulation shall not be acceptable.

PART 3 – EXECUTION:

3.1 The Contractor shall photograph any installations prior to concealment.

3.2 Insulation shall be applied on clean, dry surfaces in a neat and workmanlike manner reflecting the best current practices in the trade. Insulation shall not be applied to equipment until tested, inspected, and released for insulation.

3.3 Where more than one thickness of insulation is required, joints (both longitudinal and transverse) shall be staggered.

3.4 Existing and/or new insulation removed and/or damaged during course of construction shall be repaired or replaced by the Contractor at their expense.

3.5 Vapor barrier jackets shall be applied with a continuous unbroken vapor seal. Do not use staples through the jacket. NO EXCEPTIONS!

3.6 All insulation shall be installed with joints butted firmly together.

3.7 The Contractor shall insure that all equipment insulation is completely continuous so that condensation can, in no way, collect in or on the insulation, equipment, etc. Any such occurrence of condensation collection and/or damage therefrom shall be repaired solely at the expense of the Contractor.

END OF SECTION 230716

SECTION 230719 – HVAC PIPING INSULATION

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractor directed to Specification Section SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC.

1.2 SCOPE

A. Work under this section shall include all labor, equipment, accessories, materials, and services required to furnish and install all insulation, fittings and finishes for all mechanical systems specified herein and/or as indicated.

B. Application of insulation materials shall be performed in accordance with manufacturer's written recommendations. Where thickness of insulation is not specified, use applicable thickness recommended by manufacturer for specific use.

C. Insulation thicknesses shall comply with the latest version of ASHRAE 90.1 and IECC at a minimum.

D. All insulation materials shall be installed per the latest edition of the National Commercial and Industrial Insulation Standards.

E. Insulation shall be installed by a company regularly engaged in the application of insulation and any work deemed unacceptable by the Engineer shall be removed and properly installed at the expense of the Contractor.

F. “Concealed", where used herein, shall mean hidden from sight as in trenches, chases, furred spaces, pipe shafts, or above hung finished ceilings. "Exposed" shall mean that piping or equipment is not "concealed" as defined above. Piping in service tunnels, mechanical equipment rooms, storage areas, or unfinished rooms is to be considered "exposed".

G. The Contractor shall photograph any installations prior to concealment. This includes duct risers in chases and at rooftop equipment.

1.3 FIRE RATINGS AND STANDARDS:

A. Insulations, jackets, facings, adhesives, mastics, tapes, fitting materials, etc. shall have composite fire and smoke hazard ratings as tested by ASTM E-84, NFPA 255 and UL 723 procedures not exceeding Flame Spread 25, Smoke Developed 50, and Fuel Contributed 50.

B. All products and their packaging shall bear a label indicating above requirements are not exceeded.

C. Fiber glass duct wrap shall meet the requirements of Scientific Certification Systems Certification or Greenguard Validation of Formaldehyde Free.

D. Fiber glass mechanical board shall meet the requirement of the Greenguard Standards for Low-Emitting Products.

E. Fiber glass pipe insulation shall meet the requirement of the Greenguard Gold level standard.

PART 2 – PRODUCTS:

2.1 ACCEPTABLE MANUFACTURERS: Johns Manville, Knauf, Owens-Corning.

2.2 Unless otherwise specified or allowed, closed cell type insulation shall not be acceptable.

2.3 PIPE INSULATION MATERIAL: Insulation shall be Knauf "Earthwool 1000° Pipe Insulation ASJ+/SSL+" or approved equivalent fiberglass pipe insulation with an all service jacket. The insulation shall be a heavy density, pipe insulation with a K factor not exceeding 0.27 Btu per inch/h.ft² °F at 75°F mean temperature. The insulation shall be wrapped with a vapor barrier jacket. The jacket shall have an inside foil surface with self sealing lap and a water vapor permeability of 0.02 perm/inch. All circumferential joints shall be vapor sealed with butt strips. All insulation shall be installed in strict accordance with the manufacturer's recommendations. The following pipes shall be insulated with the minimum thickness of insulation as noted.

A. HVAC Fill Lines: 1" thick insulation

B. Hydronic Chilled Water:
   1. Piping 2" and less: 1-1/2" thick insulation
   2. Piping 2-1/2" and greater: 2" thick insulation
   3. All exterior piping: 2" thick with heat trace and jacketing

C. Hydronic Hot Water:
   1. Piping 3/4" and less 1" thick insulation
   2. Piping 1" to 1-1/2" 1-1/2" thick insulation
   3. Piping 2" to 4" 2" thick insulation
   4. Piping 5" and greater 2-1/2" thick insulation

D. Refrigerant Suction Lines:
   1. Piping 1-1/4" and less: 1/2" thick insulation
   2. Piping 1-1/2" and greater: 1" thick insulation
   3. All exterior piping: 1-1/2" thick with jacketing

E. Condensate Drain Lines: 1/2" thick.

PART 3 – EXECUTION:

3.1 The Contractor shall photograph any installations prior to concealment. This includes risers in chases and at rooftop equipment.

3.2 Insulation shall be applied on clean, dry surfaces in a neat and workmanlike manner reflecting the best current practices in the trade. Insulation shall not be applied to piping, until tested, inspected, and released for insulation.

3.3 Where more than one thickness of insulation is required, joints (both longitudinal and transverse) shall be staggered.

3.4 All insulation shall be continuous through walls, ceiling openings and sleeves. However, insulation shall be broken through fire walls. All covered pipe is to be located a sufficient distance from walls, other pipe, ductwork, and other obstacles to permit the application of the full thickness of insulation specified. If necessary, extra fittings and pipe are to be used. No noticeable deformation of insulation or discontinuity of vapor seal, where required, will be accepted. Coordinate work with plumbers, pipe fitters, etc. to assure hanger locations agree with location of insulation inserts.

3.5 Existing and/or new insulation removed and/or damaged during course of construction shall be repaired or replaced by the Contractor at their expense.

3.6 Vapor barrier jackets shall be applied with a continuous unbroken vapor seal. Do not use staples through the jacket. NO EXCEPTIONS!

3.7 All insulation shall be installed with joints butted firmly together.

3.8 The Contractor shall insure that all piping insulation is completely continuous along all conduits, equipment, connection routes, etc. carrying cold fluids (water, refrigerant, other) and that condensation can, in no way, collect in or on the insulation, equipment, conduits, etc. Any such occurrence of condensation collection and/or damage therefrom shall be repaired solely at the expense of the Contractor.

3.9 Seal insulation and jacket at all points where insulation terminates at unions, flanges, valves, and equipment. This applies to hot water lines only as cold water lines require continuous insulation and vapor barrier.

3.10 Pipe insulation shall extend around valve bodies to above drain pans in hydronic equipment over pumps, etc. to insure no condensation drip or collection.

3.11 Valves, flanges, and unions shall only be insulated when installed on cold fluid piping whose surface temperature will be at or below the dew point temperature of the ambient air.

3.12 Insulation shall not extend through fire and smoke walls. Pack sleeve at fire and smoke wall with approved fire retardant packing similar to mineral wool and seal with approved sealant.

3.13 Metal insulation shields and inserts are required at all pipe hangers where the piping is insulated. Metal shields shall be constructed of galvanized steel, formed to a 180 degree arc. Insulation shields shall be the following size:

	Pipe Size	Shield Gauge	Shield Length
i.	2” and less	20	12”
ii.	2 ½”- 4”	18	12”
iii.	5”- 10”	16	18”
iv.	Over 10”	14	24”

3.14 Insulated pipes 2” in diameter and larger shall be additionally supported with polyisocyanurate inserts of sufficient compressive strength to carry the weight of the pipe and fluid. Inserts shall extend beyond extend beyond the hanger and shall be at least 6” in length.

3.15 Provide premolded PVC insulated fitting covers on all pipe fittings, flanges, valves, and pipe terminations. Fittings shall be insulated by applying the proper factory precut insulation insert to the pipe fitting. The ends of the insulation insert shall be tucked snugly into the throat of the fitting and the edges adjacent to the pipe insulation tufted and tucked in, fully insulating the pipe fitting. The proper thickness of insulation must be applied to keep the jacket temperature less than 150°F. An approved vapor retarder mastic compatible with the PVC shall be applied around the edges of the adjoining pipe insulation and on the fitting cover throat overlap seam. The PVC fitting cover shall then be applied and secured with pressure sensitive tape along the circumferential edges. The tape shall extend over the adjacent pipe insulation and have an overlap on itself at least 2" on the downward side. On fittings where the operating temperature is below 50°F, two or more layers of the insulation inserts shall be applied with the first layer being secured with a few wrappings of fiber glass yarn to eliminate voids. One additional insert shall be used for each additional 1" of pipe insulation above 1-1/2". All joints shall be fully sealed.

END OF SECTION 230719

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SECTION 230800 – MECHANICAL COMMISSIONING REQUIREMENTS

PART 1 – GENERAL:

1.1 DESCRIPTION

A. Commissioning

Commissioning is a systematic process of ensuring that all building systems perform interactively according to the owner's project requirements and operational needs. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment startup, control system calibration, testing adjusting and balancing, performance testing and training. Commissioning during the construction phase is intended to achieve the following specific objectives:

1. Verify that applicable equipment and systems are installed according to the manufacturer's recommendations and to industry accepted minimum standards and that they receive adequate operational checkout by installing contractors.
2. Verify and document proper functional performance of equipment and systems.
3. Verify that O&M documentation left on site is complete.
4. Verify that the Owner's operating personnel are adequately trained.

1.2 RELATED WORK

A. Section 01 1000 – Summary of Work

B. Section 01 3300 – Submittal Procedures

C. Section 01 7700 – Closeout Procedures

D. Section 01 7823 – Operation and Maintenance Data

E. Section 01 7839 – Project Record Documents

F. Section 01 7900 – Demonstration and Training

G. Section 01 9113 – General Commissioning Requirements

H. Section 25 0800 – Integrated Automation Commissioning

I. Attachment 'A' to this specification section: Sample AHU Prefunctional Checklist

1.3 ABBREVIATIONS AND DEFINITIONS

A. A/E: Architect, Architect/Engineer, Engineer and/or Design-Builder

B. ASI: Architectural Supplemental Instruction

C. BAS: Building Automation System

D. BoD: Basis of Design. A narrative of how the designer plans to achieve the OPR.

E. CxA: Commissioning Authority

F. CC: Controls Contractor

G. CM: Construction Manager

H. Cx: Commissioning

I. Cx Plan: Commissioning Plan

J. Cx RFI: Commissioning Request for Information

K. DDC: Direct Digital Control System

L. Deficiency: A condition in the installation or function of a component, piece of equipment or system that is not in compliance with the Contract Documents and cannot be corrected in five (5) minutes time.

M. EC: Electrical Contractor

N. FBO: Furnished By Others

O. FT: Functional Performance Test

P. IAW: In Accordance With

Q. MC: Mechanical Contractor

R. O&M: Operation and Maintenance

S. OPM: Owner Project Manager

T. OPR: Owner Project Requirement. A dynamic document expressing how the owner expects the building systems to perform upon project completion.

U. PC: Prefunctional Checklist

V. RFI: Request for Information

W. Sub(s): Subcontractors or Prime Contractor

X. TAB: Test, Adjust and Balance

Y. TBD: To Be Determined

1.4 MECHANICAL EQUIPMENT AND SYSTEMS TO BE COMMISSIONED

A. Mechanical Systems

1. Building automation systems, including linkages to remote monitoring and control sites
2. Chilled water system, chilled water pumps, piping, and associated equipment.
3. Heating hot water system, associated pumps, piping, and equipment
4. Air Handling Units
5. Exhaust fans
6. Cabinet heaters
7. Variable Air Volume terminal units
8. Ductwork
9. Refrigeration systems
10. Test, Adjust, and Balance of HVAC air and water systems

B. Building Automation Systems (BAS)

1. The entire BAS shall be subject to commissioning, including all hardware components, software, networking, programming, and engineering services, and controls documentation.
2. Any systems connected to the BAS (monitoring or otherwise) are subject to be commissioned.

1.5 SUBMITTALS

A. Refer also to Specification Section 01 9113, Subsection 1.6.

B. Provide the CxA a copy of the following items, for the systems to be commissioned:

1. Equipment and System Submittals to include, at minimum, the following:

a. Equipment Data Sheets
b. Performance data
c. Manufacturer's pre-startup checklists
d. Manufacturer's start-up checklists
e. Installation Instructions

2. Test, Adjust, and Balance (TAB) Reports

a. Planning Report - TAB contractor shall submit one copy of planning report (execution plan) to the CxA for review prior to beginning TAB work. At a minimum this report should include:
1) Certifications on all instruments to be used throughout the testing. Certification must be documented within the previous 6 months.
2) Resumes and Certification of individuals who will be balancing the systems.
3) Detailed step-by-step plans for each procedure to be performed by the TAB Contractor.
4) Sample forms to be used for each measurement.

b. Initial Test Report – Prior to starting final Balance Phase, submit a copy of the initial test report (TAB punchlist) to the CxA to indicate problem areas to be resolved before final balance is completed.
c. Final Report – Submit one copy of final test report to the CxA within 7 days after fieldwork is complete.

3. Shop drawings (including any resubmittals required by the A/E)
4. Ductwork - Supply one copy of the duct leakage test results for each test section
5. Piping - Supply one copy of all of hydrostatic pressure test results
6. Initial Pre-startup and start-up plan
7. Startup Testing Report

a. Prepare startup testing report on a per system basis, documenting the results of executed testing plan.
b. Copies of all completed test forms and checklists shall be provided
c. List of all outstanding deficiencies and uncompleted items

8. Operational and maintenance documentation
9. Training plan and training materials
10. As-built documentation

PART 2 – PRODUCTS

2.1 TEST EQUIPMENT

A. Refer to Specification Section 01 9113, Subsection 2.1.

2.2 Cx WEB-BASED COMMISSIONING TOOL

A. Refer to Specification Section 01 9113, Subsection 2.1.

PART 3 – EXECUTION

3.1 MEETINGS

A. Refer to Specification Section 01 9113, Subsection 3.3.

3.2 START-UP, PREFUNCTIONAL CHECKLISTS AND INITIAL CHECKOUT

A. The following procedures apply to all equipment to be commissioned, according to Section 1.4 above.

B. General
Prefunctional checklists are important to ensure that the equipment and systems are hooked up and operational. It ensures that functional performance testing (in-depth system checkout) may proceed without unnecessary delays. Each piece of equipment receives full prefunctional checkout. No sampling strategies are used. The prefunctional testing for a given system must be successfully completed prior to formal functional performance testing of equipment or subsystems of the given system.

C. Start-up and Initial Checkout Plan

1. The CxA will provide prefunctional checklists (PFCs). PFCs indicate the required procedures to be executed as part of startup and initial checkout of the systems. An example of a standard AHU PFC is provided in Attachment 'A.'
2. The subcontractor responsible for providing and installing the equipment develops the full start-up plan by combining (or adding to) the CxA's prefunctional checklists with the manufacturer's detailed start-up and checkout procedures from the O&M manual and the normally used field checkout sheets. The plan will include checklists and procedures with specific boxes or lines for recording and documenting the checking and inspections of each procedure and a summary statement with a signature block at the end of the plan.
3. The full start-up plan shall consist of:

    a. The CxA's prefunctional checklists.
    b. The manufacturer's standard written start-up procedures copied from the installation manuals with check boxes by each procedure and a signature block added by hand at the end
    c. The manufacturer's normally used field checkout sheets
    d. Specifically, the mechanical start-up plan shall also include the contractors TAB plan.

4. The contractor submits the full startup plan to the CxA for review and approval.
5. The CxA reviews and approves the procedures and the format for documenting them, noting any plans that need to be added.

D. Execution of Prefunctional Checklists and Startup

1. Two weeks prior to startup, the Subs and vendors schedule startup and checkout with the OPM, CM and CxA. The performance of the prefunctional checklists, startup and checkout are directed and executed by the Sub or vendor. When checking off prefunctional checklists, signatures may be required of other Subs for verification of completion of their work.
2. The CxA and possibly the A/E will observe the procedures for selected pieces of primary equipment.
3. The CxA will observe the physical start-up of all major systems.
4. The CxA will witness piping cleanout procedures and verify any required water or lab tests.
5. For lower-level components of equipment, (e.g., VAV boxes, sensors, controllers), the CxA will observe a sampling of the prefunctional and start-up procedures.

6. The Subs and vendors shall execute startup and provide the CM with a signed and dated copy of the completed start-up and prefunctional tests and checklists. The CM reviews for completion and accuracy, then submits to the CxA.
7. Only individuals that have direct knowledge and witnessed that a line item task on the prefunctional checklist was actually performed shall initial or check that item off. It is not acceptable for witnessing supervisors to fill out these forms.
8. Completed startup test report must be provided to CxA prior to functional testing.

E. Deficiencies, Non-Conformance and Approval in Checklists and Startup

1. The Subs shall clearly list any outstanding items of the initial start-up and prefunctional procedures that were not completed successfully. The procedures form and any outstanding deficiencies shall be provided to the CxA within two days of test completion.
2. The CxA will work with the Subs and vendors to determine what is required to correct outstanding deficiencies and retest deficiencies of uncompleted items. The CxA will involve the PM and others as necessary. The installing Subs or vendors shall correct all areas that are deficient or incomplete in the checklists and tests in a timely manner and shall notify the CxA as soon as outstanding items have been corrected.
3. Items left incomplete, which later cause deficiencies or delays during functional testing may result in backcharges to the responsible party. Refer to Section 01 9113, 3.3 – Documentation, Non-Conformance, and Approval of Tests.

3.3 FUNCTIONAL PERFORMANCE TESTING

A. This sub-section applies to functional testing and demonstration for equipment and system in this division.

B. The general list of equipment and systems to be commissioned is found in section 1.4.

C. Objectives and Scope

1. The objective of functional performance testing is to demonstrate that each system is operating according to the owner's project requirements, documented project program, and Contract Documents. Functional testing facilitates bringing the systems from a state of substantial completion to full dynamic operation. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and function of the systems.
2. In general, each system shall be operated through all modes of operation where there is a specified system response.
3. Testing proceeds from components to subsystems to systems. When the proper performance of all interacting, individual systems has been achieved, the interface or coordinated responses between systems is checked.
4. The contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, tools, instruments, ladders, lifts, computers, software, cables, etc. Contractor supplied personnel must be competent with and knowledgeable of all project- specific systems, and automation hardware and software. All training documentation, submittals, installation manuals, and O&Ms, shall be at the job site before functional testing commences.

D. Development of Test Procedures

1. The CxA develops specific functional test procedures and forms to verify and document proper operation of each piece of equipment and system. The CxA provides a copy of the test procedures to the A/E, OPM and installing Sub who shall review the tests prior to testing. The A/E and Sub(s) shall point out to the CxA any specific problems as related to feasibility, safety, equipment, and warranty protection.

E. Coordination and Scheduling

1. The CM shall provide sufficient notice to the CxA regarding the Subs completion schedule for the prefunctional checklists and startup of all equipment and systems. The CxA will schedule functional tests after written notification from the CM and affected Subs. Completed startup testing report must be provided to CxA prior to functional testing. The CxA shall direct, witness and document the functional testing of all equipment and systems. The Subs shall execute the tests.
2. In general, functional testing shall not be scheduled until all hardware and software submittals are approved, Prefunctional checklists are approved, and start-up has been satisfactorily completed. Further, mechanical system functional testing shall not be scheduled until the final TAB report is approved and all reported deficiencies by TAB firm are corrected. Scheduling of functional testing shall be done with a minimum of two weeks notice prior to testing. Functional testing of the equipment and systems listed in section 1.4 of this specification section shall not be conducted out of the presence of the CxA and OPM, unless specifically approved to do so in writing by the CxA or OPM. Any functional testing which occurs outside the presence of the CxA or OPM without written authorization to do so will be required to be re-tested at no expense to the owner.

F. Test Methods

1. Functional performance testing and verification may be achieved by manual testing (persons manipulate the equipment and observe performance) or by monitoring the performance and analyzing the results using the control system's trend log capabilities or by stand-alone dataloggers.
2. Simulated Conditions. Simulating conditions (not by an overwritten value) shall be allowed, though timing the testing to experience actual conditions is encouraged wherever practical.
3. Overwritten Values. Overwriting sensor values to simulate a condition, such as overwriting the outside air temperature reading in a control system to be something other than it really is, shall be allowed, but shall be used with caution and avoided when possible. Such testing methods often can only test a part of a system, as the interactions and responses of other systems will be erroneous or not applicable. Simulating a condition is preferable. e.g., for the above case, by heating the outside air sensor with a hair dryer rather than overwriting the value or by altering the appropriate setpoint to see the desired response. Before simulating conditions or overwriting values, sensors, transducers, and devices shall have been calibrated.
4. Simulated Signals. Using a signal generator which creates a simulated signal to test and calibrate transducers and DDC constants is generally recommended over using the sensor to act as the signal generator via simulated conditions or overwritten values.
5. Altering Setpoints. Rather than overwriting sensor values, and when simulating conditions is difficult, altering setpoints to test a sequence is acceptable. For example, to see the AC compressor lockout work at an outside air temperature below 55ºF, when the outside air temperature is above 55ºF, temporarily change the lockout setpoint to be 2ºF above the current outside air temperature.
6. Indirect Indicators. Relying on indirect indicators for responses or performance shall be allowed only after visually and directly verifying and documenting, over the range of the tested parameters, that the indirect readings through the control system represent actual conditions and responses. Much of this verification is completed during prefunctional testing.
7. Setup. Each function and test shall be performed under conditions that simulate actual conditions as close as is practically possible. The Sub executing the test shall provide all necessary materials, system modifications, etc. to produce the necessary flows, pressures, temperatures, etc. necessary to execute the test according to the specified conditions. At completion of the test, the Sub shall return all affected building equipment and systems, due to these temporary modifications, to their pre-test condition.

G. Demonstration, Verification and Validation

1. TAB Validation
   a. The air balancing and water balancing is de-bugged, completed and approved before the CxA completes a TAB validation of air-related and water-related equipment or systems. The CxA will direct a TAB checkout by verifying the values reported in the final TAB report. The contractor

shall supply all personnel and equipment for the checkout, including, but not limited to, tools, instruments, ladders, lifts, computers, software, cables, etc. The TAB verification shall verify:
1) grilles, diffusers, and registers
2) terminal devices
3) all main HVAC systems
4) general exhaust fans
5) kitchen hood exhaust
6) hydronic systems (e.g. HW/CHW) equipment and distribution components

2. Metering System
   a. Demonstrate meters are calibrated in accordance with the manufacturer's published data approved.
   b. Demonstrate accuracy of all meters.
   c. Demonstrate utility monitoring integration with BAS.

H. Problem Solving

1. The CxA will recommend solutions to problems found, however the burden of responsibility to solve, correct and retest problems is with the CM, Subs and A/E.

3.4 DOCUMENTATION, NON-CONFORMANCE, AND APPROVAL OF TESTS

A. Refer to Specification Section 01 9113, Subsection 3.7.

3.5 OPERATION AND MAINTENANCE MANUALS

A. In addition to Installation manuals, the contractor shall provide one copy of the Operation and Maintenance Manuals to the CxA for the systems to be commissioned. The O&M Manuals shall be provided to the CxA at least 8 weeks prior to the start of Functional Testing. O&M Manuals shall be in electronic form, the file format shall be Adobe Acrobat readable document. The document shall be formatted to include level 1 bookmarks that link to each main section of equipment. Refer to specification section 01 9113, subsection 3.8 for further detail.

B. Refer to specification section 01 9113, Subsection 3.8 for further details.

3.6 TRAINING OF OWNER PERSONNEL

A. See Specification Section 01 9113, Subsection 3.9.

B. CxA shall document the completion of comprehensive Owner training. Training shall include the understanding of the systems and the operation and maintenance of each major piece of HVAC equipment or system.

C. Training shall include classroom sessions, if necessary, followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including AHUs, pumps, VAV terminals, VFDs, etc.

3.7 DEFERRED TESTING

A. See Specification Section 01 9113, Subsection 3.10.

END OF SECTION 230500

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SECTION 230900 - BUILDING AUTOMATION SYSTEM

PART 1 GENERAL SCOPE

1.01 RELATED DOCUMENTS

A. The provisions of the General Conditions, Supplementary Conditions, and the Sections included under Division 1, General Requirements, are included as a part of this Section as through bound herein.

1.02 SUMMARY

A. This document contains the specification for a Building Automation System (BAS).

B. The system shall provide the Direct Digital Control (DDC), Energy Management and Building Automation System (BAS) for the air conditioning, heating and ventilating systems, lighting controls and shall interface with other microprocessor based building subsystems as shown on the drawings and as specified.

C. Related Work Specified Elsewhere:

1. Section 23 05 13 – Common Motor Requirements for HVAC Equipment.
2. Section 23 52 16 – High Efficiency Condensing Boilers.
3. Section 23 64 26 – Rotary Screw Water Chillers.
4. Section 23 08 00 – HVAC Systems Commissioning.

D. Refer to Division 01 for Alternates that may affect the Work of this Section.

1.03 SCOPE OF WORK

Contractor's Responsibilities: The Contractor shall furnish a complete, tested, fully integrated and completely operational Building Automation System including all necessary software and hardware, wiring, and control equipment in compliance with this Specification and the Construction Documents.

1. Standard Material/Products: All material and equipment used shall be standard components and software, regularly manufactured and available, and not custom designed especially for this project.
2. Modular Design: The system architecture shall be fully modular permitting expansion of application software, system peripherals, and field hardware.
3. Performance: The system, upon completion of the installation and prior to acceptance of the project, shall perform all operating functions as detailed in this specification.
4. The intent of this specification is to provide a system that is consistent with BMS systems throughout WCPSS facilities running the Niagara AX™ or N4 Framework.
5. System architecture shall fully support a multi-vendor environment and be able to integrate third party systems via existing vendor protocols including, as a minimum, LonTalk, BACnet, and Modbus.
6. System architecture shall provide secure Web access using MS Internet Explorer from any computer on the WCPSS LAN.
7. BAS Communication trunk shall be independent from the WCPSS network and operate without switches. There shall be a single point connection from the BAS to the WCPSS network for remote monitoring.
8. Contractor shall be responsible for providing a temporary wireless BAS communication network with adequate speed and capacity to allow for efficient systems start up, Test & Balance, and functional testing prior to WCPSS permanent network installation/activation.

B. Equipment:

1. System Hardware:
   The Contractor shall provide the following:
   a. All sensing devices, relays, switches, indicating devices, and transducers, power supplies, interface modules, etc. required to perform all require functions.
   b. All monitoring and control wiring.
   c. Owner shall furnish remotely located database server hardware.

2. System Software:
   a. Prior to installation, the Controls Contractor shall determine the current system software version utilized by WCPSS. The Controls Contractor shall request written approval from WCPSS for any deviations from the currently installed version. The Controls Contractor shall provide Niagara N4™ Framework Version 4.7.X.X of all software required to configure, monitor, link, and program all components of the completed system, including the BAS Server Software. The existing software version located on the server is Version 4.7.X.X. The controls contractor shall provide the latest version of all third-party software required (excluding computer operating system software). The system shall be fully configured, including database, graphics, reports, schedules, alarm/events, trends etc. The Graphical User Interface (GUI) shall be Web based as specified herein.

3. Acceptable field controllers are Schneider IA, Honeywell Spyder, Distech by Johnson Controls, Trane Tracer UC or approved equal.

C. General Notes to Designers and Contractor

1. Coordination with the appropriate sections of the mechanical and electrical specifications is required by the design team in order for mechanical and electrical systems to interface with the BAS control standards. The Construction Documents and Specifications must appropriately reference the BAS Specifications.
2. Coordinate power requirements with electrical engineer and cross-reference responsibilities with other system designers (e.g. HVAC, electrical, fire protection, plumbing, etc.). Coordinate power requirements for HVAC system and show all bas power points on electrical drawings. The goal of WCPSS is to insure 120 vac power is provided within a common area (e.g. mechanical room) adjacent to control devices. The control contractor would then be responsible for all final power (120 vac and >) and low voltage (24vac and <) to all control components within the common area. Locate BAS panels on the mechanical room floor plan drawings.
3. All BAS controller and point names shall reference final WCPSS approved room numbers, not construction document room numbers. The BAS contractor shall submit all naming conventions to WCPSS for approval by the prior to programming. See 2.02.2 E
4. Project Sequence

   a. The control system work for this project shall proceed in the following order:
      1) Submit and receive approval on the Shop Drawings, Product Data, and Certificates specified under the paragraph entitled "SUBMITTALS."
      2) Perform the control system installation work, including all field check-outs and tuning.
      3) Provide support to TAB personnel
      4) Submit BAS Graphics for review by WCPSS personnel for approval
      5) Submit and receive approval of the Controls System Operators Manual Submit and receive approval of the Performance Verification Testing Plan and the Pre-PVT Checklist
      6) Perform the Performance Verification Testing.

7) Submit and receive approval on the PVT Report.
8) Submit and receive approval on the Training Documentation. Submit at least 30 days before training.
9) Deliver the final Controls System Operators Manuals.
10) Conduct Training.
11) Submit and receive approval of Closeout Submittals

1.04 GENERAL CONDITIONS

A. Correction of Work:
1. Contractor's Responsibility. The Contractor shall promptly correct all work the Owner finds defective or failing to conform to the Contract Documents. The Contractor shall bear all cost of correcting such work.
2. During Warranty. If, within the warranty period required by the Contract Documents, any of the work is found to be defective in material or workmanship or not in accordance with the Contract Documents, the Contractor shall correct it promptly after receipt of notice from Owner to do so. Owner shall give notice promptly after discovery of the condition. Contractor shall notify owner within 24 hours of proposed corrections and schedule.

B. Coordination of Work During Construction:
1. The Contractor shall protect the installed works by other trades.
2. The Contractor shall coordinate with other trades.
3. The Contractor shall repair any damage caused by his work to building(s) and equipment.
4. The contractor shall maintain functionality of all existing systems throughout the project.

C. Warranty and Service:
1. Standard Warranty
a. The Contractor shall warrant the system to be free from defects in material and workmanship for a period of one (1) years from the date of completion and acceptance of the work by the Owner. Any defects shall be repaired or replaced, including materials and labor at no cost to WCPSS.
b. Niagara 4 Software Maintenance Agreement
1. Building automation vendor shall provide 3 year software maintenance agreement (SMA) with any installation of Niagara 4.X system.
2. WCPSS reserves the right to make changes to the BAS during the Warranty Period. Such changes do not constitute a waiver of warranty. Contractor shall warrant parts and installation work regardless of any such changes made by WCPSS, unless the Contractor provides clear and convincing evidence that a specific problem is the result of such changes to the BAS.
3. Service Response Requirements During the Warranty Period
a. Emergency Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would result in property damage or loss of comfort control shall be corrected and repaired following telephonic, text, or email notification by the Owner to the Contractor. Emergency service shall be provided 24 hours per day, 7 days per week, and 365 days per year with no exceptions and at no cost to WCPSS.
b. Response by telephone, text, or email to any request for service shall be provided within two (2) hours of WCPSS's initial request for service.
c. In the event that the malfunction, failure, or defect is not corrected through the telephonic communication, at least one (1) hardware and software technician, trained in the system to be serviced, shall be dispatched to the WCPSS site within four (4) hours of the WCPSS initial request for such services, as specified.
d. Normal Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would not result in property damage or loss of comfort control shall be corrected and repaired following telephonic, text, or email notification by the WCPSS to the Contractor.

e. Response by telephone, text, or email to any request for service shall be provided within eight (8) working hours (Contractor specified 40 hours per week normal working period) of the WCPSS initial request for service.
f. In the event that the malfunction, failure, or defect is not corrected through the telephonic communication, at least one (1) hardware and software technician, trained in the system to be serviced, shall be dispatched to the WCPSS site within three (3) working days of the WCPSS initial request for such services, as specified.
g. At any time during the Warranty Period that Contractor is on Site for maintenance, emergency, or normal service, Contractor shall notify WCPSS and the local building operating personnel. Contractor shall notify said personnel of all work anticipated being involved for the service work. In addition, no work affecting system operation shall commence until express permission is granted. After the work is completed a work order ticket describing in detail all work performed (i.e. hardware replaced or serviced, software or firmware modifications made, etc.), hours worked, follow-up work required, etc., must be signed by an authorized building operator.
h. WCPSS Telephonic Request for Service: Contractor shall specify a maximum of three telephone numbers for WCPSS to call in the event of a need for service. At least one of the lines shall be attended at any given time at all times. Alternatively, text messaging can be used for technicians trained in system to be serviced. One of the three notified technicians shall respond to every call within 15 minutes.
i. Technical Support: Contractor shall provide technical support by telephone throughout the Warranty Period.
j. Preventive maintenance shall be provided throughout the Warranty Period in accordance with the hardware component manufacturer's requirements.
k. In the last month of the Warranty Period, all System software and controller firmware, software, drivers, etc. will be upgraded to the latest release (version) in effect at the end of the Warranty Period.

D. Post-warranty Service
1. Contractor shall ensure accessibility to technical support and replacement parts for ten (10) years past the warranty period.

1.05 SUBMITTALS, DOCUMENTATION, ACCEPTANCE AND TRAINING

A. Product Data Submittals: Submit, manufacturer's technical product data for each control device, panel, and accessory furnished, indicating dimensions, capacities, performance and electrical characteristics, and material finishes. Also include installation and start-up instructions.
1. Products: Within twenty one (21) days after date of execution of General Contractor/Sub-Contractor agreement, submit for acceptance a list of all material and equipment manufacturers whose products are proposed, as well as names of all subcontractors whom the Contractor proposes to employ.
a. Provide the following in schedule form on 8½ x 11 sheets. The schedule shall be organized by columns to define as a minimum for all new devices to be installed as part of the BAS system upgrade the location, system served, controlling unit, model number and where applicable, performance data, size, range, accuracy, span, operating pressure, etc.
1) Automatic Valves
2) Automatic Dampers
3) Temperature Sensors
4) Access Doors
5) Humidity Sensors
6) Smoke Detectors
7) Carbon Monoxide Detectors
8) Heat Detectors
9) Pressure Transducers and Transmitters

10) Digital Control Panels
11) Relay Contactors

b. Submit documentation indicating interoperability achieved using BACnet Standard ASHRAE/ANSI 135 or for LonWorks Standard Network Variable Types (SNVTs) or for LONMARK® products provide documentation indicating LONMARK compliance and conformance to LONMARK® Interoperability Standards including but not limited to: Product Information Files (XIF) product literature, and standard configuration parameters for the following. All XIF files, product literature, and standard configuration parameters shall be compiled and submitted on CD-ROM in addition to hard copies provided.
   1) Intelligent Sensors and Actuators
   2) Application Specific Controllers
   3) Programmable Control Units
   4) Interface Panels
   5) Network Management Equipment (Routers, Protocol Analyzers, etc.)

c. Submit detailed cut sheets indicating the features, accessories, and sub-assemblies of the following:
   1) All ancillary devices including temperature sensors, flow sensors, and the like, including thermal wells where necessary.
   2) Pressure gauges, thermometers and indicating devices where shown on the drawings.
   3) Transformers required for control devices.
   4) Relays.
   5) Electrical enclosures and back-plates.
   6) Wire for LON, or BACnet, FAC LAN, and all sensors and actuators.
   7) FAC LAN Hub(s), Switches, and Routers.
   8) LON or BACnet Repeaters.
   9) Equipment Racks.
   10) UPS Modules.
   11) Gateway and interface devices.
   12) Enterprise Network Controllers and Software.
   13) User Interface Workstation Operating System and Associated Software.
   14) Network Management Utility Software.
   15) Application Programming Tools / Software (DDC controller programming software).
   16) Interface devices to Modbus and proprietary devices.
   17) Web based configuration and programming for control devices.
   18) Note any discrepancies with Section 17860/17865 regarding the Graphical User Interface. Specifically identify features that cannot be provided and submit for Owner's approval as a substitution.

2. Shop Drawings: Within six (6) weeks after date of execution of the contract agreement, submit a list of all shop drawings which will be submitted in the course of the project. The list shall show disposition of each item, including date of submission, date of acceptance, and the like. List shall be kept current throughout entire construction period.
3. Submit Shop Drawings electronically in PDF format for each control system, including a complete drawing for each air handling unit, system, pump, device, etc. with all point descriptors, addresses and point names indicated. Include mounting details and power supplies. Shop Drawings shall contain the following information:
   a. System Architecture and System Layout:
      1) One-line diagram indicating schematic locations of all NCs, Controllers, CSS, OWS, FAC LAN interface devices, etc. Indicate network number, device ID, address, device instance, MAC address, drawing reference number, and controller type for each NC. Indicate media, protocol, baud rate, and type of each FAC LAN segment. All controllers, optical isolators, repeaters, end-of- line resistors, junctions, ground locations etc. shall be located on the diagram.

2) Provide floor plans locating all NCs, controllers, workstations, servers, LAN interface devices, etc. Include all WAN, FAC LAN and LON or BACnet communication wiring routing, power wiring, power originating sources, and low voltage power wiring. Indicate network number, device ID, address, device instance, MAC address, drawing reference number, and controller type for each NC. Indicate media, protocol, baud rate, and type of each FAC LAN segment. All controllers, sensors located in finished areas, I/O devices installed in mechanical systems, optical isolators, repeaters, end-of-line resistors, junctions, ground locations, other BAS related components, sensors, and actuators, etc. shall be located on the floor plans. Wiring routing as-built conditions shall be maintained accurately throughout the construction period and the drawing shall be updated to accurately reflect accurate, actual installed conditions.

b. Schematic flow diagram of each air and water system showing fans, coils, dampers, valves, pumps, heat exchange equipment and control devices. Include written description of sequence of operation.

c. All physical and logical points on the schematic flow diagram shall be indicated with names, descriptors, and point addresses as identified in the point list schedule.

d. With each schematic, provide a point summary table listing building number and abbreviation, system type, equipment type, full point name, point description, Ethernet backbone network number, network number, device ID, object ID (object type, instance number). If this information is not available at the time of Shop Drawings submittals, furnish with O&M manual documentation for Owner review and approval. See CSI Master Format for additional requirements.
   1) Label each control device with setting or adjustable range of control.
   2) Label each input and output with the appropriate range.
   3) Provide a Bill of Materials with each schematic. Indicate device identification to match schematic and actual field labeling, quantity, actual product ordering number, manufacturer, description, size, voltage range, pressure range, temperature range, etc. as applicable.
   4) With each schematic, provide valve and actuator information including size, Cv, design flow, design pressure drop, manufacturer, model number, close off rating, etc. Indicate normal positions of spring return valves and dampers.

e. Provide detailed schematics for LONWORKS, BACnet and Modbus interface connections including installation and commissioning specifics. Include detailed terminal interconnect diagrams for connecting to equipment manufacture's integral communications boards.

f. Indicate all required electrical wiring. Electrical wiring diagrams shall include both ladder logic type diagram for motor starter, control, and safety circuits and detailed digital interface panel point termination diagrams with all wire numbers and terminal block numbers identified. Provide panel termination Drawings on separate Drawings. Ladder diagrams shall appear on system schematic. Clearly differentiate between portions of wiring that exists, factory-installed and portions to be field- installed. Provide details for wiring color code assignment.

g. Provide details of control panels, including controls, instruments, and labeling shown in plan or elevation indicating the installed locations.

h. Sheets shall be consecutively numbered.

i. Each sheet shall have a title indicating the type of information included and the HVAC system controlled.

j. Table of Contents listing sheet titles and sheet numbers.

k. Provide User Interface Graphic Screens.
   1) Proposed method of Navigation.
   2) Summary.
   3) Floor Plans.
   4) Trends.
   5) Alarms.

l. Legend and list of abbreviations.
m. Memory allocation projections.
n. Submit along with Shop Drawings but under separate cover calculated and guaranteed system response times of the most heavily loaded LON or BACnet segment in the system.
o. Submit in Schedule format a detailed list of all spare parts to be provided per the contract documents.

4. Control Drawings: Laminated control Drawings including system control schematics, Sequence of Operation, and panel termination Drawings, shall be provided in panels for major pieces of equipment, such as air handling units, chillers, boilers, etc. Drawings should be of sufficient size to be easily read. Terminal unit Drawings shall be located in the central plant equipment panel or mechanical room panel.

5. Control Logic Documentation:
   a. Submit control logic program listings (for graphical programming) and logic flow charts illustrating (for line type programs) to document the control software of all control units. Submit functional temperature control diagrams for each mechanical system served by the BAS. Indicate and tag each input/output served by each ASC or PCU and show locations and functions of BAS.
   b. Submit logical control diagram indicating each node, node address, Network Variables in and out of each node including message bindings. Provide a detailed list of network variable inputs (NVI), network variable outputs (NVO), network configuration inputs (NCI) and use of standard network variable types (SNVT). Indicate total number of NVIs, NVOs and NCIs available for each controller. In the same document list a percentage used in terms of capacity and identify all remaining spare SNVTs on each controller.
   c. Control logic shall be annotated to describe how it accomplishes the sequence of operation. Annotations shall be sufficient to allow an operator to relate each program component (block or line) to corresponding portions of the specified Sequence of Operation. Include all control parameters, system variables, and constants that will affect the system operation.
   d. Include written description of each control sequence.
   e. Include control response, settings, set points, throttling ranges, gains, reset schedules, adjustable parameters, and limits.
   f. Sheets shall be consecutively numbered.
   g. Each sheet shall have a title indicating the controller designations and the HVAC system controlled.
   h. Include Table of Contents listing sheet titles and sheet numbers.
   i. Submit one complete set of programming and operating manuals for all digital controllers concurrently with control logic documentation. This set will count toward the required number of Operation and Maintenance materials specified below and in Division 01.

6. As Built Drawings. All drawings, documentation and manuals shall be reviewed after the final system checkout and updated or corrected to provide 'as-built' drawings to show exact installation and configuration and programming. The system will not be considered complete until the 'as-built' documentation has received final approval, by owner.

7. Shop Drawings. Shop drawings shall be submitted and shall consist of a complete list of equipment, software, materials, manufacturer's technical literature, cut-sheets, and installation instructions. Drawings shall contain proposed layout, complete wiring, list of I/O points, routing, schematic diagrams, ladder diagrams, communication architecture drawings, tag number of devices, software descriptions, graphical sequence calculations, installation details, control system components, control system schematics, test and verification plan and any other details required to demonstrate that the system will function

properly. Shop drawings shall be approved by WCPSS before any equipment is purchased.

B. Documentation: Operating and Maintenance (O&M) manuals for the system shall be made available electronically, accessible from the control system JACE, and include the following categories: User's Manual, Project Engineering Handbook, and Software Documentation. Submit two (2) copies of system documentation directly after receipt of reviewed shop drawings.
   1. BAS User's Manual shall contain as a minimum:
      a. System overview.
      b. Contractor’s name, address, 24-hour telephone number, and job control number. As applicable, also include telephone numbers, and contact names for service during normal hours, service during off-hours, parts ordering, and technical support.
      c. Name, signature, and title of Contractor’s representative responsible for preparation of technical manual. Include date of issuance and revision number.
      d. Warranty information including start and end dates. Coverage’s as they pertain to labor, service parts, replacements, etc. Warranty limitations if any exist.
      e. Alphabetical list of all system components installed as part of this job, including control devices, relays, power supplies, sensors, and accessory items. List manufacturer name and manufacturer's part number, and include the name, address, and 24-hour phone number of the company responsible for servicing and supplying each item during the first year of operation or warranty period, whichever is greater. Identify where each replacement part can be purchased by the owner for future replacement.
      f. Include a wiring identification matrix which shows wire color codes and assignments, and labeling definitions.
      g. Generate a maintenance procedure for all aspects of the system. The procedures shall indicate recommended durations and frequency for each task as well as the means and methods to accomplish each item. This procedure shall include the following minimum requirements:
         1) Procedure for updating operating software on the system controllers. This shall include a procedure for obtaining security patches, updates, and network software updates and patches. Coordinate this procedure with the Network Integrator.
         2) Calibration routines, frequency, and procedures for all sensors and actuators.
         3) Required maintenance for all other system components.
      h. Include installation and service manuals for each device supplied by the controls contractor as part of this project.
      i. Include a documented list of every user name and password required to access all aspects of the system. This shall include user names and passwords to gain access and modify the following components but shall not be limited to:
      j. DDC Controllers.
      k. Network Electronics.
      l. Networking concepts.
      m. Launching a web browser from a networked PC and login.
      n. Web Browser Graphical User Interface (GUI) screen menus and their definitions.
      o. Creating, modifying, or deleting schedules.
      p. Uploading and downloading software to the field hardware.
      q. Creating historical trends, collecting trend data, and generating trend graphs.
      r. Enabling and assigning alarms and messages to reporting actions/groups.
      s. Report generation and ‘third party software’.
      t. Backing up software and data files.
      u. Creating, modifying, or deleting control loop logic.

   2. Project Engineering Manual shall contain as a minimum:
      a. System architecture overview and networking configuration.
      b. Hardware cut-sheets and product descriptions.
      c. The BAS Contractor shall deliver 'as-built' drawings and written sequences of

operation in accordance with Division 1 that reflect final WCPSS assigned device and room numbers. All drawings shall be reviewed after the final system checkout and updated to provide 'as-built' drawings. The system will not be considered complete until the 'as-built' drawings have received their final approval.

d. Include the following as-built drawings as a minimum. All drawings requested shall be updated to include field modifications and change orders. The drawings shall be printed on 11x17 sheets, folded to 8.5 x 11, and included in the binder.
   1) All submittal drawings updated to include field modifications and change orders, and all information requested below:
      i) Functional temperature control diagrams for each mechanical system served by the BAS. Indicate and tag each input/output served by each ASC or PCU.
      ii) Floor plans indicating the exact installed location of the following equipment and/or devices:
         a. All control panels and miscellaneous control devices.
         b. All network controllers, Web Server, and operator workstations.
         c. Indicate all communications / network wiring between control devices.
         d. Indicate all BAS FACLAN wiring.
         e. All major BAS integrated equipment (i.e. Air Handlers, Boilers etc.)
   2) Additional drawings to include:
      i) Legend of all symbols, line types, and abbreviations used.
      ii) Wiring details for any device wiring or interconnection that varies from accepted industry practices or for which none exist.
      iii) Logical program flow diagram for every programmable controller. Flow diagrams shall be developed and designed in accordance with industry standards and shall indicate the natural flow of the control software. Flow charts shall clearly indicate each source line or program block of programming code.

e. Installation, mounting and connection details for all field hardware and accessories.

f. Commissioning, setup and backup procedures for all control modules/accessories, BAS server software, and database.

g. Listing of basic terminology, alarms/messages, error messages and frequently used commands or shortcuts.

3. BAS Software Documentation shall contain as a minimum:
   a. The Contractor shall provide all Graphical Programs, detailing their application to specific HVAC equipment and electrical/mechanical subsystems, together with a glossary or icon symbol library detailing the function of each graphical icon. Revisions made as a result of the submittal process, during the installation, start-up, or acceptance portion of the project, shall be accurately reflected in the "as-builts".
   b. Graphical representation of the mechanical equipment hierarchy for the project including all equipment controlled by the BAS. For example: a VAV terminal box may be the source for increased cooling demand and require the primary VAV AHU to operate which, in turn, requires the chillers to operate.
   c. Detailed listing of all alarm and event messages programmed for designated mechanical/electrical equipment and required operator action.

C. On Site documentation:
   1. At each field controller provide a laminated diagram, showing all connected control points, point naming, and system name.
   2. At building main controller provide laminated diagram of entire controller network. Include device name, and room location.
   3. Provide manual for local users describing method to access, monitor and schedule systems operation.

1.06 QUALITY ASSURANCE

A. Comply with all current codes, ordinances, regulations, and WCPSS insurance underwriters. In all cases of conflict between the work of this Division and Building Code, or omission of items required for code compliance, the issue shall be brought to the attention of the WCPSS at the time of bid proposal submission. Any items of conflict or omission shall be identified, resolved and included in the bid proposal price.

B. The BAS work shall comply with all applicable requirements of the following codes. The latest edition is assumed unless stated otherwise or as amended by the Local Code Authorities
   1. NFPA
   2. BOCA, UBC, SBC
   3. Local City and State Building Codes
   4. National Electric Code, as modified by Local Code

C. Where codes are listed herein, the applicable portions of the latest editions apply.

D. Drawings, specifications, codes, and standards are minimum requirements. Where requirements differ, apply the more stringent.

E. Should any change in Drawings or Specifications be required to comply with regulations, the Contractor shall notify the Owner prior to execution of the work and wait for direction from the Owner.

F. Codes and Regulations:
   1. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
   2. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
   3. Standards Authority. All equipment and material, and its installation, shall conform to the current requirements of the following authorities:
      a. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).
      b. American National Standards Institute (ANSI) ANSI/ASHRA 135BACnet – Data Communication Protocol for Building Automation and Control Networks
      c. American Society of Mechanical Engineers (ASME)
      d. American Society for Testing and Materials (ASTM)
      e. American Refrigeration Institute (ARI)
      f. ATA 878.1 Local Area Network
      g. Electronics Industries Alliance:
         1) EIA-709.1-A-99: Control Network Protocol Specification.
         2) EIA-709.3-99: Free-Topology Twisted-Pair Channel Specification.
         3) EIA-232: Interface between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
         4) EIA-458: Standard Optical Fiber Material Classes and Preferred Sizes.
         5) EIA-485: Standard for Electrical Characteristics of Generator and Receivers for use in Balanced Digital Multipoint Systems.
         6) EIA-472: General and Sectional Specifications for Fiber Optic Cable.
         7) EIA-475: Generic and Sectional Specifications for Fiber Optic Connectors and all Sectional Specifications.
         8) EIA-573: Generic and Sectional Specifications for Field Portable Polishing Device for Preparation Optical Fiber and all Sectional Specifications.
         9) EIA-590: Standard for Physical Location and Protection of Below-Ground Fiber Optic Cable Plant and all Sectional Specifications.
      h. Underwriters Laboratories:
         1) UL 916: Energy Management Systems.

2) UUKL 864: UL Supervised Smoke Control if the BAS is used for smoke control.
3) UL 873 Temperature Indicating Equipment
4) All electrical products to be listed and labeled by UL and comply with NEMA Standards.

i. NEMA Compliance:
1) NEMA 250: Enclosure for Electrical Equipment.
2) NEMA ICS 1: General Standards for Industrial Controls.

j. NFPA Compliance:
1) NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.
2) NFPA 70 National Electrical Code (NEC).

k. Instrument Society of America (ISA)

l. Institute of Electrical and Electronics Engineers (IEEE)
1) IEEE 142: Recommended Practice for Grounding of Industrial and Commercial Power Systems.
2) IEEE 802.3: CSMA/CD (Ethernet – Based) LAN.
3) IEEE 519: Recommended Practices and Requirements for Harmonic Control in Electric Power Systems.

m. Joint Industrial Council (JIC)

n. LonMark® International

o. Occupational Safety and Health Act (OSHA)

p. Federal Communications Commission (FCC), Parts 15 and 16

q. National Electric Code (NEC).

r. Uniform Mechanical Code.

s. Uniform Building Code.

t. Uniform Plumbing Code.

G. Product Applicable Standards. All distributed, standalone, and unitary controllers supplied shall be in compliance with the following listings and standards:
1. UL916 for Open Energy Management (for U.S. and Canada).
2. FCC Part 15, Sub-Part B, Class A.
3. CE Electro Magnetic Compatibility.

H. All microprocessor based control products used shall conform to either the LONMARK® or LonWorks Interoperability Standards or the BACnet ASHRAE/ANSI 135 Standard including all current addenda and annexes dependent upon which communications protocol is being utilized.

I. For equipment types that LONMARK® or BACnet devices do not exist, a Modbus interface to that equipment must be provided upon approval of WCPSS. The use of all proprietary equipment is prohibited. It is the Contractor’s responsibility to verify that the equipment manufacturers provide the appropriate interface boards as defined in these specifications and design drawings.

J. The contractor shall provide hardware and software components of the same manufacturer wherever possible.

K. The contractor shall use standard off-the-shelf components and/or products whenever possible. Custom products shall not be used unless approved by WCPSS prior to the installation.

L. Materials and equipment shall be catalogued products and shall be manufacturer’s latest standard design that complies with the specification requirements. Where multiple units of the same type or function are required for this project, these units shall be products of a single manufacturer.

M. All equipment shall be manufactured, installed, and tested to comply with the acceptance testing requirements specified herein.

N. Product Line Demonstrated History: The product line being proposed for the Project must have an installed history of demonstrated satisfactory operation for a length of two (2) years since date of final completion in at least ten (10) installations of comparative size and complexity. Submittals shall document this requirement with references.

O. Installer's Qualifications: The Contractor shall have a successful history in the design and installation of LONWORKS® or BACnet based Building Automation Systems with web browser based monitoring and control via and Enterprise network. Contractor must demonstrate experience in BAS installations for not less than 5 years and in DDC installation projects with point counts equal to this Project and systems of the same character as this Project. If installer is a Value Added Reseller (VAR) of a manufacturer's product, installer must demonstrate at least three years prior experience with that manufacturer's products. Experience starts with awarded Final Completion of previous projects. Submittals must document this experience with references.

P. Installer's Experience with Proposed Product Line: Firms shall have specialized in and be experienced with the installation of the proposed product line for not less than five years from date of final completion on at least ten (10) projects of similar size and complexity. Submittals shall document this experience with references.

Q. Installer's Field Coordinator and Sequence Programmer Qualifications: Individual(s) shall specialize in and be experienced with LONWORKS® or BACnet and Niagara N4 control system installation for not less than five (5) years. Installer shall include a list of qualified employees on staff with specific experience that will be committed to the project. Proposed field coordinator shall have experience with the installation of the proposed product line for not less than five (5) projects of similar size and complexity. Installer shall submit the names of the proposed individual and at least one alternate for each duty. Submittals shall document this experience with references. Proposed individuals must show proof of the following training:
   1. Product Line Training: Individuals overseeing the installation and configuration of the proposed product line must provide evidence of the most advanced training and certifications offered by the manufacturer(s) on that product line for installation and configuration.
   2. Programming Training: Individuals involved with programming the Site-specific sequences shall provide evidence of the most advanced programming training and certifications offered by the vendor of the programming application offered by the manufacturer(s). Engineering services shall be performed by factory-trained engineers. Include relevant documentation in submittal package.

R. Installer's Service Qualifications: The installer must be experienced in control system operation, maintenance, and service. Installer must document a minimum five (5) year history of servicing installations of similar size and complexity. Installer must document at least a one year history of servicing the proposed product line. Installer must also provide references and examples of projects that have been completed.

S. Coordinate with the Owner to ensure that the BAS will perform in the Owner's IT environment without disruption to any of the other activities taking place on that LAN or WAN. Coordinate device IDs with owner to prevent duplication within existing WCPSS BAS environment.

T. Uniformity: To the extent practical, all equipment of the same type serving the same function shall be identical and from the same manufacturer.

U. Installer's Response Time and Proximity:
   1. Installer shall have an office, which is staffed with LONWORKS® or BACnet and network infrastructure trained engineers and technicians fully capable of providing instruction and

routine emergency maintenance service on all system components within 24 hours of notification.

2. Installer shall have a service facility within a 50-mile radius of the job site, staffed with qualified service personnel as defined above, fully capable of providing instructions and routine or emergency maintenance service. The Installer must also have qualified staff able to respond to the job site to insure a response time of one hour or less for all construction and warrantee related issues. The Installer shall provide a dedicated team to the project if working on different projects simultaneously. Provide evidence of this as a condition of acceptance of bid. Local staff shall be qualified in all aspects related to the BAS control system repair and troubleshooting including, HVAC and mechanical equipment operation, network management, and DDC controller programming and configuration.

V. Install control devices in accessible location with reasonable working access. Coordinate all control device locations with other trade contractors. Contractor to report to A/E conditions that prevent reasonable accessibility.

W. Provide weather protection cover or weatherproof control devices where required for control devices located outdoors.

X. All control devices located outdoors shall be rated for the anticipated environment.

1.07 PROJECT CLOSEOUT

A. At conclusion of each day's work, clean up and remove from the site all rubbish, debris and trash accumulated during the day as a result of work of the Contractor. Sidewalks and streets adjoining the property shall be kept broom clean and free of debris, rubbish, trash, and obstructions of any kind caused by work of this Contract.

B. Upon completion of the work and at times during progress of the work when requested by WCPSS, the Contractor shall remove all surplus materials, rubbish, and debris resulting from the operation, and shall leave the entire building and involved portions of the site, insofar as the work of the Contract is concerned, in neat, clean, and acceptable condition as approved by Owner.

C. Marks on walls or ceiling tiles caused by the Contractor shall be cleaned by the Contractor. Ceiling tiles, drywall, carpet, paint, and all architectural finishes damaged by the Contractor shall be replaced by the Contractor.

1.08 ABBREVIATIONS AND ACRONYMS

AHU	Air Handling Unit
AI	Analog Input
ANSI	American National Standards Institute
AO	Analog Output
Approx.	Approximately
ASC	Application Specific Controller
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
ASPE	American Society of Plumbing Engineers
ASME	American Society of Mechanical
Engineers ASTM	American Society for Testing and
Materials ATC	Automatic Temperature Control System

AWG	American Wire Gauge (Standard)
BAS	Building Automation System
BMS	Building Management System
CAD	Computer Aided Design
CCC	Central Communications Controller
CCU	Central Control Unit
Contr.	Contractor
COS	Change of State
CPU	Central Processing Unit
CRAC	Computer Room Air Conditioning
CRT	Cathode Ray Tube
DALI	Digital Addressable Lighting Interface
DCP	Digital Control Panel
DDC	Direct Digital Controls
Deg. C or °C	Degree Celsius
DI	Discrete Input
Dia. or diam.	Diameter
DMA	Direct Memory Access
DO	Discrete Output
Dpr.	Damper
Dwgs.	Drawings
EP	Electric-pneumatic
EMCS	Energy Management Control System
FAC LAN	Facility Local Area Network
FPB	Fan powered (VAV) box
FPM	Feet per minute
FACP	Fire Alarm Control Panel
FCC	Fire Command Center
FCIP	Firefighters' Control and Indicating Panel
FMS	Facility Management System
Galv.	Galvanized
GUI	Graphical User Interface
HVAC	Heating Ventilating and Air Conditioning
I/O	Input/Output
ISA	Intelligent Sensor or Actuator
LNS	LONWORKS® Network Services
NC	Network Controller

NSS	Network Services Server
NSI	Network Services Interface
Mfr.	Manufacture
Mfgr.	Manufacturer
Max.	Maximum
Min.	Minimum, Minute
MMI	Man-Machine Interface
MSCP	Mass Storage Control Protocol
MSI	Master System Integrator

NCP	Network Control Panel
NEC	National Electrical Code
NI	Network Integrator
NIC	Not in Contract
NFPA	National Fire Protection Association
O.C.	On Center
O.D.	Outside Diameter
OS	Operating System
PE	Pneumatic-electric
Per	According to, in accordance with
PCU	Programmable Control Unit
PRV	Pressure Reducing Valve
Provide	Furnish and install
RAM	Random Access Memory
ROM	Read Only Memory
RTD	Resistance Temperature Device
SCADA	Supervisory Control and Data Acquisition System
SI	Systems Integrator
SNVT	Standard Network Variable Type
TCP/IP	Transmission Control Protocol / Internet Protocol
THHN	Thermoplastic High Heat Resistant Nylon Coated-Cable coating
TP	Twisted Pair
UBC	Uniform Building Code
UL	Underwriters' Laboratory
UMC	Uniform Mechanical Code
UML	Unified Modeling Language
UPS	Uninterruptible Power Supply
VAV	Variable Air Volume
VCS	Voice Communication System
VFD	Variable Frequency Drive
XIF	LONMARK® Product Information Files
XML	Extensible Markup Language

PART 2 PRODUCTS

2.01 MANUFACTURERS: CONTROLS CONTRACTORS SHALL BE TRIDIUM AND/OR LONMARK OR BACNET FACTORY AUTHORIZED AGENT OR DEALER OF control hardware and controls system interface. The controls contractors' principal business shall be providing building automation systems. Bids by contractors, franchised dealers, wholesalers, or any other firm whose principal business is not that of manufacturing, or installing building automation systems, shall not be acceptable.

2.02 BAS SERVER & WEB BROWSER GUI

2.02.1 SYSTEM OVERVIEW:

A. The BAS Contractor shall provide system software based on server/thin-client architecture, designed around the open standards of web technology. The BAS server shall communicate using Ethernet and TCP\IP. Server shall be accessed using a web browser over Owner intranet and remotely over the Internet.

B. Graphic software shall facilitate user-friendly interface to all aspects of the System Software. The intent of this Specification is to require a graphic package that provides for intuitive operation of the systems without extensive training and experience. It shall facilitate logical and simple system interrogation, modification, configuration, and diagnosis. The Operator Interface shall provide for overall system supervision, graphical user interface, management report generation, alarm annunciation, and remote monitoring. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™. No special software, other than free public domain programs such as "JAVA VIRTUAL MACHINE" shall be required to be installed on PC's used to access the BAS via a web browser.

C. The systems shall be configured for mobile devices. Refer to Section 2.03.5 Mobile Device for detailed description.

D. The number of network controllers required is dependent on the type and quantity of devices installed. It is the responsibility of the Contractor to determine the quantity and type of devices. The Contractor shall be responsible to properly install the correct number (increase if required) of network controllers from the designed minimum shown on the BAS documents. The Contractor shall confirm the designed network load and architecture with the capabilities of the selected Network Controller. If network communications issues arise as a result of a limited Network Controller resource count the Network Integrator shall furnish, install, and implement additional Network Controllers to reduce the network traffic on each Network Controllers Local Operating Network to less than 50% of maximum bandwidth as recommended by the manufacturer. The total capacity includes all imbedded applications as well as design specific applications. Refer to Section 1.05.A.3.n for calculated and guaranteed system response time for submittal requirements.

E. The web browser GUI shall provide an interactive user interface and must offer and be configured with the following features as a minimum:
1. Trending.
2. Scheduling.
3. Electrical demand limiting.
4. Real time 'live' Graphic Programs.
5. Tree Navigation.
6. Parameter change of properties.
7. Set-point Adjustments.
8. Alarm / Event information.
9. Configuration of operators.
10. Execution of global commands.
11. Add, delete, and modify graphics and displayed data.

F. Software Components: All software components of the BAS system software shall be provided and installed as part of this project. BAS software components shall include:
   1. System Configuration Utilities for future modifications to the system, and controllers shall include all software and programming not specifically itemized in these specifications, which is necessary to implement, maintain, operate, and diagnose the system in compliance with these Specifications.
   2. Graphical Programming Tools.
   3. Direct Digital Control Software.
   4. Application Software.

2.02.2 WEB BROWSER GRAPHICAL USER INTERFACE

A. Web Browser Navigation: The Thin Client web browser GUI shall provide a comprehensive user interface. Using a collection of web pages, it shall be constructed to "feel" like a single application and provide a complete and intuitive mouse/menu driven operator interface. It shall be possible to navigate through the system using a web browser to accomplish requirements of this specification. The Web Browser GUI shall (as a minimum) provide for navigation, and for display of animated graphics, schedules, alarms/events, live graphic programs, active graphic setpoint controls, configuration menus for operator access, reports, and reporting actions for events and trends.

B. Login: On launching the web browser and selecting the appropriate domain name or IP address, the operator shall be presented with a login page that will require a login name and password. Navigation in the system shall be dependent on the operator's role privileges.
   1. Sites with multiple JACE's shall have a single log in to observe graphics and trending for that location. Multiple logins for JACE's located on the same site will be unacceptable.

C. Navigation: Navigation through the GUI shall be accomplished by clicking on appropriate level of a navigation tree (consisting of expandable and collapsible tree control like Microsoft's Explorer program), and/or by selecting dynamic links to other system graphics. Both the navigation tree and action pane shall be displayed simultaneously, enabling the operator to select a specific system or equipment, and view the corresponding graphic. The navigation tree shall as a minimum provide the following views: Home, Files, History and Configuration.
   1. Home view shall display graphical categories such as Floor Plans, Central Plant, Air Handlers, Service Screens, and As-Builts.
   2. Configuration View shall display all the configuration categories (Services, Drivers, Global Folder, Schedules Folder).

D. Action Pane: The Action Pane shall provide several functional views for each HVAC or mechanical/electrical subsystem specified. A functional view shall be accessed by clicking on the corresponding button:

   1. Graphics: Using graphical format suitable for display in a web browser, graphics shall include, color building floor-plans, equipment drawings, active graphic set-point controls, web content and other valid HTML elements. Real-time values displayed on a Web page shall update automatically without requiring a manual "refresh" of the Web page.
   2. Properties: Shall include graphic controls and text for the following: Locking or overriding objects, demand strategies, and any other valid data required for setup. Changes made to the properties pages shall require the operator to depress an 'accept/cancel' button.
   3. Schedules: Shall be used to create, modify/edit and view schedules based on the systems geographical hierarchy (using the navigation tree). The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphical User Interface. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.
   4. Alarms: Shall be used to view alarm information geographically (using the navigation tree), acknowledge alarms, sort alarms by category, actions and verify reporting actions.
   5. Trends: Shall be used to display associated trend and historical data, modify colors, date range,

axis, and scaling. Refer to O&M documents for definition of trends, i.e. duration, start/stop points and set-points and example graphics.

6. Logic - Live Graphic Programs: Shall be used to display' live' graphic programs of the control algorithm, (micro block programming) for the mechanical/electrical system selected in the navigation tree.
7. Other actions such as Print, Help, Command, and Logout shall be available via a drop- down window.

E. Point Structuring and Naming
1. The intent of this Section is to require a consistent means of naming points across WCPSS WAN. Configure the systems from the perspective of WCPSS WAN, not solely the local Project. The following requirement establishes a standard for naming points and addressing Buildings, Networks, Devices, Instances, and the like. The convention is tailored towards WCPSS WAN and as such, the interface shall always use this naming convention. LonMark and BACnet systems shall also use this naming convention. For non-LonMark and BACnet systems, the naming convention shall be implemented as much as practical, and any deviations from this naming convention shall be approved by WCPSS.
2. Each Network Controller shall have English language descriptors for all system points, variables, parameters etc. located and accessible from the NC memory. All point naming shall match between all system files and record documents.
3. Point Summary Table: The term 'Point' is a generic description for the class of object represented by analog and binary inputs, outputs, and values. With each schematic, Network Integrator shall provide a Point Summary Table listing:
   a. Equipment type.
   b. Equipment number.
   c. Equipment code.
   d. Full point name (see Point Naming Convention paragraph).
   e. Point description.
   f. Object type.
   g. Engineering units.
   h. Network variable.
4. Additional fields for non-LonMark or BACnet systems shall be appended to each row. Point Summary Table shall be provided in both hard copy and in electronic format (ODBC-compliant).
5. Point Summary Table shall also illustrate Network Variable Data Links.
6. The System Integrator shall coordinate with WCPSS representative to compile and submit a proposed Point Summary Table for review prior to any object programming or Project startup. WCPSS shall grant approval of final point names to be verified through Commissioning by issuing the approved alarms to the System Integrator.
7. The Point Summary Table shall be kept current throughout the duration of the Project by the installer as the Master List of all points for the Project. Project closeout documents shall include an up-to-date accurate Point Summary Table. The System Integrator shall deliver to WCPSS the final Point Summary Table prior to final acceptance of the system. The Point Summary Table shall be used as a reference and guide during the Commissioning process.
8. The Point Summary Table shall contain all data fields on a single row per point. The Point Summary Table is to have a single master source for all point information in the building that is easily sorted and kept up-to-date. Although a relational database of Device ID-to-point information would be more efficient, the single line format is required as a single master table that will reflect all point information for the building. The point description shall be an easily understandable English-language description of the point.

Point Summary Table - Example	
(Transpose for a single point per row format)	
Equipment Type	Air Handler (AH)
Equipment Number	031

Point Summary Table - Example	
(Transpose for a single point per row format)	
Equipment Code	SAT
*Point Name (Object Name)	LIB04_1000a_AH031_SAT
*Point Description (Object Description)	AH031 Supply Air Temperature
Object Type	AI
Engineering Units	Deg F
Network Variable	SNVT_temp
*Represents information that shall reside in the relevant property for the object	

F. Color Graphics: The Web Browser GUI shall make extensive use of color in the graphic pane to communicate information related to set-points and comfort. Animated .gifs or .jpg, vector scalable, active set-point graphic controls shall be used to enhance usability. Graphics tools used to create Web Browser graphics shall be non-proprietary and conform to the following basic criteria:
   1. Display Size: The GUI workstation software shall graphically display in 1024 by 768 pixels 24 bit True Color.
   2. Color Floor Plans: Floor plan graphics shall show heating and cooling zones, as well as lighting, security, and refrigeration equipment zones throughout the buildings in a range of colors, as selected by Owner. Provide a visual display of temperature relative to their respective set-points. The colors shall be updated dynamically as a zone's actual comfort condition changes.
   3. Mechanical Components: Mechanical system graphics shall show the type of mechanical system components serving any zone through the use of a pictorial representation of components and shall include selected I/O points being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Animation shall be used for rotation or moving mechanical components to enhance usability.
   4. Minimum System Color Graphics: Color graphics shall be selected and displayed via a web browser for the following:
      a. Each piece of equipment monitored or controlled including each terminal unit.
      b. Each building.
      c. Each floor and zone controlled.

G. Zone Set-point Adjustments: Color floor plans displayed via a web browser shall utilize a contiguous band of colors, as selected by Owner. Each corresponding actual zone temperatures shall vary color relative to the desired active set-point. The ideal temperature shall be shown as a neutral (white, transparent) color band. Temperatures slightly warmer than ideal shall be shown in light red, and even warmer temperature band shall be shown in red. Temperatures slightly cooler than ideal shall be light blue, and even cooler temperatures shall be shown as dark blue. Active Zone Graphic Set-point Controls: Utilizing a mouse, it shall be possible to select occupied or unoccupied set-points to increase or decrease heating and cooling set-points. In addition, an operator may type the numeric value of the heating and cooling set-points.

H. Hierarchical Schedules: Utilizing the Navigation Tree displayed in the web browser GUI, an operator (with password access) shall be able to define a Normal, Holiday or Override schedule for an individual piece of equipment or room, or choose to apply a hierarchical schedule to the entire system, site, or floor area. For example, Independence Day 'Holiday' for every level in the system would be created by clicking at the top of the geographic hierarchy defined in the Navigation Tree. No further operator intervention would be required and every control module in the system with would be automatically downloaded with the 'Independence Day' Holiday.
   1. Schedules: Schedules shall comply with the LonWorks or BACnet standards, (Schedule Object, Calendar Object, Weekly Schedule property and Exception Schedule property) and shall allow events to be scheduled based on:
      a. Types of schedule shall be Normal, Holiday or Override.
      b. A specific date.
      c. A range of dates.
      d. Any combination of Month of Year (1-12, any), Week of Month (1-5, last, any), Day of Week (M-Sun, Any).
      e. Wildcard (example, allow combinations like second Tuesday of every month).
   2. Schedule Categories: The system shall allow operators to define and edit scheduling categories (different types of "things" to be scheduled; for example, lighting, HVAC occupancy, etc.). The categories shall include: name, description, icon (to display in the hierarchy tree when icon option is selected) and type of value to be scheduled.
   3. Schedule Groups: In addition to hierarchical scheduling, operators shall be able to define functional Schedule Groups, comprised of an arbitrary group of areas/rooms/equipment scattered throughout the facility and site. For example, the operator shall be able to define an 'individual tenant' group – who may occupy different areas within a building or buildings. Schedules applied to the 'tenant group' shall automatically be downloaded to control modules affecting spaces occupied by the 'tenant group.'
   4. Intelligent Scheduling: The control system shall be intelligent enough to automatically turn on any supporting equipment needed to control the environment in an occupied space. If the operator schedules an individual room in a VAV system for occupancy, for example, the control logic shall automatically turn on the VAV air handling unit, chiller, boiler, and/or any other equipment required to maintain the specified comfort and environmental conditions within the room.
   5. Partial Day Exceptions: Schedule events shall be able to accommodate a time range specified by the operator (ex: board meeting from 6 pm to 9 pm overrides Normal schedule for conference room).

I. Alarms: Alarms associated with a specific system, area, or equipment selected in the Navigation Tree, shall be displayed in the Action Pane by selecting an 'Alarms' view. Alarms, and reporting actions shall have the following capabilities:
   1. Alarms View: Each Alarm shall display an Alarms Category (using a different icon for each alarm category), date/time of occurrence, current status, alarm report, and a bold URL link to the associated graphic for the selected system, area, or equipment. The URL link shall indicate the system location, address, and other pertinent information. An operator shall easily be able to sort events, edit event templates and categories, acknowledge, or force a return to normal in the Events View as specified in this section.
      a. System shall support displaying of alarms on any display as a user defined sizable object, which may be placed by itself or along with other objects in a window. It shall be possible to scroll forward or backward through the alarm displays by depressing command buttons. Current Alarms shall be available as an Alarm Summary Object and a chronological summary of Alarms shall be available as an Alarm History object.
      b. The operator shall be able to select the alarms displayed by an object alarms by group and/or priority by using command buttons. Up to 999 priority levels shall be supported.

2. Alarm Categories: The operator shall be able to create, edit or delete alarm categories such as HVAC, Maintenance, Fire, or Generator. An icon shall be associated with each alarm category, enabling the operator to easily sort through multiple events displayed.
3. Alarm Notification: It shall be possible to configure the system such that the operator is notified of an alarm no matter what display he or she is currently viewing. Notification shall include the option of a pop-up alarm display window, a flashing process symbol, such as a process vessel, an alarm text message that is available on each display, or a dedicated alarm display window on the screen.
   a. The user shall be able to display alarms on an individual or a group basis, with support for sixteen (16) groups, each having up to sixteen (16) subgroups. The alarm hierarchy shall be capable of being nested up to eight (8) levels deep.
   b. It shall be possible to inform the operator of an alarm condition via an audible tone, a pop-up display, or any combination of animation types on the screen. Alarm acknowledgment may be performed on all alarms, alarms in a single group, and alarms in a collection of groups as defined in an alarm group hierarchy or on a point- by-point basis.
4. Alarm File Capability:
   a. Alarms shall be logged to a file for future viewing or review of alarm history data. The user shall have the capability to review the file for cause and event analysis.
   b. The alarms that are logged shall be configurable from a choice of the parameters.
5. Alarm Transmission Capability:
   a. Alarms shall be transmitted over WCPSS secure internal wide area network.
   b. Each alarm shall be associated with a priority level and unique user-defined list of operator devices including any combination of local or remote workstations, printers, workstation disk files, e-mail addresses, and pagers. All alarms associated with a given priority level shall be routed to all operator devices on the user-defined list associated with that priority level. For each priority level, alarms shall be automatically routed to a default operator device in the event that alarms are unable to be routed to any operator device assigned to the priority level.
6. Alarm Templates: Alarm template shall define different types of alarms and their associated properties. As a minimum, properties shall include a reference name, verbose description, severity of alarm, acknowledgement requirements, and high/low limit and out of range information.
7. Alarm Areas: Alarm Areas enable an operator to assign specific Alarm Categories to specific Alarm Reporting Actions. For example, it shall be possible for an operator to assign all HVAC Maintenance Alarm on the 1st floor of a building to email the technician responsible for maintenance. The Navigation Tree shall be used to setup Alarm Areas in the Graphic Pane.
8. Alarm Time/Date Stamp: All events shall be generated at the DDC control module level and comprise the Time/Date Stamp using the standalone control module time and date.
9. Alarm Configuration: Operators shall be able to define the type of Alarm generated per object. A ‘network’ view of the Navigation Tree shall expose all objects and their respective Alarm Configuration. Configuration shall include assignment of Alarm, type of Acknowledgement and notification for return to normal or fault status.
10. Alarm Summary Counter: The view of Alarm in the Graphic Pane shall provide a numeric counter, indicating how many Alarms are active (in alarm), require acknowledgement, and total number of Alarms in the BAS Server database.
11. Alarm Auto-Deletion: Alarms that are acknowledged and closed shall be auto-deleted from the database and archived to a text file after an operator defined period.
12. Alarm Reporting Actions: Alarm Reporting Actions specified shall be automatically launched (under certain conditions) after an Alarm is received by the BAS server software. Operators shall be able to easily define these Reporting Actions using the Navigation Tree and Graphic Pane through the web browser GUI. Alarms shall be color coded according to the state of the alarm, including an acknowledged alarm, unacknowledged alarm, and an alarm that has returned to normal, but is not yet acknowledged. The user shall be able to choose from 32 different colors for display of each of these alarm states. The alarm display object may also support event display with the color used for events also being one of the 32 different colors. Reporting Actions shall be as follows:
    a. Email: Email shall be sent via any POP3-compatible e-mail server (most Internet Service

Providers use POP3). Email messages may be copied to several email accounts.
b. Note: Email reporting action shall also be used to support alphanumeric paging
c. Services, where email servers support pagers.
d. File Write: The ASCII File write reporting action shall enable the operator to append
e. Operator defined alarm information to any alarm through a text file. The alarm information that is written to the file shall be completely definable by the operator. The operator may enter text or attach other data point information (such as AHU discharge temperature and fan condition upon a high room temperature alarm).
f. Write Property: The write property reporting action updates a property value in a hardware module.
g. SNMP: The Simple Network Management Protocol (SNMP) reporting action sends an SNMP trap to a network in response to receiving an alarm.
h. Run External Program: The Run External Program reporting action launches specified program in response to an event.

J. Trends: Trends shall both be displayed and user configurable through the Web Browser GUI. Trends shall comprise all analog, digital or calculated points simultaneously. A trend log's properties shall be editable using the Navigation Tree and Graphic Pane.
1. Viewing Trends: The operator shall have the ability to view trends by using the Navigation Tree and selecting a Trends button in the Graphic Pane located on every page. The system shall allow y- and x-axis maximum ranges to be specified and shall be able to simultaneously graphically display multiple trends per graph.
2. Local Trends: Trend data shall be collected locally by the JACE or Web Supervision, and periodically uploaded to the BAS server if historical trending is enabled for the object. Trend data, including run time hours and start time date shall be retained in non-volatile module memory. Systems that rely on a gateway/router to run trends are NOT acceptable.
3. Events: Events shall be logged for review by the operator, engineering, or management personnel. The system shall log each new operator log-on, and whenever an operator changes a set-point or turns any device on or off. Each time the event log records an event, it will record the operator logged in and the type of action taken (set-point change, state change, etc.), along with a date and time stamp.
4. Resolution. Sample intervals shall be as small as one second. Each trended point will have the ability to be trended at a different trend interval. When multiple points are selected for displays that have different trend intervals, the system will automatically scale the axis.
5. Dynamic Update. Trends shall be able to dynamically update at operator-defined intervals.
6. Zoom/Pan. It shall be possible to zoom-in on a particular section of a trend for more detailed examination and 'pan through' historical data by simply scrolling the mouse.
7. Numeric Value Display. It shall be possible to pick any sample on a trend and have the numerical value displayed.
8. Trend Point Naming. The naming convention for points shall be in plain English and separate the data using the underscore (_). (Example: AHU01_SupplyAirTemp, Vav01_15_SpaceTemp, Chilled Water Chiller Enable, HotWater_Boiler02_FireRate).
9. Copy/Paste. The operator must have the ability to pan through a historical trend and copy the data viewed to the clipboard using standard keystrokes (i.e. CTRL+C, CTRL+V).

K. Security Access: Systems that Security access from the web browser GUI to BAS server shall require a Login Name and Password. Access to different areas of the BAS system shall be defined in terms of Roles, Privileges and geographic area of responsibility as specified:
1. Roles: Roles shall reflect the actual roles of different types of operators. Each role shall comprise a set of 'easily understood English language' privileges. Roles shall be defined in terms of View, Edit and Function Privileges.
a. View Privileges shall comprise: Navigation, Network, and Configuration Trees, Operators, Roles and Privileges, Alarm/Event Template and Reporting Action.
b. Edit Privileges shall comprise: Set-point, Tuning and Logic, Manual Override, and Point Assignment Parameters.
c. Function Privileges shall comprise: Alarm/Event Acknowledgement, Control Module Memory Download, Upload, Schedules, Schedule Groups, Manual Commands, Print, and Alarm/Event Maintenance.

2.02.3 GRAPHICAL PROGRAMMING

The system software shall include a Graphic Programming Language (GPL) for all DDC control algorithms resident in all control modules. All systems shall use a GPL as a method used to create a sequence of operations by assembling graphic microblocks that represent each of the commands or functions necessary to complete a control sequence. Microblocks represent common logical control devices used in conventional control systems, such as relays, switches, high signal selectors, etc., in addition to the more complex DDC and energy management strategies such as PID loops and optimum start. Each microblock shall be interactive and contain the programming necessary to execute the function of the device it represents.

Graphic programming shall be performed while on screen and using a mouse; each microblock shall be selected from a microblock library and assembled with other microblocks necessary to complete the specified sequence. Microblocks are then interconnected on screen using graphic "wires," each forming a logical connection. Once assembled, each logical grouping of microblocks and their interconnecting wires then forms a graphic function block which may be used to control any piece of equipment with a similar point configuration and sequence of operation.

A. Graphic Sequence: The clarity of the graphic sequence must be such that the operator has the ability to verify that system programming meets the specifications, without having to learn or interpret a manufacturer's unique programming language. The graphic programming must be self-documenting and provide the operator with an understandable and exact representation of each sequence of operation.

B. GPL Capabilities: The following is a minimum definition of the capabilities of the Graphic Programming software (Refer to Part 4 – Appendix for specific examples):
   1. Function Block (FB): Shall be a collection of points, microblocks and wires which have been connected together for the specific purpose of controlling a piece of equipment or a single mechanical system.
   2. Logical I/O: Input/Output points shall interface with the control modules in order to read various signals and/or values or to transmit signal or values to controlled devices.
   3. Microblocks: Shall be software devices that are represented graphically and may be connected together to perform a specified sequence. A library of microblocks shall be submitted with the control contractors shop drawings, submittals and as-builts.
   4. Wires: Shall be Graphical elements used to form logical connections between microblocks and between logical I/O.
   5. Reference Labels: Labels shall be similar to wires in that they are used to form logical connections between two points. Labels shall form a connection by reference instead of a visual connection, i.e. two points labeled 'A' on a drawing are logically connected even though there is no wire between them.
   6. Parameter: A parameter shall be a value that may be tied to the input of a microblock.
   7. Properties: Dialog boxes shall appear after a microblock has been inserted which has editable parameters associated with it. Default parameter dialog boxes shall contain various editable and non-editable fields and shall contain 'push buttons' for the purpose of selecting default parameter settings.
   8. Icon: An icon shall be graphic representation of a software program. Each graphic microblock has an icon associated with it that graphically describes its function.
   9. Menu-bar Icon: Shall be an icon that is displayed on the menu bar on the GPL screen, which represents its associated graphic microblock.
   10. Live Graphical Programs: The Graphic Programming software must support a 'live' mode, where all input/output data, calculated data, and setpoints shall be displayed in a 'live' real-time mode.

   For each piece of equipment, the entire graphic program shall be displayed through the Web Browser GUI. The operator must have the ability to scroll or page through the entire 'live' graphic program as necessary. Piecemeal graphic programs that only show one part of equipment program at any one time are NOT acceptable. For example, when viewing an AHU live graphic program, the operator shall see

as much of the AHU graphic program as practical, not just the Heating Coil control.

2.03 BAS SYSTEM HARDWARE

2.03.1 BAS SERVER HARDWARE

A. Computer Configuration (Hardware Independent):

1. Central Server. Owner shall provide a dedicated BASserver.

B. Standard Client: The thin-client Web Browser BAS GUI shall be Microsoft Internet Explorer compatible to the latest version available at the time of project execution, (8.0 or later) capable of running on the latest Microsoft OS version available at the time of project execution. No special software shall be required to be installed on the PCs used to access the BAS via a web browser.

2.03.2 BUILDING LEVEL SUPERVISORY CONTROLLER (JACE):

A. These controllers contain the Niagara N4™ Framework. These controllers are designed to manage communications between the General Purpose Multiple Application Controllers, General Purpose Single Application Controllers, and Unitary Controllers which are connected to its communications trunks, manage communications between itself and other JACE's and with any operator workstations (OWS) that are part of the BAS, and perform control and operating strategies for the system based on information from any controller connected to the BAS.

B. The communication protocols utilized for peer-to-peer communications between Building Level Supervisory Controllers will be Niagara N4, BACnet TCP/IP and SNMP. Use of a proprietary communication protocol for peer-to-peer communications between Building Level Supervisory Controllers is not allowed.

C. Building Level Supervisory Controller must provide the following hardware features as a minimum:

1. One Ethernet Port-10/100 Mbs
2. One RS-232/485 port
3. One LonWorks Interface Module – 78KB FTT-10A, or BACnet equivalent.
4. Battery Backup for JACE soft shutdown
5. Flash memory for long term data backup
6. Up to 2 GB DDR3 SDRAM
7. Firmware Updates: The Building level supervisory controllers shall allow firmware updates to be performed remotely
8. Provide Uninterruptible Power Supply (UPS) capable of sustaining 30 minute utility power failure.

2.03.3 STANDALONE CONTROLLERS

The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system utilizing the EIA-709.1 protocol and BACnet or LonMark/LonWorks products, technology communication protocol in one open, interoperable system.

A. General Purpose Multiple Application Controllers:
1. General Purpose Multiple Application controllers must use LonWorks or BACnet as the native communication protocol between controllers.
2. General Specification. Each General Purpose Multiple Application Controller must be capable of standalone direct digital operation utilizing its own processor, non-volatile flash memory, input/output, and voltage transient and lightning protection devices. All non-volatile flash memory shall have a battery backup. Firmware revisions to the module shall be made from the BAS server or remotely over the Intranet or Internet. Controllers that require component changes to implement firmware revisions are NOT acceptable.
3. Point Programming. All point data, algorithms and application software within a controller shall be custom programmable. Program Execution. Each General Purpose Multiple Application

Controller shall execute application programs, calculations, and commands via a microcomputer resident in the controller. All operating parameters for application programs residing in each controller shall be stored in read/writable nonvolatile flash memory within the controller and will be able to upload/download to/from the BAS.

4. Self-Test Diagnostics. Each controller shall include self-test diagnostics, enabling the controller to report malfunctions to the BAS.Building level supervisory controller.
5. PID Loops. Each General Purpose Multiple Application Controller shall contain both software and firmware to perform full DDC Proportional, Integral, Derivative (PID) control loops and programs.
6. Digital Outputs shall be relays, or solid state switching 24 Volts AC or DC maximum, 3 amp maximum current. Each configured as normally open or normally closed
7. Universal Inputs shall be industry standard thermistors, RTD, 0-20mA - 24 VDC loop power, 250 Ohm input impedance, 0-5vdc, dry contact - 0.5mA maximum current.
8. Analog Output shall be electronic, voltage mode 0-10VDC or current mode 4-20mA.

B. General Purpose Single Application Controllers:
1. The General Purpose Single Application Controllers must use LonMark or BACnet as the native communication.
2. General Specification: General Purpose Single Application controllers must be capable of stand-alone DDC operation utilizing its own processor, nonvolatile flash memory, input/output, and voltage transient protection devices. Firmware revisions to the module shall be made from the Building level supervisory controller or remote locations over the Internet. Controllers that require component changes to implement Firmware revisions are NOT acceptable.
3. Point Programming: All point data, algorithms, and application software within the controllers shall be custom programmable.
4. Program Execution: Each General Purpose Single Application Controller shall execute application programs, calculations, and commands via a microcomputer resident in the controller. All operating parameters for the application program residing in each controller shall be stored in read/writable nonvolatile flash memory within the controller and will be able to upload/download to/from the Building level supervisory controller.
5. Self-Test Diagnostics: Each controller shall include self-test diagnostics, enabling the controller to report malfunctions the Building level supervisory controller.
6. PID Loops: Each General Purpose Single Application Controller shall contain both software and firmware to perform full DDC PID control loops.
7. Rooftop Mounting. The General Purpose Single Application Controllers shall be capable of being mounted directly in or on rooftop AHU equipment.
8. Operating Temperature. The General Purpose Single Application Controllers shall be capable of proper operation in an ambient temperature environment of -20□F to +150□F. (-28.9□ to 65.6□C.).
9. Input-Output Processing:
    a. Digital Outputs shall be relays, or solid state switching 24 Volts AC or DC maximum, 3 amp maximum current. Each configured as normally open or normally closed.
    b. Universal Inputs shall be industry standard thermistors, RTD, 0-20mA - 24 VDC loop power, 250 Ohm input impedance, Dry Contact - 0.5mA maximum current.
    c. Analog Electronic Outputs shall be voltage mode 0-10VDC or current mode 4- 20mA.
    d. Enhanced Zone Sensor Input shall provide a digital display of room temperature and setpoint, setpoint adjustment and push button override with status indicator. The sensor shall provide capability for connection to the controller network for controller programming. Selected locations will have this connection wired.

C. Unitary Controller Network (VAV TERMINALS):
1. Unitary Controllers:
    a. The Unitary Controllers shall LonMark or BACnet using EIA-709.1 as the native communications protocol between controllers on the unitary controller network.
    b. Enhanced Zone Sensor Input shall provide a digital display of room temperature and setpoint, adjustment and push button override with status indicator. The sensor shall provide capability for connection to the controller network for controller programming.

Selected locations will have this connection wired.

c. Airflow Transducer. In order to provide reliable Pressure Independent VAV operation, Unitary Controllers for pressure independent VAV applications shall have airflow transducer for accurate air measurement.

d. Actuator. Each Unitary Controller for VAV applications shall have a direct coupled electronic actuator with the following features:
   1) The actuator shall provide on-off/floating point control with a minimum of 35 in-lb. of torque, or greater if required due to terminal size or system pressure.
   2) The assembly shall mount directly to the damper operating shaft.
   3) The actuator shall not require any limit switches and shall be electronically protected against overload.
   4) The actuator shall automatically stop when reaching the damper or actuator end position.
   5) A visual pointer for the position of the actuator.
   6) The assembly shall have an anti-rotational strap supplied with the assembly that will prevent lateral movement.
   7) The actuator may be an integral controller/actuator assembly or a matched controller/actuator pair.

e. Visual Status. Each Unitary Controller and Unitary Controller Interface shall have LED indication for visual status of communication, power, and faults.

f. Standalone Algorithm. In the event of a loss of communication, each Unitary Controller shall control from a standalone algorithm, which maintains the assigned space temperature until communication with the Building level controller is restored.

g. Input/Output Processing:
   1) Digital outputs shall be relays, or solid state switching 24 Volts AC or DC maximum, having a 1 Amp maximum current. Each relay shall be configured as normally open or normally closed and provide a dry contact. Each unitary controller shall have a minimum of one spare programmable digital output.
   2) Universal inputs shall be dry contacts or 0-5VDC. 0-20ma dc or 0-20K Ohm input impedance.
   3) Analog output electronic, voltage mode 0-10VDC, current mode 0-20ma.

2.03.4 MOBILE DEVICE

A. Mobile Device Interface:
   1. General Purpose. A graphical interface shall be made available to mobile devices as a way to observe and address alarms, view general graphics, and make minor setpoint changes.
   2. Interface. The graphics shall be made available for use on Apple or Android technology, as specified by WCPSS. The display shall utilize English language descriptors rather than cryptic code and a menu penetration technique to access data.
   3. Points of Interest. Control interface points for the mobile devices shall include but not be limited to the following:
      a. Alarms
      b. Temperature setpoints
      c. On/off status of equipment in graphical or line based form.

2.03.5 BUILDING SYSTEMS INTEGRATION

A. The BAS System shall establish a seamless interconnection with other building, electrical and/or mechanical subsystems that employ the LONTALK or BACnet protocol (Chillers, Variable frequency drives, etc.). These systems shall be controlled, monitored, and graphically programmed with the same Graphical Programming Language (GPL) used for all other control modules.
   1. OEM Cooperation. Full cooperation by the Original Equipment Manufacturer (OEM) in this open protocol effort shall be a requirement for bidding this project.

2.03.6 FIELD HARDWARE/INSTRUMENTATION

A. Provide all remote sensing points and instrumentation as required for the systems. All sensors shall have accuracies as stated.

B. FIELD WIRING: For each digital device shall be two or three conductor No. 22 AWG, or larger twisted sets of copper conductors 300 volts, thermoplastic. When line voltage is present in conduits or wiring trays the insulation on all conductors shall be 600 volts. For multi-conductor wire having four or more conductors, wire size shall be not less than No. 20 AWG solid copper. Concealed accessible wiring may be installed as properly supported cable. Provide protective sleeves at wall and floor penetrations. Concealed inaccessible locations and mechanical rooms shall have wiring installed in properly sized, blue colored conduit.

C. SAFETY/STATUS SWITCHES
1. Snap action SPDT switches shall operate from a neoprene slack diaphragm, corrosion- resistant stainless steel diaphragm or copper diaphragm capable of being adjusted through the total pressure range. Switches shall withstand at least twice the working pressure of the system including any standing head and have a temperature range exceeding the worst case liquid and ambient temperature range conditions. Provide a NEMA 4 enclosure for the switch assembly. For ease of service and maintenance, install the switch with a 3 valve manifold piped in copper to pressure taps in the liquid lines.
2. Current sensing relay shall be used for pump motor status. The current sensing relay shall be adjustable within three ranges; .1-6amps, 6-40amps and 40-200amps. Contact rating shall be .15amps at 30VDC.
3. Differential air pressure switches shall be piped in parallel across fans for positive indication of flow. Static pressure sensing tips shall be used for both high and low inputs. Pressure range shall be adjustable between .07 and 1.0" W.C. Snap acting contact shall be rated at 300 VA at 120 VAC.

D. TEMPERATURE SENSOR
1. Stem or tip sensitive types.
2. Sensing elements shall be hermetically sealed.
3. Stem and tip construction shall be 304 stainless steel.
4. All external trim material shall be corrosion resistant designed for the intended application.
5. Thermometer wells shall be stainless steel. Heat transfer compounds shall be compatible with the sensors. All piping system sensors shall be installed in thermowells.

E. SENSOR ACCURACY - Sensors are only one element in the overall system accuracy to which the CU can respond. That response includes alarm decision, value display, value calculation on which analog values must be multiplied, subtracted, square rooted, etc. As such, the system end-to-end accuracies are herein stated. The following range/ accuracies are required:

± .5 for the air temperatures.
± 1.0 for water temperatures.
± 0.5 for water temperatures in the range 40 - 55 F. KWH and

KW monitoring within 1.0% of full scale value.

± 2.0 psig for water or steam pressure in the range of 0 - 200 psig.
± 1.0% of full scale value for potential or current transducers.
± 3.0% for 0-100% RH.
Sensors for differential temperature readings to be used in BTU calculations shall be a matched pair with a differential accuracy of plus or minus 0.1 degrees F.

F. Temperature Devices:
1. Type & Accuracy. Temperature sensors shall be of the type and accuracy indicated for the application. Sensors shall have an accuracy rating within 1% of the intended use temperature range.
2. Mixed Air Application. Sensors used for mixed air applications shall be the averaging type and have an accuracy of +1□F. (0.5□C). Sensors shall be of adequate length to accurately measure average temperature of coil or plenum area.
3. Outside Air Temperature Sensors. Outside air temperature sensors accuracy shall be within +1□F. (0.5□C.). Minimum operating span shall -50□F. to 150□F. Outside Air Temperature and Humidity Sensors (separate devices) shall be mounted in the outdoors where natural air flow occurs, away from any artificial affect from mechanical sources. The humidity sensor span shall be 0 – 100% RH. The sensors shall be independent devices, designed for exterior application; provide all required shielding.
4. Duct Temperature Sensors shall have an insertion measuring probe 6 inches long with a temperature range of -40 to 250 degrees F. The sensor shall include a utility box and gasket to prevent air leakage and vibration noise. For all mixed air and coil discharge air applications, install bendable averaging duct sensors with a minimum 5 foot long sensor element. Element shall provide adequate coil coverage.
5. Liquid Immersion Temperature Sensors shall have a temperature range of -40 to 250 degrees F.
6. Room Temperature Sensors. Room temperature sensors shall have an accuracy of ±1.0□F. Minimum operating span shall 45□F. to 95□F.). Sensors in corridor areas, gym, and locker rooms shall have a temperature range of 45□F. to 95□F. The corridor, gym, and locker room sensor shall be stainless steel plate with a thermistor thermally bonded to back, with fully insulated gasket. The gym and locker room stainless steel plate sensor shall include a push button override. Room sensors shall have a digital display of room temperature and setpoint, setpoint adjustment, integrated occupancy sensor and push button override with status indicator.
7. Chilled Water and Condenser Water Sensors. Chilled water and condenser water sensors shall have an accuracy of ±1.0□F. in their range of application. Minimum operating span shall be 0□F. to 125□F. Sensors shall be installed in stainless steel sensor wells.
8. Hot Water Temperature Sensors. Hot water temperature sensors shall have an accuracy of 1.0□F. Minimum operating span shall 0□F to 250□F. Sensors shall be installed in stainless steel sensor wells.
9. Kitchen Cooler and Freezer Sensors: Cooler and freezer sensors shall be thermobuffer style sensor. The probe shall be a minimum of 2 inches long constructed of stainless steel. The wiring connections shall be completed using sealant filled connectors to protect from moisture and oxidation. The operating span shall be from -40□F to185□F.

G. Pressure Instruments:
1. Differential Pressure and Pressure Sensors: Air pressure transmitter shall universally measure very low static or differential pressure using a variable capacitance technique. Static pressure shall measure in ranges from 0 to 10 inches water column. Operating pressure span and either unidirectional or bidirectional measurement shall be field selectable. Transmitter accuracy, including non-linearity, hysteresis and non- repeatability shall be within 1% of full scale. Pressure transducers shall have LCD display.
2. Pressure Switches: Snap action SPDT switches shall operate from a neoprene slack diaphragm, corrosion resistant stainless steel diaphragm or copper diaphragm capable of being adjusted through the total pressure range. Switches shall withstand at least twice the working pressure of the system including any standing head and have a temperature range exceeding the worst case liquid and ambient temperature range conditions.
3. Air pressure transmitter shall universally measure very low static or differential pressure using a variable capacitance technique. Static pressure shall measure in ranges from 0 to 10 inches water column. Operating pressure span and either unidirectional or bidirectional measurement shall be field selectable. Transmitter accuracy, including non-linearity, hysteresis and non-repeatability shall be within 1% of full scale. Pressure transducers shall have LCD display.
4. Flow Switches: Differential-pressure Venturi-type designed for installation in piping. Actuating

flow rated shall be field adjustable for the specified and indicated service. Switch location shall preclude exposure to turbulent or pulsating flow conditions. Where possible, install in a straight run of pipe at least 15 diameters in length to minimize false indications. Flow switch shall not cause pressure drop exceeding 2 psid at maximum system flow rate.

5. Status Switches: Current sensing relay shall be used for pump motor status. The current sensing relay shall be adjustable within three ranges; 0.1 - 6 amps, 6 – 40 amps, and 40 – 200 amps. Contact rating shall be 0.15 amps at 30 VDC.

H. Humidity Instruments
1. Duct Relative Humidity Sensors shall be duct-mounted devices that produce a linear output over the complete range of 0-100% RH. A thin film polymer sensing element shall respond quickly to changes in humidity and shall be protected from contamination by a sintered filter. The sensor shall be factory calibrated with periodic field recalibration capability. The sensor shall be mounted in a duct probe assembly and be installed only after the construction or renovation area is free of contamination.
2. Space Relative Humidity Sensors: The sensor shall be an analog precision capacitance type relative humidity detector. Sensing element shall be rated for the relative humidity range 0-100%.

I. CO2 Instruments: CO2 sensor shall utilize Non-dispersive infrared technology (NDIR) repeatable. Sensor repeatability shall be +/- 20 ppm, 0-2000. Sensor accuracy shall be <= 75 ppm over 0-1500 ppm range. Field selectable 4-20MA/0-5V/0-10V output with LCD display equal to Veris CD series.

J. Air Flow Monitoring Stations: Unless otherwise noted, monitor outdoor air volumes from duct mounted thermal dispersion air flow measurement systems. System shall employ bead in glass thermistor technology. Sensors shall be installed using an equal area sensor distribution. Thermistor signals shall be process by a 12 bit microprocessor based transmitter. Transmitter shall be 24vac powered. System shall be capable or processing any air flow rate from 0 to 5000FPM. Sensor accuracy shall be +/- 2% of reading with a +/- .25% repeatability. Sensors shall operate in conditions of -20˚ F to 160˚ F and 0 to 90% RH, non-condensing. Where indicated provide Air Flow Monitoring Station equal to Ebtron with remote indicating readout panels. Install readout panels a maximum of 6’-0” above the finished floor in the closest Mechanical Room.

K. Water Flow Metering – Hydronic heating and cooling: Provide water flow meters equal to Onicon F-1210 Dual Turbine.

L. WATER DIFFERENTIAL PRESSURE SENSOR
1. Sensor shall have three switch selectable ranges: (5, 10, 25, 50).
2. Sensor shall have test mode to produce full-scale output automatically.
3. Sensor shall have provision for zeroing by pushbutton or digital input.
4. Sensor shall have field selectable outputs of 0-5v, 0-10v, and 4-20ma.
5. Sensor shall have two pressure sensors.
6. Sensor shall operate from 24vdc or 24vac. (AC power applies to operation in voltage mode only).
7. Sensor housing shall be powder-coated steel.
8. Sensor shall have NEMA 4 rating.
9. Sensor shall have a port swap feature.
10. Sensor accuracy shall be +/-1% FS combined linearity, hysteresis, and repeatability.
11. Sensor overpressure ratings shall be 2x max. FS range proof and 5x max. FS range burst.
12. Sensor shall be provided with LCD display.
13. Provide pressure differential transmitter equal to Veris PWL-N-04 with Kele BVA enclosure. Provide pressure gauge upstream and downstream of transmitter.

M. Output Devices:
1. Control Relays.
2. Solid State Relays (SSR).

N. Valve and Damper Actuators:
   1. Basis of design: Belimo.
   2. Electronic Direct-Coupled. Electronic direct-coupled actuation shall be provided.
   3. Actuator Mounting. The actuator shall be direct-coupled over the shaft, enabling it to be mounted directly to the damper shaft. Where a shaft extension is required a manufactured option accessory shall be used. Field fabricated extensions and couplers will not be allowed. The actuator shall employ a V-bolt and toothed V-clamp fastening technique. Single point bolt or screw type fastener for circular valve and damper shafts is unacceptable.
   4. Electronic Overload Sensing. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the entire rotation of the actuator. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable.
   5. Power Failure/Safety Applications. For power failure/safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Non- mechanical forms of fail-safe operation are not acceptable.
   6. Spring Return Actuators. All spring return actuators shall be capable of both clockwise and counterclockwise spring return operation by simply changing the mounting orientation.
   7. Proportional Actuators. Proportional actuators shall accept a 0 to 10VDC or 0 to 20mA control input and provide a 2 to 10VDC or 4 to 20mA operating range. An actuator capable of accepting a pulse width modulating control signal and providing full proportional operation of the damper is not acceptable.
   8. 24 Volts (AC/DC) actuators. All 24VAC/DC actuators shall operate on Class 2 wiring and shall not require more than 20VA for AC or more than 8 watts for DC applications. Actuators operating on 120VAC power shall not require more than 20VA. Actuators operating on 230VAC shall not be acceptable.
   9. Non-Spring Return Actuators. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators shall have a manual crank for this purpose.
   10. Modulating Actuators. All modulating actuators shall have an external, built-in switch to allow reversing direction of rotation.
   11. Conduit Fitting. Actuators shall be provided with a conduit fitting.
   12. U.L. Listing. Actuators shall be Underwriters Laboratories Standard 873 listed.
   13. Warranty. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque and shall have a minimum 5-year manufacturer's warranty.
   14. Actuators shall be selected utilizing no more than 80% of the cataloged torque rating.
   15. Actuators shall be electronic, low voltage (24 VAC/VDC), NEMA 2 rated for all applications. Two- position may utilize 120 VAC actuators. Actuators shall have UL, CSA and ISO 9001 certification and approvals. Actuators shall have a minimum operating range of –22□ to 122□F. Optional auxiliary switches shall be available if required by the sequence. Actuators shall be fully modulating/proportional, floating/tri-state, or two- position as required. Pulse width modulation is unacceptable. Actuators shall have visual position indicators. Proportional actuators shall be field programmable to operate in sequence with other devices without additional transducers. All actuators except two- position shall be capable of providing a constant rotation rate independent of the load. Actuators used on dampers or valves shall be designed to directly couple to a stem, shaft or ISO style-mounting pad. Damper actuators or damper actuators adapted for use with control valves shall utilize V-bolt toothed V-clamp shaft fastening technique. Single point, bolt, or single screw type shaft fastening techniques for circular or round damper or valve shafts is unacceptable.

O. Valves: Controls subcontractor shall be responsible for selection of the proper control valves including line size, pressure rating, flow-coefficient, shutoff rating and allowable leakage factor. Valves 2 1/2 inches and larger shall have minimum 125 psig cast-iron body and shall have stainless steel stems and Flanged connections with field replaceable packing. Valves smaller than 2 1/2 inches shall be constructed of brass with screwed connections, stainless steel stems and field replaceable packing. Ball Valves 2” and less shall have forged brass or bronze bodies rated for a minimum 250 psi,

bronze or reinforced Teflon seats, equal percentage flow characteristics in 2-Way applications, liner or constant flow in 3-Way applications, a spring loaded Teflon , EPDM or dual EPDM o-ring packing, and stainless steel or brass stems. Butterfly valves shall have a fully lugged, drilled, and tapped, cast iron body. Flanges shall meet ANSI 125/150 standards. The one-piece body shall have an extended neck allowing clearance for flanges and piping insulation. The disc shall be stainless steel and provide bi-directional bubble-tight close off in either direction. The flow characteristic shall be modified equal percentage for 2-way and linear for 3-way valves. Furnish a cartridge type, non-collapsing, EPDM seat. The disk shall have full 360-degree concentric seating. The shaft shall be supported at multiple (minimum three) locations. No gaskets shall be required between the valve and flange faces. Three-way butterfly valves shall utilize independent actuators for each valve body; connecting linkage is not acceptable.

P. Dampers: Control dampers shall be opposed blade (except where two-position action is indicated) with interlocking gasketed edges, jamb seals and ball type oilite bearings. Blades and frames shall have galvanized finish. Frames shall not be less than 5" X 1/2" X 16 gauge channel steel and shall be reinforced to form a rigid assembly. Blades shall be 16 gauge with maximum blade width of 10". All outside air and relief/exhaust air dampers shall be spring return normally closed and have independent control.

Dampers over four feet high or wide, or over 16 sq. ft. shall be built in two or more sections with interconnections on every other blade. Gasket material shall be molded neoprene or approved equal. Damper leakage shall not exceed 6.0 CFM/SF at 1" SP, fully closed. Damper shall be installed with damper shafts in horizontal plane, unless supplied with bearing rated for vertical thrust.

Q. VARIABLE VOLUME TERMINAL CONTROL UNIT: Provide PID control for damper and valve control. The Room Sensor for VAV terminal units shall have a digital display of room temperature and set-point, set-point adjustment and push button override with status indicator. The VAV terminal unit discharge sensor shall be an insertion type probe.

R. Mylar labels shall be provided to identify all control components and points of connection.

2.04 DDC SOFTWARE

2.04.1 OVERVIEW

The system shall continuously perform Direct Digital Control (DDC) functions at the local control module in a stand-alone mode. Using Graphical Programming, the operator shall be able to design and modify control sequence of operation and all tuning parameters.

A. Minimum Function: Each control module shall perform the following functions:
   1. Identify, time/date stamp.
   2. Execute all application programs specified.
   3. Execute DDC algorithms.
   4. Trend and store data.

B. Control Failure Mode: In the event of a control module failure, all points under its control shall be commanded to the failure mode. All DDC software shall reside in the respective control module.
   1. Orderly Shutdown. Power failures shall cause the control module to go into an orderly shutdown with no loss of program memory.
   2. Automatic Restart. Upon resumption of power, the control module shall automatically restart and print out the time and date of the power failure and restoration at the respective Workstation system.
   3. Automatic Restart. The restart program shall automatically restart affected field equipment. The operator shall be able to define an automatic power up time delay for each piece of equipment under control.

2.05 APPLICATIONS SOFTWARE

2.05.1 GENERAL

All software application algorithms described below MUST reside at the local Building/Area level, Multi-Application, Single-Application, or Unitary Controller level. Systems that rely on a workstation PC, server, or router to perform these functions are NOT acceptable. The following applications software shall be provided for the purpose of optimizing energy consumption while maintaining occupant comfort:

A. Time of Day Scheduling (TOD): The system shall be capable of the following scheduling features:
   1. Schedule by Type. Scheduling by building, area, zone, groups of zones, individually controlled equipment, and groups of individually controlled equipment. Each schedule shall provide beginning and ending dates and times (hours: minutes). A weekly repeating schedule, i.e. between 8:00 a.m. and 5:00 p.m., Monday through Friday shall constitute one schedule.
   2. Schedule in Advance. Dated schedules shall be entered up to 9 (nine) years in advance.
   3. Self-Deleting. Schedules shall be self-deleting when effective dates have passed.
   4. Leap Year. Leap years shall be adjusted automatically without operator intervention.

B. Optimum Start/Stop (OSS)/Optimum Enable/Disable (OED): This application provides software to start and stop equipment on a sliding schedule based on the individual zone temperature and the heating/cooling capacity in °F. /hour of the equipment serving that zone. The heating/cooling capacity value shall be operator adjustable. Temperature compensated peak demand limiting shall remain in effect during morning start up to avoid setting a demand peak.
   1. Optimum Stop: Optimum Stop shall not be enabled on equipment more than one (1) hour prior to previously scheduled stop.

C. Demand Limiting (DL) - Temperature Compensated: The DL application shall be capable of four separate times of day KW demand billing rate periods. The system shall be capable of measuring electrical usage from multiple meters serving one building and each piece of equipment being controlled on the LAN shall be programmable to respond to the peak demand information from its respective meter.
   1. Sliding Window. The demand control function shall utilize a sliding window method. The sliding window interval and increment shall be operator selectable in increments of one minute, up to 60 minutes.
   2. Set-points for Defined Demand Level. The operator shall have the capability to set a initial set-point and a maximum set-point for each demand period. The initial set-point shall automatically increase by a user defined increment if the electrical demand is above set-point and all loads have been shed. The set-point shall only increase to the maximum set-point value.
   3. Information Archiving. The system shall archive demand and usage information for use at a later time. System shall permit the operator access to this information on a current day, month to date and a year to date basis.

D. Unoccupied High/Low limit: The system shall allow the space temperature to drift down [up] within a preset [adjustable] unoccupied temperature range. The heating [cooling] shall be activated upon reaching either end of the High/low limit range and shall remain activated until the space temperature returns to the High/low limit range.
   1. Outside & Exhaust Air. The system shall close all outside air and exhaust air dampers and stop all exhaust fans during the unoccupied period
   2. Unoccupied Space Temperature. Unoccupied space temperature shall be monitored by the DDC temperature sensors located in the individual zones being controlled or within a representative room.
   3. Parameter Changes. Operator shall be able to define, modify or delete the following parameters.
      a. Unoccupied High/Low limit set-point temperature(s).
      b. Temperature band for Unoccupied operation.

E. Timed Local Override (TLO): The system shall have TLO input points that permit the occupants to request an override of equipment that has been scheduled OFF. The system shall turn the equipment ON upon receiving a request from the local input device. Local input devices shall be push button (momentary contact). Equipment on Time: If a push button is used the system operator shall be able to define the duration of equipment ON time per input pulse. The system shall maintain a trend log of override usage. The log shall include, date, time and area of override.

F. Space Temperature Control (STC): There shall be two space temperature set-points, one for cooling and one for heating, separated by a dead band. Only one of the two set-points shall be operative at any time. The cooling set-point is operative if the actual space temperature has more recently been equal to or greater than the cooling set-point. The heating set-point is operative if the actual space temperature has more recently been equal to or less than the heating set-point. There are three modes of operation for the set-points, one for the occupied mode (example: heating = 72□F. or 22□C., cooling = 74□F. or 23.3□C.), one for the unoccupied mode (example: heating = 55□F. or 12.7□C., cooling = 90□F. or 32□C.), and one for the standby mode (example: heating = 68□F. or 22□C., cooling = 76□F. or 24.4□C.). Where occupancy sensors are integrated with the space temperature sensor, the occupancy control shall override based on the occupancy sensor output.

G. Schedule. The occupied/unoccupied modes may be scheduled by time, date, or day of week.

H. Color Code. Colors shall be generated to represent the comfort conditions in the space and shall be displayed graphically at the operator station. (Discuss colors)
   1. If the actual space temperature is in the dead band between the heating setpoint and the cooling set-point, the color displayed shall be white for the occupied mode, representing ideal comfort conditions.
   2. If the space temperature rises above the cooling set-point, the color shall change to light red. Upon further rise beyond the cooling set-point plus an offset, the color shall change to red. When space temperature falls below the heating setpoint, the color shall change to light blue. Upon further temperature decrease below the heating setpoint minus an offset, the color shall change to dark blue.

I. Operator Definable. All set points and offsets shall be operator definable. When in the occupied mode, start-up mode, standby mode, or when heating or cooling during the unoccupied mode, a request shall be sent over the network to other equipment in the HVAC chain, such as to an AHU fan that serves the space, to run for ventilation. The operator shall be able to disable this request function if desired.

J. Optimum Start. An optimum start-up program transitions from the unoccupied set points to the occupied set points. The optimum start-up algorithm considers the rate of space temperature rise for heating and the rate of space temperature fall for cooling under nominal outside temperature conditions; it also considers the outside temperature; and the heat loss and gain coefficients of the space envelope (AI: Space Temperature).

2.06.1 UTILITY METERING

A. Electrical demand shall be from pulsing dry contacts provided by Owner and installed by the Utility Company at the power meter. The DDC system shall be capable of measuring and scaling any pulse rate provided by the Utility Company.

B. Gas usage in cubic feet per hour shall be from pulsing dry contacts provided by the Utility Company at the gas meter. The DDC system shall be capable of measuring and scaling any pulse rate provided by the utility company.

C. Water usage in gallons per hour shall be monitored from pulsing dry contacts provided by installation of a contractor provided water meter. The DDC system shall be capable of measuring and scaling any pulse rate provided by the water meter. Provide meter with all installation hardware necessary to enable insertion and removal of meter without system shutdown. The flow meter shall be hand insertable up to 400 psi. Turbine rotation shall be detected by electronic impedance base sensing (non-

magnetic). The water meter shall be equal to Onicon F-1130 series, with scaled output (1 gallon per pulse). Meter to be supplied by controls contractor installed by Plumbing contractor.

D. VFD sub-metering shall be monitored and measured by way of the LON communication or BACnet output of the VFD.

E. For buildings that have multiple meters such as electrical sub meters, VFD meters, etc., the graphics shall show a list of building areas and equipment on each meter. Coordinate naming of equipment with Owner.

2.06.2 SURGE AND LIGHTNING PROTECTION

A. Line voltage protection: The JACE panels, Central Station Air Handling Units and Central Plant equipment shall be powered by 120 VAC circuits provided with surge protection. These circuits shall be provided and installed by controls subcontractor. This protection is in addition to any internal protection provided by the manufacturer. A grounding conductor, (minimum 12 awg), shall be brought to each control panel from either a system grounding point or the ground bus in a breaker panel. Conduit grounds will not be acceptable. The surge protection device should be mounted so the LEDs are readily visible.
   1. Surge protector requirements:
      a. Diagnostic LED indicates ground presence, system power and SPD function
      b. UL listed
      c. IEEE Cat A and Cat B
      d. Parallel configuration, external mount
      e. 22,500 amp peak surge current
      f. Operating Frequency: 0 Hz – 400 Hz
      g. Protective Modes: L-G, L-N, N-G
      h. Warranty: Ten Year Warranty
      i. Housing NEMA 4 ABS

B. Inter-unit Communications: All panel to panel data networks that are routed outside or between buildings shall be protected with proper surge protection. The protection device shall match the voltage levels of the inter-unit communications network.
   1. Communications trunk wiring shall be protected with a transient surge protection device providing the minimal protection specifications of the General semiconductor, Model #422E device.
   2. Power and Communication Wiring Transient Protection: The control manufacturers shall submit catalog data sheets providing evidence that all BAS products offered by the manufacturer are tested and comply with the standard for Transient Surge withstand capabilities for electrical devices ANSI C62.41, IEEE-587-1980, Categories A and B. Such testing shall have included power and communication trunk wiring. Compliance with IEEE-587 shall imply conformance with IEEE-472 transient standards based on the stated position of ANSI and IEEE regarding applicability of the rated standards.
   3. The communications circuitry, input/output circuitry, and CU's, shall provide protection against a 1,000 volt, 3 amp transient signal, directly applied to the communication or input/output terminations. The manufacturer's catalog data sheet shall provide evidence of conformance with this requirement. Systems not complying with this requirement shall provide equivalent protection external to the BAS controller. Protection shall be provided for the individual communications and input/output terminations for each BAS controller. Submittal documentation shall clearly define how this requirement will be met and how the external protection will not affect the performance of the controllers.

PART 3 EXECUTION

3.01 INSTALLATION

A. General: Work schedule shall be in accordance with Division 1.

B. Wiring: The term wiring is construed to include furnishing of wire, conduit, miscellaneous material, and labor to install a working system. Outdoor installations shall be of weatherproof construction or in new NEMA 3R or 4 enclosures. Wiring shall be yellow jacketed No. 22 TSP for inputs and outputs. Wiring shall be purple jacketed No. 22 TSP for communication bus. Cat 5 wiring shall not be utilized.
   1. Concealed accessible wiring may be installed as properly supported cable using bridal rings a minimum of 2" in diameter and located a maximum of 10'-0" on center so as to prevent excess sagging from occurring. Wire-ties or cable straps shall not be used for cable support. Provide protective sleeves at wall and floor penetrations. Concealed inaccessible locations and mechanical rooms shall have wiring installed in properly sized, blue colored conduit.
   2. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
   3. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
   4. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables, example, blue conduit shall be used for communication and equipment wiring.
   5. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.
   6. An example of the required colored wiring is below:

Purpose	Function	Color
Primary Communications LON	Field Device Communication	Purple
Analog Points	I/O Wiring	Yellow
Digital Points	I/O Wiring	Yellow
24VAC	Control power	White/Black tracer

C. Routing: Except for short apparatus connections, run conduit parallel to or at right angles to the building structure. Conceal conduit in finished spaces. Do not run conduit concealed under insulation or inside ducts. Mount control devices, and conduit located on ducts or apparatus with external insulation on stand-off support to avoid interference with insulation.

Run wire connecting devices on or in control cabinets parallel with the sides of the cabinet neatly racked to permit tracing. Rack connections bridging a cabinet door along the hinge side and protect from damage.

D. Field Materials:
   1. Sensors and Controls: Permanently mark terminal blocks for identification. Protect all circuits to avoid interruption of service due to short-circuiting or other conditions. Line- protect all wiring that comes from external sources to the site from lightning and static electricity. Label or code each field wire at each end. Permanently label or code each point of all field terminal strips to show the instrument or item served. Color-coded cable with cable diagrams may be used to accomplish cable identification.
      a. Temperature sensors: Temperature sensors shall be readily accessible and adaptable to each type of application in such a manner as to permit for quick, easy replacement and servicing without special tools or skills. Mount duct sensors in locations to sense the correct temperature of the air only, within the vibration and velocity limits of the sensing element. Mount extended surface element, when used, securely within the duct and position to measure the best average temperature. Thermally isolate elements from brackets and

supports to respond to air temperature only. Securely seal duct penetrations. Install pipe sensors in top of pipe for horizontal runs and at a positive slope on vertical runs to prevent condensation from flowing to sensor head.

b. Temperature sensing elements installed in liquid systems shall be installed in thermowells.

c. Relative humidity sensors shall have air guards when installed in air flows of more than 15 meters per minute across the sensor element.

d. Pressure Instruments:
Pressure sensors (all types) installed on liquid lines shall have drains. Pressure sensors installed on steam lines shall have drains and siphons. All pressure sensors shall have valves for isolation, venting, and taps for calibration. Pressure sensors shall be verified by calibration. Differential pressure sensors shall have nulling valves. Pressure switches (all types) installed on liquid lines shall have drains. Pressure switches installed on steam lines shall have drains and siphons. All pressure switches shall have valves for isolation and taps for calibration. Pressure switches shall be adjusted to proper setpoint and shall be verified by calibration. Differential pressure switches shall have nulling valves. Switch contact ratings and duty shall be selected for the application. The duct static-pressure sensing element, (tap or pitot tube), shall be located approximately two-thirds of the distance from the supply fan to the end of the duct with the greatest pressure drop. Do not locate adjacent to branches, transitions, elbows, etc. Provide taps for transmitter calibration.

e. Install potential and current transformers in new NEMA enclosures. Current transformer leads shall be shorted when they are not connected to the measurement circuits.

f. Install relays and contactors in new NEMA enclosures. H-O-A switches and override switches shall be installed so that controls function through the automatic position. Safety and fire or life safety interlocks shall function through both hand and automatic switch positions.

g. Damper Actuators:
Outside air, return air, and relief dampers shall have individual actuators unless installed on factory assembled mixing boxes.
Actuators shall be installed so that their action shall seal the damper to the extent required to maintain leakage at or below the specified rate and shall move the blades smoothly.

h. Variable Frequency Drives (VFDs):

Point Name	Hardwired	Interface Com Card	GUI Display
VFD Command Start/Stop	X	X	Hardwired
VFD Speed Command (%)	X	X	Hardwired
Fan Status (via VFD)	X	X	Hardwired
VFD Speed Feedback (Hz)		X	Com
Fan Alarm (Command/Status mismatch)		X	Com
VFD Fault Status		X	Com
VFD Fault Reset		X	Com
VFD Power (kW)		X	Com
Timestamp		X	Com

E. Signal Transmission System Equipment:

1. General: Install all system components in accordance with the National Electrical Code and the manufacturer's recommendations; fuse and ground them properly.

a. Splices: Splices in shielded and coaxial cables shall consist of terminations and the use of shielded cable couplers. Terminations shall be in accessible locations. Cables shall be harnessed with cable ties.

b. Equipment: Fit all equipment contained in cabinets or panels with service loops, each loop being at least 12 inches long. Equipment for fiber optics system shall be rack mounted, as

applicable, in ventilated, self-supporting, code gauge steel enclosure. Cables shall be supported for minimum sag.

c. Cable Runs: Keep cable runs as short as possible. Connecting to the terminal board. Do not bend flexible coaxial cables in a radius less than ten times the cable outside diameter. Use vinyl tape, sleeves, or grommets to protect cables from abrasion or damage. Allow extra length for vibration at points where they pass around sharp corners, through walls, and panel cabinets.

d. Grounding: Ground system per manufacturer's requirements for proper and safe operation.

F. Field Test and Inspections:

1. System Equipment: Upon completion of installation of each piece of equipment, field- inspect and mechanically and electrically test equipment for proper function.
2. Field Materials: Upon completion of installation of each piece of equipment, field-inspect and mechanically and electrically test equipment for proper function.
3. Acceptance Testing. Upon completion of the installation, the Contractor shall start up the system and perform all necessary trending, scheduling calibration, testing, and debugging operations. The Contractor in the presence of the Owners' representative shall perform an acceptance test. Acceptance test procedure to be submitted, for approval no later than 4 weeks prior to testing. Submission of test procedure shall imply that systems are complete, functional and that contractor has verified performance.

   Successful completion of acceptance testing shall be required prior to substantial completion.
4. Perform the following field tests and inspections and prepare test reports:
   a. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
   b. Test and adjust controls and safeties.
   c. Test calibration of controllers inputs, outputs, and sensors.
   d. Test each point through its full operating range to verify that safety and operating control set points are as required.
   e. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
   f. Test each system for compliance with sequence of operation.
   g. Test software and hardware interlocks.
5. DDC Verification:
   a. Verify that instruments are installed before calibration, testing, and loop or leak checks.
   b. Check instruments for proper location and accessibility.
   c. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
   d. Check instrument tubing for proper fittings, slope, material, and support.
   e. Check installation of air supply for each instrument.
   f. Check flow instruments. Inspect tag number and line and bore size and verify that inlet side is identified and that meters are installed correctly.
   g. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
   h. Check temperature instruments and material and length of sensing elements.
   i. Check control valves. Verify that they are in correct direction.
   j. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
   k. Check DDC system as follows:
      1) Verify that DDC controller power supply is from emergency power supply, if applicable.
      2) Verify that wires at control panels are tagged with their service designation and approved tagging system.
      3) Verify that spare I/O capacity has been provided.
      4) Verify that DDC controllers are protected from power supply surges.
   l. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

6. Calibrating and Adjusting:
   a. Calibrate instruments.
   b. Make three-point calibration test for both linearity and accuracy for each analog instrument.
   c. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
   d. Control System Inputs and Outputs:
      1) Check analog inputs at 0, 50, and 100 percent of span.
      2) Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
      3) Check digital inputs using jumper wire.
      4) Check digital outputs using ohmmeter to test for contact making or breaking.
      5) Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
   e. Flow:
      1) Calibrate the input sensors to the specified accuracy.
      2) Manually operate flow switches to verify that they make or break contact.
   f. Pressure:
      1) Calibrate pressure transmitters at 0, 50, and 100 percent of span.
      2) Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
   g. Temperature:
      1) Calibrate the input sensors to the specified accuracy.
      2) Calibrate temperature switches to make or break contacts.
   h. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
   i. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
   j. Provide diagnostic and test instruments for calibration and adjustment of system.
   k. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures. Document all tests and provide to WCPSS.

G. Adjust initial temperature and humidity set points.

H. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three (3) visits to Project during other than normal occupancy hours for this purpose.

I. System Graphics and Navigational Format:

1. General Notes
   a. Show the following on each graphic screen: OAT, OAH, OA Enthalpy, CHW sup temp, HW sup temp, current time, Alarm portal link, Raleigh weather service (in AX or N4 web supervisor), Master schedule link, Building calendar link, and trend link.
   b. Alarm background red and blinking.
   c. Valves show modulating from 0% in closed to coil position to 100% in open to coil position.
   d. Dampers show modulating from 0% in closed position to 100% in open position.
   e. With multiple central plants, show what zones are served on each central plant screen. On each AHU screen, indicate which Central Plant serves the AHU.
   f. Service screens for each major system.
   g. Sequence of operation folder shown in Nav Bar tree.
   h. Gas usage should be “CCF”.
   i. Provide service screens for exhaust fans and lighting contactors. Containing area served, tagging and override.

j. In the navigational bar, parent folder "Home" shall contain at a minimum the following subfolders: Overview (entire building floor plan), FloorPlans (zoned floor plans), CentralPlant (Chillers, Boilers, etc), AirHandlers, ServiceScreens (described below), Sequence of operations, Control drawings, WCPSS Home Page.
k. In the navigational bar, parent folder "Config\Drivers\"controller"network" shall contain at a minimum the following subfolders: CentralPlant, AirHandlers, VavBoxes, Global, Schedules, Exhaust Fans, Lights,Overrides, AverageTemps, FloorPlans, ServiceScreens.
l. All digital and analog points shall be able to be overridden from either the graphic or service screen (ie- dampers, actuators, fans, VFDs, pumps)

2. Service Screen
   a. Global space cooling and heating set-points override.
   b. Master start/stop override.
   c. Interior lights SS & O/R.
   d. Exterior lights SS & O/R.
   e. Tab HW valves.
   f. Tab CHW valves.
   g. Tab OA dampers.
   h. Fire alarm status.
   i. Security panel armed status (this should cancel all pushbutton occupancy overrides when armed).
   j. Overall site layout with zone status/override (link from status to schedule).
   k. Admin zone in red, Media zone in yellow, Multipurpose or Gym zone in purple, Auditorium in a lighter shade of purple, Café/Kitchen zone in green, classroom zones in various colors. Show average space temp for each zone.
   l. Electrical demand, demand limit set-point, 3 shed level set-points.
   m. Cooler & freezer temp. Red and blinking when in alarm.
   n. Domestic hot water temp, status/override (link to schedule), and pump status/override.
   o. Global heat mode (VAV reverse acting) set-point.
   p. Unoccupied low limit and high limit set-points.
   q. Economizer low limit, high limit, and enthalpy set-points. Status.
   r. OA dampers enable/override with link to schedule.
   s. Electrical, gas and water usage today.
   t. Link to Utilities Usage screen.

3. Zone screen
   a. Room numbers.
   b. Zone status override.
   c. Cause of status ("Master Override", "Zone Override", "Master Building Schedule", Timed Override", "Optimal Start", "Optimal Stop", "Zone Schedule")
   d. Link to zone schedule.
   e. Temperature range spectrum.
   f. Show zones with links in small inset on lower right area of screen.
   g. Zone timestamp.
   h. Link to temp control equipment (VAV, AHU).

4. VAV box screen
   a. AHU supply temp at inlet of VAV box.
   b. Link back to AHU from inlet temp.
   c. Link back to zone screen.
   d. Box flow setpoint.
   e. Box flow.
   f. Cooling demand (%).
   g. Hot water valve position.
   h. Occupancy status (Unoccupied, Standby, Occupied).

i. Box supply air temp.
j. Space temp.
k. Set-point control status/override (Local control/Remote control).
l. Effective space cooling set-point.
m. Remote cooling set-point with override.
n. Heat mode direct/reverse acting control status.
o. Maximum space temp set-point.
p. Minimum space temp set-point.

5. VAV AHU screen
   a. Link to service screen.
   b. Unit override.
   c. AHU command status.
   d. Cause of status ("Unit Override", "Night Low Limit", "Night High Limit", "Zone Schedule").
   e. VAV reverse acting control set-point and status.
   f. AHU duct layout.
   g. Hardware sensors graphically shown with values.
   h. Fan VFD graphical display points shall be as shown previously in section 3.01,D, 1, h.
   i. Dampers and valves with actuator command position.
   j. OA minimum flow set-point.
   k. Freeze protection status.
   l. Supply air temp set-point with override.
   m. Supply static pressure set-point.
   n. Timestamp for each fan.
   o. Economizer status.
   p. OA damper enable status.
   q. Damper control cause ("Fan Status Off", "OA Damper Enable Off","Mixed air low limit", "High CO2", "Outside Air Flow", "Economizer").
   r. Indicate which zones are served by this AHU.

6. VAV AHU service screen
   a. All sensor values, set-points with override, and actuator command position values with override.
   b. Fan VFD graphical display points shall be as shown previously in section 3.01,D, 1, h
   c. Economizer command.
   d. Unit start/stop with override.
   e. Test and Balance HW Valves command with override.
   f. Test and Balance CHW Valve command with override.
   g. Test and Balance OA Dampers command with override.
   h. Force all VAV's to minimum/maximum flow, full open/full closed command with override.
   i. All VAV boxes with the following information: occupancy, set-point control/override (Local control/Remote control), effective set-point, space temp, supply air temp, hw valve position with override, flow set-point, air flow, cooling demand (%), force damper open/force damper closed, total air flow of all boxes.
   j. Supply air temp outside air reset parameters (adjustable).
   k. VAV reverse acting control status with override.

7. Single Zone AHU screen
   a. Link to service screen.
   b. Unit override.
   c. Link back to zone screen.
   d. AHU command status.
   e. Cause of status ("Unit Override", "Night Low Limit", "Night High Limit", "Zone Schedule").

f. AHU duct layout.
g. Hardware sensors graphically shown with values.

h. Fan VFD graphical display points shall be as shown previously in section 3.01,D, 1, h.
i. Dampers and valves with actuator command position.
j. OA minimum flow set-point.
k. Freeze protection status.
l. Space temp cooling set-point.
m. Space temp heating set-point.
n. Timestamp for each fan.
o. Economizer status.
p. OA damper enable status.
q. Damper control cause ("Fan Status Off", "OA Damper Enable Off", "Mixed air low limit", "High CO2", "Outside Air Flow", "Economizer").
r. Indicate which zones are served by this AHU.

8. Single zone AHU service screen
a. All sensor values, set-points with override, and actuator command position values with override.
b. Fan VFD graphical display points shall be as shown previously in section 3.01,D, 1, h.
c. Economizer command.
d. Unit start/stop with override.
e. Test and Balance HW Valves command with override.
f. Test and Balance CHW Valve command with override.
g. Test and Balance OA Dampers command with override.

9. Chilled water system screen
a. System status with override.
b. Cooling outdoor temperature low limit set-point and cooling enable status.
c. Chiller(s) specific alarm (string text), not just Alarm/Normal (if available).
d. Pump VFD graphical display points shall be as shown previously in section 3.01,D, 1, h.
e. Secondary loop differential pressure sensor values and set-point.
f. Timestamp for each pump and chiller.
g. Chilled water system piping layout.
h. Hardware sensors graphically shown with values.
i. Chilled water set-point with override.
j. Freeze protection status from AHU's.
k. Primary pump(s) command (if available), status, and alarm.
l. Chiller(s) command, status, and active set-point.
m. Link to service screen.
n. Cause of status ("Cooling outdoor temperature low limit", "Override", "AHU Call", "Dehum").

10. Hot water system screen
a. System status with override.
b. Heating outdoor temperature high limit set-point and heating enable status.
c. Boiler(s) specific alarm (string text), not just Alarm/Normal (if available).
d. Pump VFD graphical display points shall be as shown previously in section 3.01,D, 1, h.
e. Secondary loop differential pressure sensor values and set-point.
f. Timestamp for each pump and boiler management panel.
g. Hot water system piping layout.
h. Hardware sensors graphically shown with values.
i. Hot water set-point with override.
j. Freeze protection status from AHU's.
k. Boiler management panel command and status.
l. Link to service screen.
m. Cause of status ("Heating outdoor temperature high limit", "Override", "AHU Call",

"VAV Reheat", "Freeze").

11. Central Plant service screen
    a. All sensor values and set-points with override.
    b. Pump VFD graphical display points shall be as shown previously in section 3.01,D, 1, h.
    c. Cooling enable status, Cooling outdoor temperature low limit set-point, and cooling system override.
    d. Heating enable status, Heating outdoor temperature high limit set-point, and heating system override.
    e. Chiller(s) command/override, status, alarm, timestamp, and temp set-point override.
    f. Boiler management panel command/override, status, timestamp, temperature set- point override, and runtime with reset.
    g. HW temp outside air reset parameters (adjustable).
    h. CHW temp outside air reset parameters (adjustable).
    i. Chiller pump(s) status.
    j. Chiller circuit(s) runtime and current (amps).
    k. Chiller voltage.
    l. Domestic Hot Water system. Temperature, heater and pump command and override.

12. Utilities Usage screen
    a. Current month KWH value.
    b. Last month KWH value.
    c. Last meter value reset time and date.
    d. Current 15 minute KW demand value.
    e. Current month peak demand.
    f. Current month peak demand time and date.
    g. Last month peak demand.
    h. Last month peak demand time and date.
    i. Load shed set-point.
    j. 3 shed level set-points.
    k. KWH this hour value.
    l. KWH last hour value.
    m. KWH today value.
    n. KWH yesterday value.
    o. Current gas demand (cf/hr).
    p. Current month gas usage value (ccf).
    q. Last month gas usage value (ccf).
    r. Last meter value reset time and date.
    s. Gas usage value this hour (ccf).
    t. Gas usage value last hour (ccf).
    u. Gas usage value today (ccf).
    v. Gas usage value yesterday (ccf).
    w. Current water demand (gal/hr).
    x. Current month water usage value (gal).
    y. Last month water usage value (gal).
    z. Last meter value reset time.
    aa. Water usage value this hour (gal).
    bb. Water usage value last hour (gal).
    cc. Water usage value today (gal).
    dd. Water usage value yesterday (gal).

3.02 LIGHTING CONTROL

The Control Subcontractor shall provide the number of outputs for lighting control as indicated on the drawings. Lighting will be controlled by arming/disarming the security system. The Control Subcontractor shall provide all wiring between the DDC system and the lighting contactors. Lighting Contactors and all power wiring shall be by the Electrical Contractor.

3.03 SECURITY CONTROLS

The Control Subcontractor shall connect to a dry contact point in the each of the school's security systems. The Control Subcontractor shall provide all wiring between the DDC system and the security armed and alarmed contacts. Security contacts are supplied by others. For schools with multiple security systems such as whole building and cafeteria, these systems shall remain separate to allow access by both parties without disarming the second system. The security armed and alarmed contacts shall be monitored by this system.

3.04 FIRE ALARM

Smoke detectors are supplied and wired by Electrical Contractor. Electrical Contractor shall supply and install a relay near each motor controller to shut down the unit. Central fire alarm panel shall be provided with one contact output to the DDC system to indicate system trouble or alarm. Wiring required for alarm points shall be provided by the Control Subcontractor.

3.05 MAINTENANCE MANAGEMENT

The DDC system shall measure and record run time for all start/stop points in the system. Based upon the accumulated run time provide maintenance messages on the interval recommended by the equipment manufacturers.

Any digital input point that is used for maintenance purposes (i.e. Fan Status) shall also generate a maintenance message.

3.06 TROUBLE ALARMS

The Control Subcontractor shall establish a trouble high and trouble low alarm limit for each analog input and annunciate a corresponding alarm message. Alarm and event messages shall be in plain English and not LON or any other code language.

3.07 MODIFICATION

All software set-points, limits, alarms, messages, schedules, sequences, etc., as specified herein are to provide an initial setup of the control system. The Control Subcontractor shall provide software customization that may be required to adapt the DDC system to accurately respond to actual building parameters and installed equipment. Further, these software functions shall be readily modifiable by WCPSS personnel as changes in building operation dictate.

3.08 COOLERS AND FREEZERS

Real-time temperatures for coolers and freezers shall be included on all graphical pages. The cooler and freezer locations shall be shown on graphical floor plan where the units are located.

3.09 MESSAGES AND ALARMS

The installer is required to submit a point summary to confirm point names as specified herein The installer shall submit this point summary with the addition of identifying all alarms which includes detail information on the alarm parameters to WCPSS for approval prior to the beginning of any Commissioning process of the integrated automation system. WCPSS will provide the format form to the installer upon request.

All alarms which have been identified by the Owner as a nuisance alarm due to numerous times in and out of alarm, shall be addressed and corrected by the System Integrator in a manner that the Owner has approved.

PART 4 APPENDIX - GRAPHIC STANDARDS

4.01 STANDARD COLORS

The following tables and legend lists all of the standard colors for Graphics:
Table 4.1.0.1: Standard Text Colors

Description	Text Color	Background Color
Normal	Black	White
Alarm	Black	Red
Warning	Black	Red
Trouble	Black	Yellow
Off-line	Black	Yellow
Override	Black	Magenta

State indication shall be determined by status indicating equipment such as current sensing switches, auxiliary contacts, or position switches. Commands to field devices shall be shown separately.

Table 4.1.0.2: Standard Object Colors

Description	Color
Graphic Background Color	Light Gray
Navigation Button Background Color	Med. Gray
Ductwork	Blue or Gray
Hot Water Supply Piping	Dark Red
Hot Water Return Piping	Light Red
Chilled Water Supply Piping	Dark Blue
Chilled Water Return Piping	Light Blue
Cond. Water Supply Piping	Grey
Cond. Water Return Piping	Grey

4.2.0 USING Gx TEXT STANDARDS

All fonts shall be bold Trebuchet MS, Serif, or Arial. The minimum font size for the display of values shall be 9 point.

Table 4.2.0.1: Standard Fonts

Description	Standard Font
Graphic Title Block	White 16 point Serif Bold with Gray shadow
Text on Buttons	Black 9 point Serif Bold
All other text	White Serif Bold, minimum of 9 point

4.3.0 PRINTER DRIVERS & VIDEO RESOLUTION

4.3.1 PRINTER DRIVERS

Printer drivers shall not affect Graphics.

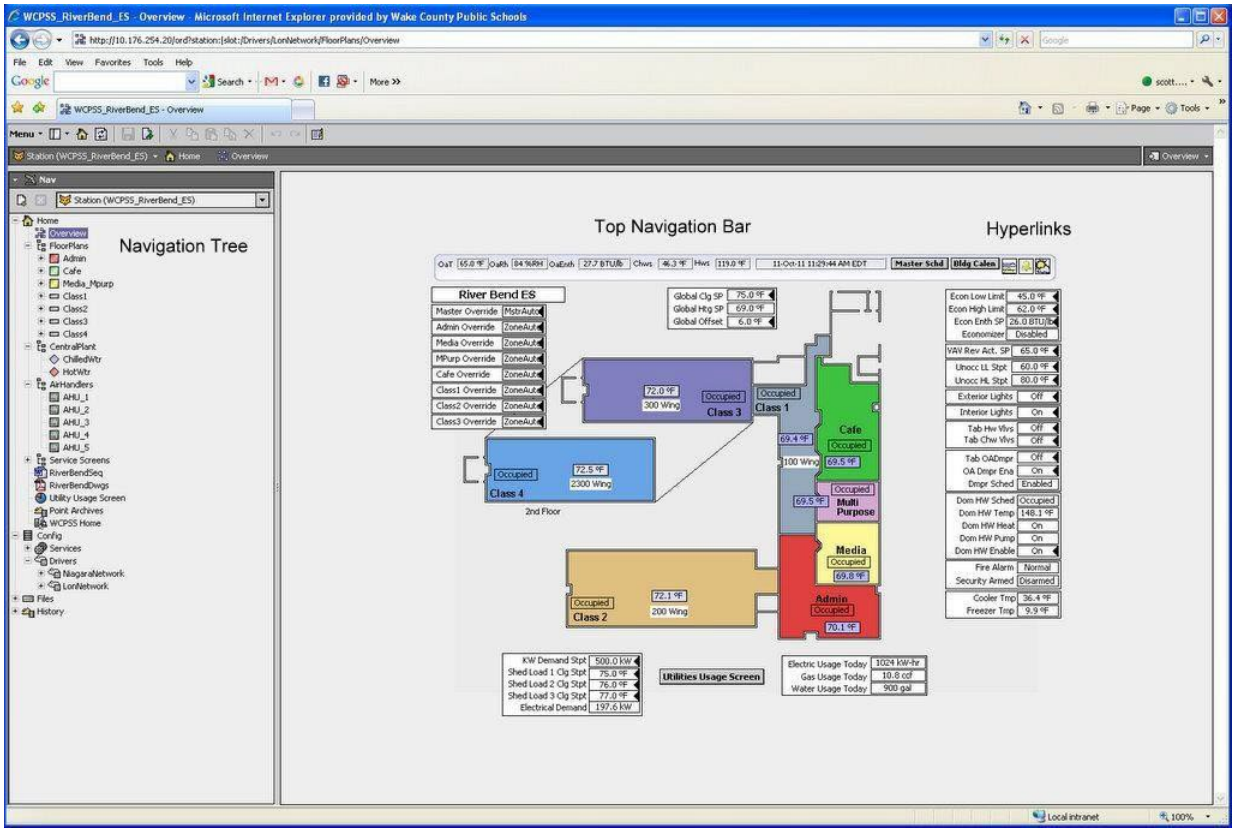
4.3.2 VIDEO RESOLUTION

Graphics shall be scaled to a minimum resolution of 1024x768. Graphics will display better at higher resolutions. A 19" monitor shall be the minimum size used to display Graphics.

4.4.0 GRAPHICS TEMPLATE

All Standard Graphics shall be based upon the template shown in Figure 4.4.0.1 below. All features of the Standard Graphics, such as title block, navigation buttons, etc., shall always be located in the same general area on each Graphic. For example, the navigation buttons shall always start at the left frame of the graphic. The Home, Charts and Alarm buttons shall always start in the upper right corner of the graphic.

Figure 4.4.0.1: Standard Graphic Template



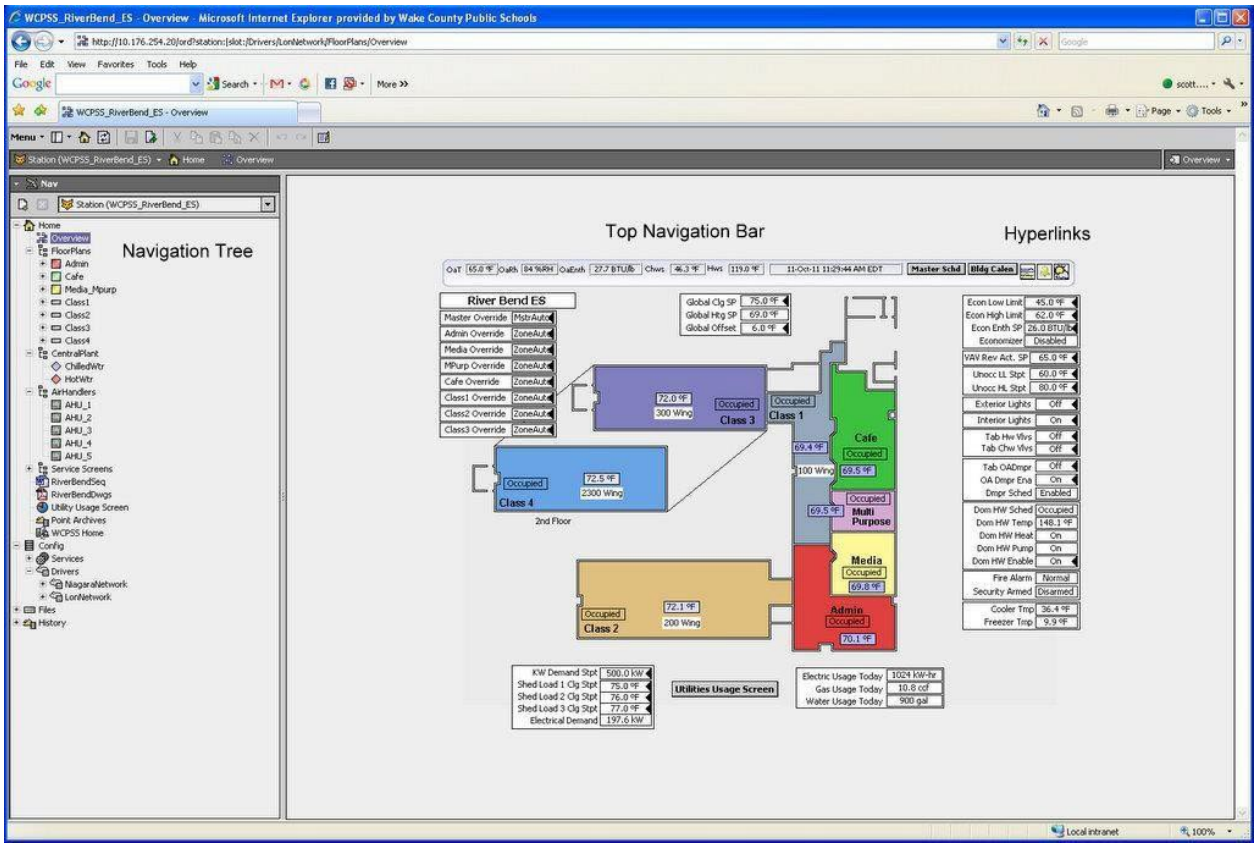
4.5.0 LABELING ON GRAPHICS

A description of a point shall be included on the Graphic next to the object's value whenever there is any ambiguity about the value's meaning. For example, when status and command points are both shown on a Graphic, they shall both be labeled with separate identifying descriptions. If a description of a point in a point block is not adequate, then a separate Note may be added to the Graphic Background near the point block clarifying function or purpose. This shall prevent any confusion about what a value represents.

4.6.1 NAVIGATION STANDARDS

Figure 4.6.1.1 below illustrates sample navigation.

Figure 4.6.1.1: Navigation Flow Example



4.7.0 STANDARD BUTTONS

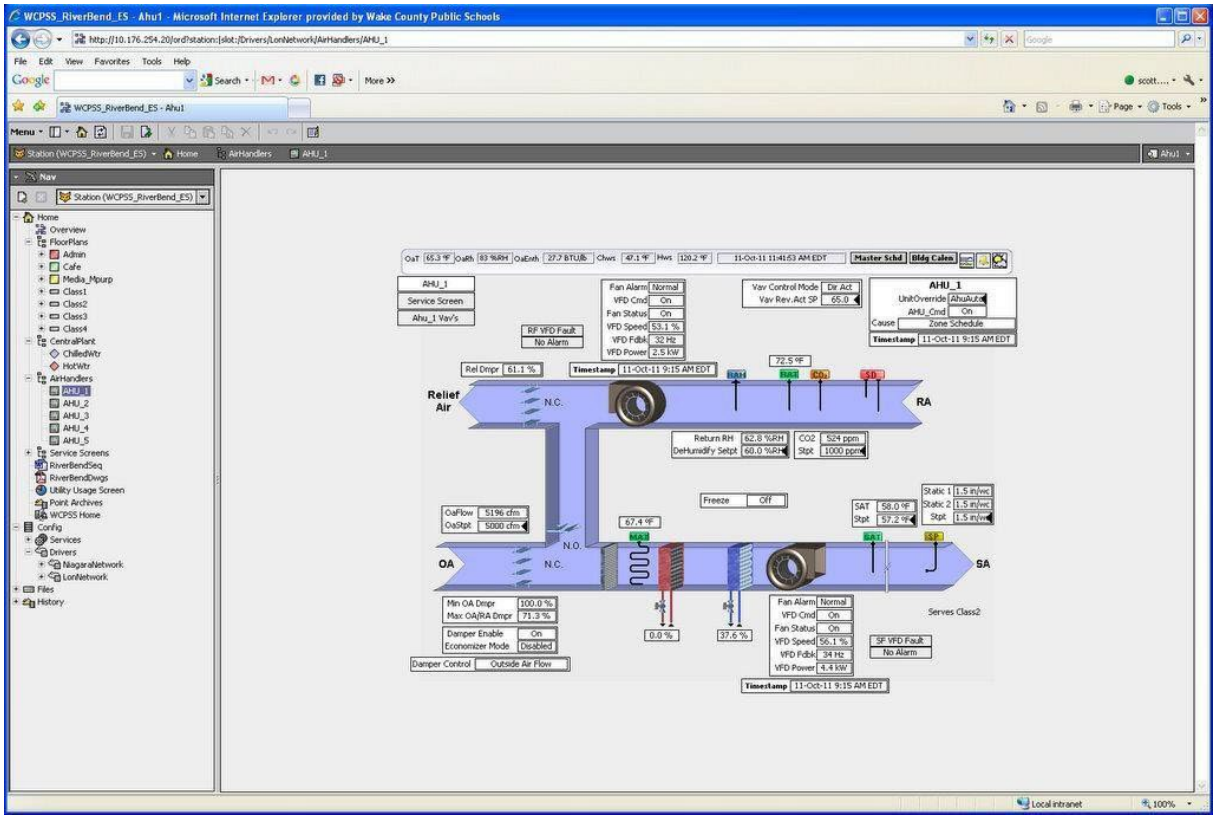
All buttons shall be the same height to accommodate the 9 point font. All buttons on a specific graphic will be the same width to match the widest button on the graphic.

4.8.0 EXAMPLE GRAPHICS

4.8.1 EXAMPLE AHU GRAPHIC

Figure 4.8.1.1 below shows an example of a standard single zone AHU Graphic.

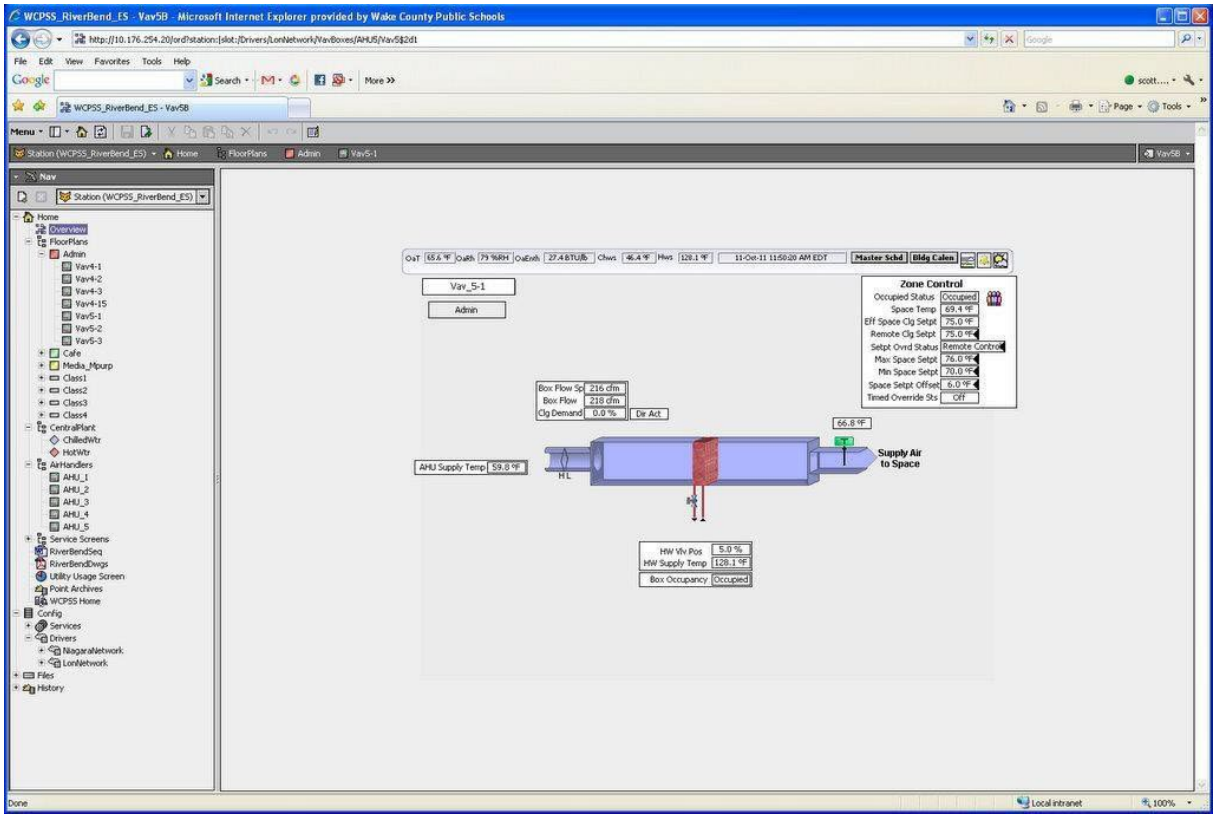
Figure 4.8.1.1: Example Single Zone AHU Graphic



4.8.2 EXAMPLE PIU GRAPHIC

The figure below shows an example of a Graphic for a Variable Air Volume (VAV) box with reheat.

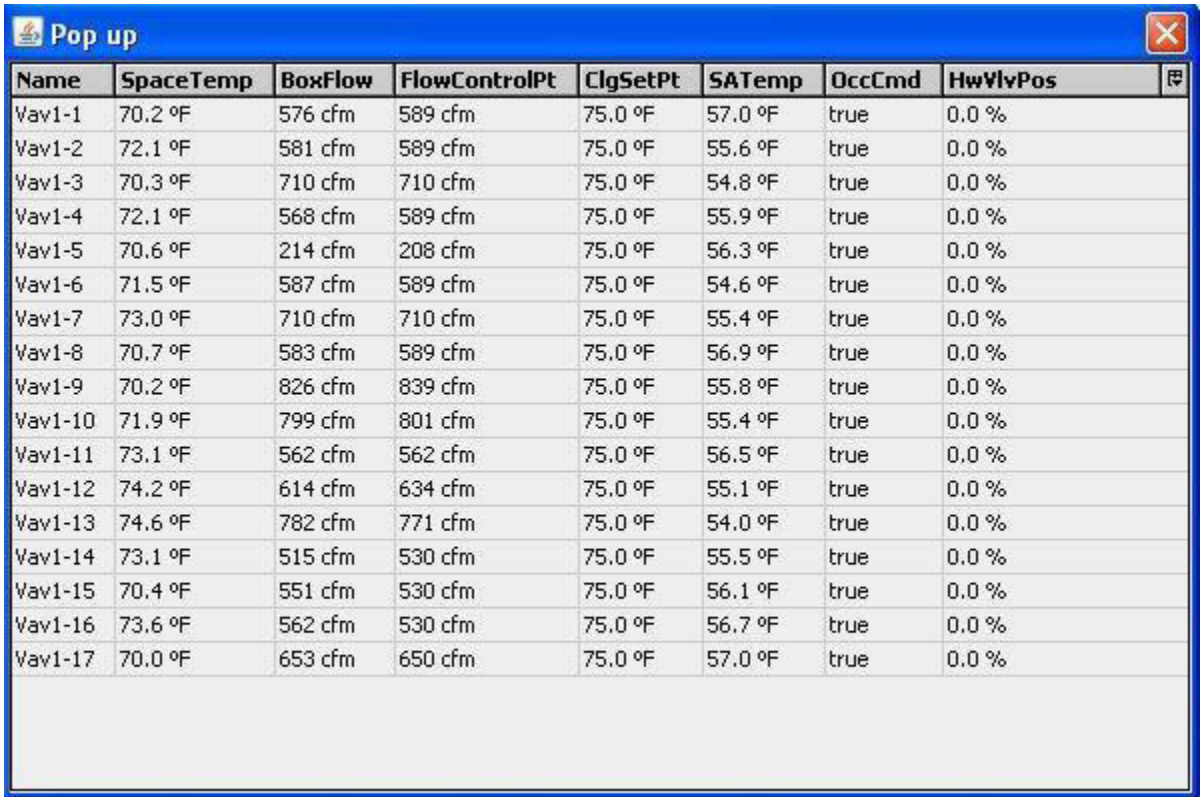
Figure 4.8.2.1: Example VAV Box with Reheat Graphic



4.8.3 EXAMPLE SUMMARY GRAPHIC

In addition to each item as shown on Figure 4.8.2.1, one summary Graphic showing multiple items shall be provided. Figure 4.8.3.1 is an example of a summary Graphic. Navigation to the summary graphic shall be provided on the floor where the boxes are located.

Figure 4.8.3.1: Example Summary Graphic



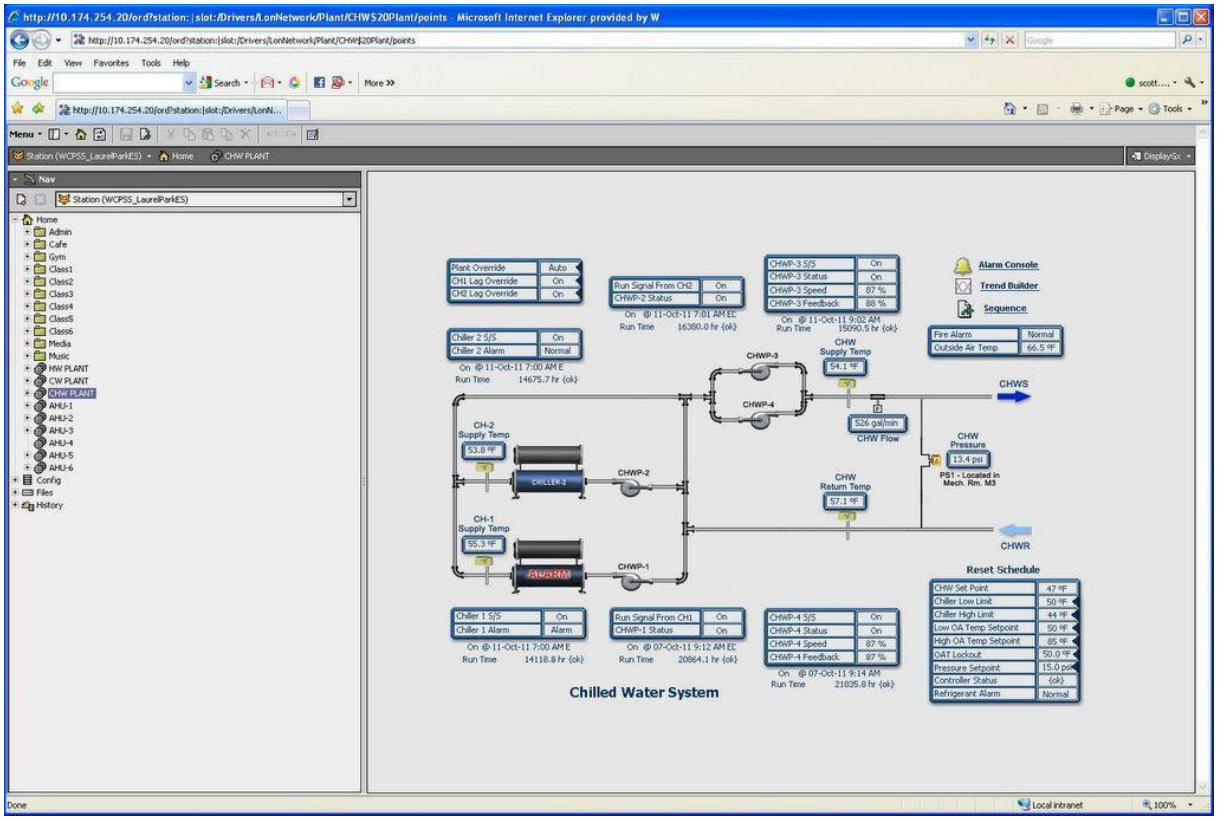
Name	SpaceTemp	BoxFlow	FlowControlPt	ClgSetPt	SATemp	OccCmd	HwVlvPos
Vav1-1	70.2 °F	576 cfm	589 cfm	75.0 °F	57.0 °F	true	0.0 %
Vav1-2	72.1 °F	581 cfm	589 cfm	75.0 °F	55.6 °F	true	0.0 %
Vav1-3	70.3 °F	710 cfm	710 cfm	75.0 °F	54.8 °F	true	0.0 %
Vav1-4	72.1 °F	568 cfm	589 cfm	75.0 °F	55.9 °F	true	0.0 %
Vav1-5	70.6 °F	214 cfm	208 cfm	75.0 °F	56.3 °F	true	0.0 %
Vav1-6	71.5 °F	587 cfm	589 cfm	75.0 °F	54.6 °F	true	0.0 %
Vav1-7	73.0 °F	710 cfm	710 cfm	75.0 °F	55.4 °F	true	0.0 %
Vav1-8	70.7 °F	583 cfm	589 cfm	75.0 °F	56.9 °F	true	0.0 %
Vav1-9	70.2 °F	826 cfm	839 cfm	75.0 °F	55.8 °F	true	0.0 %
Vav1-10	71.9 °F	799 cfm	801 cfm	75.0 °F	55.4 °F	true	0.0 %
Vav1-11	73.1 °F	562 cfm	562 cfm	75.0 °F	56.5 °F	true	0.0 %
Vav1-12	74.2 °F	614 cfm	634 cfm	75.0 °F	55.1 °F	true	0.0 %
Vav1-13	74.6 °F	782 cfm	771 cfm	75.0 °F	54.0 °F	true	0.0 %
Vav1-14	73.1 °F	515 cfm	530 cfm	75.0 °F	55.5 °F	true	0.0 %
Vav1-15	70.4 °F	551 cfm	530 cfm	75.0 °F	56.1 °F	true	0.0 %
Vav1-16	73.6 °F	562 cfm	530 cfm	75.0 °F	56.7 °F	true	0.0 %
Vav1-17	70.0 °F	653 cfm	650 cfm	75.0 °F	57.0 °F	true	0.0 %

If an AHU serves many VAVs, PIUs, or other boxes and do not all fit neatly onto one summary Graphic, the summary shall be broken into multiple Graphics. Buttons shall be added to each summary Graphic to allow the user to easily go from one summary Graphic to another.

4.8.4 EXAMPLE CENTRAL PLANT GRAPHICS

Figure 4.8.4.1 show examples of some central plant Graphics. Note that the flow diagram shown in Figure 4.8.4.1 may not fit on a single Graphic for large or complex Central Plants. If this happens, the condenser water system and the chilled water system shall be broken out into separate Graphics.

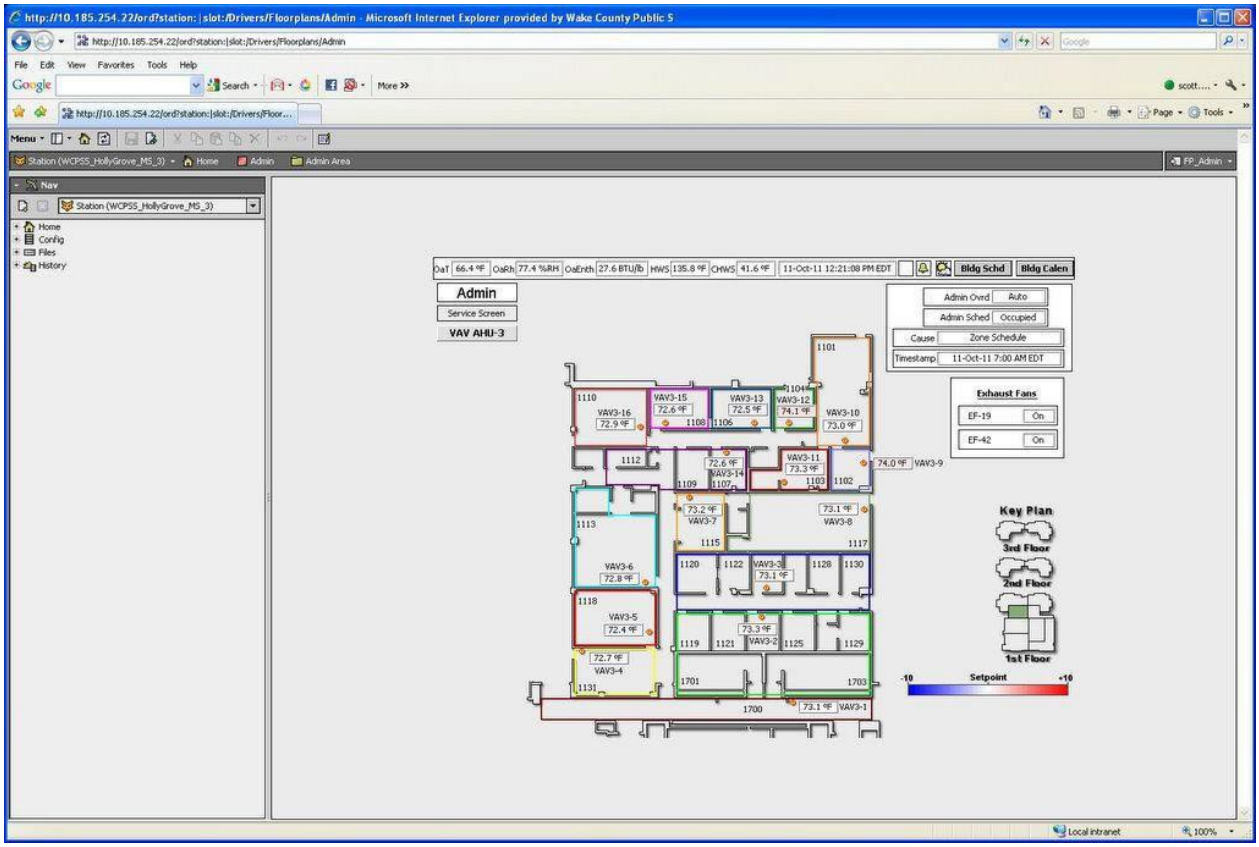
Figure 4.8.4.1: Example Central Plant Flow Diagram



4.8.5 EXAMPLE FLOOR PLAN

Figure 4.8.5.1 below is an example of a Floor Plan. The WCPSS Project Manager for any given project shall provide the site building plans, as requested, in AutoCAD Rev. 14 format. The room area is a static picture and shall be the same color for all floors. The data blocks shall follow the color legend in Figure 4.1.0.3.

Figure 4.8.5.1 Example Floor Plan



END OF SECTION 230900

SECTION 230910 - FACILITY MONITORING SYSTEM

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractor directed to Specification Section INSTRUMENTATION AND CONTROL FOR HVAC.

C. The Contractor directed to Specification Section VARIABLE FREQUENCY MOTOR CONTROLLER.

D. The Contractor directed to Specification Section HYDRONIC PUMPS.

E. The Contractor directed to Specification Section CENTIFUGAL HVAC FANS.

F. The Contractor directed to Specification Section AIR TERMINAL UNITS.

G. The Contractor directed to Specification Section MODULAR INDOOR CENTRAL STATION AIR HANDLING UNITS.

1.2 SCOPE

A. The controls system for this project shall be a web-based digital controls system. All controllers, control interface hardware, services, installation, warranty, training, etc., shall be included as hereinafter specified. The system shall utilize a network controller and unitary" type controllers. Including such minor details not specifically mentioned or shown, as may be necessary for the complete operation of the system.

B. The Temperature Control Contractor (TCC) shall furnish all labor, materials, equipment, and service necessary for a complete and operating Building Automation System (BAS), utilizing Direct Digital Controls. All labor, materials, tools, equipment, software, software licenses, software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, samples, submittals, testing, commissioning, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, temporary protection, cleaning, cutting and patching, warranties, services, and items, even though these may not be specifically mentioned shall be included for the complete, fully functional and commissioned temperature controls system.

C. The TCC shall provide all items, articles, materials, devices, operations, or methods listed, mentioned, or scheduled on the drawings including all labor, materials, equipment, and incidentals necessary and required for their completion to provide a complete and operating temperature control system. This will include connecting to any mechanical equipment furnished with a control interface device and contacting the equipment suppliers and/or manufacturers for information for the proper interface to the equipment being furnished.

D. Control sequences on plans. Provide all control equipment required to perform sequences described. Coordinate all dampers with the sheet metal contractor and equipment provider. It is the responsibility of the control contractor to ensure all required dampers in the sequence of operations are provided.

E. Include all power wiring and cabling for the operation of the controls system. Refer to Electrical Division Specifications for additional requirements.

F. APPROVED MANUFACTURER’S: Schneider Electric, Honeywell, Distech by Johnson Controls, Trane Tracer or approved equal.

G. The installation shall comply with the Local Authorities and State Fire Marshal code requirements, including normal operating and smoke mode functions (where applicable). The installation shall comply with the requirements of the NEC, NFPA, UL and the Building Codes, including referenced mechanical, electrical, energy codes, etc.

H. Prior to installation, the Controls Contractor shall determine the current system software version utilized by WCPSS. The Controls Contractor shall request written approval from WCPSS for any deviations from the currently installed version. The Controls Contractor shall provide Niagara N4™ Framework Version 4.7.X.X of all software required to configure, monitor, link and program all components of the completed system, including the BAS Server Software. The existing software version located on the server is Version 4.7.X.X. The controls contractor shall provide the latest version of all third-party software required (excluding computer operating system software). The system shall be fully configured, including database, graphics, reports, schedules, alarm/events, trends etc. The Graphical User Interface (GUI) shall be Web based as specified herein.

H. ABBREVIATIONS:
1. TCC – Temperature Control Contractor
2. I/O: Input/output.
3. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.
4. MS/TP: Master slave/token passing.
5. PC: Personal computer.
6. PID: Proportional plus integral plus derivative.

PART 2 - PRODUCTS

2.1 NETWORK CONTROLLER

A. Install the Network Controller in a surface mounted panel, NEMA type 12 enclosures, with a removable hinged door. Provide a flush mounted key lock. All control panels must be painted the same color and identified. The boxes are to be made from 16 gauge material. Panels should not be provided with knockouts.

B. Control panels shall be constructed by a UL approved panel manufacturer. The standard used shall be UL508A. All proper labels are to be attached, a parts list and laminated copy of as-built control drawing will be in a door pocket. Panel shall meet arc flash requirements.

C. The Network Controller shall be web-based and communicate BACnet IP. It shall issue all time schedules, summer/winter commands, customized trending, holiday scheduling, alarm handling, clock, or other shared commands to all unitary controllers within the building network. If for any reason communications between the unitary(s) and the Network Controller is lost, the unitary(s) shall operate in a stand-alone manner (in day operation) until communications is restored. It shall also operate in the “summer” or “winter” mode as last commanded.

D. The Network Controller shall be integrated and interoperable with the facility infrastructure and include user access to all system data locally over the Local Area Network (LAN) / Wide Area Network (WAN) within the building and remotely by a standard Web Browser over the Internet. Any computer connected to the network, utilizing a web browser, and having the proper password.

E. The Network Controller shall be a fully user-programmable, supervisory controller. It shall monitor the network of distributed unitary controllers, provide global strategy and direction, and communicate on a peer-to-peer basis with other Network Controllers.

F. The Network Controller shall have battery back-up to allow a minimum of seven days of operation. The Network Controller shall be composed of one or more independent, stand-alone, microprocessor to manage the network strategies described in Application software section. The network controller shall have ample memory to support its operating system, database, and programming requirements. The operating system of the

Network Controller shall manage the input and output communications signals to allow distributed unitary controllers to share real and virtual point information and allow central monitoring and alarms. The database and custom programming routines of the Network Controller shall be editable from a single operator station.

G. The Network Controller shall be remotely monitored via the internet. Additionally, it shall include automatic emailing and texting out alarms, gathering alarms, reports and logs, programming and downloading database.

H. The Network Controller shall continually check the status of all processor and memory circuits. If a failure is detected, the controller shall:
   1. Assume a predetermined failure mode.
   2. Emit an alarm.
   3. Display card failure identification.

I. Under no circumstance shall more than 75% of the total number of sensor and control points be connected through a single Network Controller. Each DDC system component shall provide for the future addition of at least 20% of each type of the number of sensor and control points connected to that component including a minimum of one universal input and one universal output.

J. The Network "Building Level" Controller power shall be a dedicated circuit taken from emergency power electrical panel.

K. Minimum of 3' working clearance shall be provided in front of all enclosures and panels; clearances shall be ensured to permit the enclosure door to open at least 90 degrees from its closed position of all panels containing control components for servicing.

2.2 UNITARY CONTROLLER

A. Unless otherwise specified, each piece of equipment shall have its own Unitary Controller (i.e., heat pump, AHU, terminal unit, etc.). The Unitary Controller for each piece of equipment shall be mounted on the side of the unit. The Unitary Controller for all other equipment shall be mounted in a panel and properly labeled.

B. Each Central Station Air Handler and/or Outside Air Unit shall have its own Unitary Controller mounted where shown on the drawings. If an installation location is not clear, the Contractor shall notify the Engineer for clarification prior to installation.

C. Unitary Controllers used in conditioned ambient shall be mounted in dust-proof enclosures, and shall be rated for operation at 32 degrees F to 120 degrees F. All Unitary Controllers shall have an RJ-11 or similar type connection for monitoring or programming access by room or local equipment level with access to any unitary within the network without modification.

D. Control panels shall be constructed by a UL approved panel manufacturer. The standard used shall be UL508A. All proper labels are to be attached, a parts list and laminated copy of as-built control drawing will be in a door pocket. Panel shall meet arc flash requirements.

E. Unitary Controllers utilized in the network shall have full stand alone capability including time of day and holiday scheduling as well as all energy management functions such as optimal start/stop, duty cycling, etc. The terminal unit Unitary Controllers may be pre-programmed with the project specific sequence of operation as specified for the application. Any re-programming of the electronics shall be performed on location using a portable personal computer with appropriate software or through the Network Controller. The entire unitary data base shall have the capability of being backed up and or downloaded locally.

F. All points to have a unique digital input to the BAS system. The use of digital point count expanders is not an acceptable replacement to digital inputs to the unitary controller. The conversion of a single universal input channel to accept up to multiple voltage free contacts such as relay contacts, auxiliary starter contacts, differential pressure switches, etc. IS NOT ACCEPTABLE.

G. Unitary Controllers shall communicate via BACnet MSTP. A BACnet Protocol Implementation Conformance Statement (PICS) shall be provided for each Unitary Controller that will communicate on the BACnet MS/TP Bus.

H. All Unitary Controllers shall be fully application programmable. All control sequences within or programmed into the unitary controller shall be stored in non-volatile memory, which is not dependent upon the presence of a battery shall be retained.

I. Local controllers shall be mounted at eye level for accessibility and service, and located within 50' of the system served, unless otherwise shown on plans.

J. All unitary controllers shall be fully application programmable. Controllers require a 10% spare point capacity to be provided for all applications. All control sequences within or programmed into the unitary controller shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.

K. The Unitary Controller for each VAV box shall be mounted on the side of the unit. The unitary controller for all other equipment shall be mounted in a panel and properly labeled. Prior to installation, insure through coordination with all trades, that appropriate clearances (36" minimum) as required by the N.E.C. are maintained at all control panels, including unitary controllers for VAV terminals, etc.

L. After a power failure, the Unitary Controller shall operate the control application using the current setpoints and configuration. Reverting to default or factory setpoints are not acceptable.

M. Digital expanders, multiplexers or other devices which gang multiple signals into or out of a signal point are not allowed. Each input or output called for shall have its own discrete point on the controller. All points to have a unique digital input to the BAS system. The use of digital point count expanders is not an acceptable replacement to digital inputs to the unitary controller. The conversion of a single universal input channel to accept up to multiple voltage free contacts such as relay contacts, auxiliary starter contacts, differential pressure switches, etc. IS NOT ACCEPTABLE.

N. The unitary controller for each VAV box shall be mounted on the side of the unit. The unitary controller for all other equipment shall be mounted in a panel and properly labeled.

O. Enclosures must be appropriately rated and properly installed and for their intended use. Enclosures installed in areas are subject to falling dirt and circulating dust, lint, fibers, and flyings as well as dripping or light splashing should be NEMA12. Mechanical rooms would typically fall under this category.

P. Minimum of 3' working clearance shall be provided in front of all enclosures and panels; clearances shall be ensured to permit the enclosure door to open at least 90 degrees from its closed position of all panels containing control components for servicing.

Q. Connect manual-reset limit controls independent of manual-control switch positions.

R. Locations mounted above ceiling shall be marked on ceiling grid.

S. Temperature control panel power shall be on a dedicated circuit taken from nearest appropriate emergency power electrical panel unless otherwise indicated.

PART 3 – EXECUTION:

3.1 A mandatory pre-installation meeting shall occur prior to the TCC beginning any work on site. This meeting shall be attended minimally the prime contractor, mechanical contractor superintendent, TCC superintendent, Engineer, Owner, and Architect. The purpose of the meeting is to have the controls installer communicate their understanding of the system design and how the system is intended operate to the Engineer and get the

Engineer's input and agreement. The agreement between the TCC and the mechanical engineer is to be thoroughly documented by the TCC for later reference.

3.2 The installation shall comply with the Local Authorities and State Fire Marshal code requirements, including normal operating and smoke mode functions (where applicable). The installation shall comply with the requirements of the NEC, NFPA, UL and the Building Codes, including referenced mechanical, electrical, energy codes, etc.

3.3 The Ethernet LAN: This is a shared, routed system extended to each building by the Information Technologies. The new BAS/ATC will be connected to the LAN.

3.4 All labeling for this system shall utilize actual final room names and numbers. The room names and numbers on the Contract Documents may not be the Owner's exact requirements. Coordinate with the Owner to ensure compliance.

3.5 Include in the bid for the Controls Contractor to perform additional 40 on-site hours of on-site programming, adjustments, modifications, etc. as requested by the Engineer during the warranty period after the date of substantial completion for the project.

3.6 WIRE MANAGEMENT, ELECTRICAL POWER, ETC.

A. Refer to CABLING section of this specification for additional requirements.

B. Electrical work required for system interlock and installation of the temperature control system shall be included in the bid and installed per all applicable codes. Coordinate with other trades as required for installation of a complete system.

C. All wiring and cabling in mechanical and electrical rooms shall be in conduit. No wiring or conduit can be exposed to view in any other area. Conceal all wiring and cabling in conduit in wall from thermostats or other controls devices to above ceiling. Install conduit in wall from wall thermostats to above ceiling for cabling. Route wiring directly to cable tray from control points above the ceiling. Rough-in for control devices shall be in compliance with the requirements of the ELECTRICAL SPECIFICATIONS.

D. Any power for controls shall be fed from dedicated circuits in emergency electrical panels, when provided for a project, and shall not be obtained from receptacles, lighting, or equipment circuits. Unitary control power may be obtained from the equipment served. If power is obtained from the equipment served, the power may not be interrupted to the electronics if the equipment is off for any reason.

E. The TCC shall be responsible for the power source to any control panels, unitary controllers, etc. on any controlled equipment and all other control power requirements. This includes circuit breakers, wiring, conduit, etc. installed in strict accordance with NEC. The TCC may contract with the electrical contractor for the power wiring installation.

F. Prior to installation, insure through coordination with all trades, that appropriate clearances (36" minimum) as required by the N.E.C. are maintained at all control panels, including unitary controllers for VAV terminals, heat pumps, etc.

G. The TCC shall provide all CAT6 cabling network cabling for a complete system. This shall include cabling to the Owner's data drop. The main system data drop will be provided by others.

H. All control circuits within the electrical panels shall be marked to indicate equipment served.

I. The TCC shall perform all temperature control interlock wiring. This shall include control valves, dampers, thermostats, indoor/outdoor HVAC systems, etc. Electrical work required for system interlock and installation of the temperature control system shall be included in the bid and installed per all applicable codes. Coordinate with other trades as required for installation of a complete system.

J. The TCC shall be responsible for any power required for the unitary controls or control panels. This includes circuit breakers, wiring, conduit, etc. installed in strict accordance with NEC. The TCC may contract with the electrical contractor for the power wiring installation.

K. Provide one duplex outlet mounted inside the control panel and separately fused with a non-time delay fuse at 15 A at any panel location containing electronic control components. This receptacle may be served from the control panel 120 VAC power source.

L. All wiring shall be continuous runs. Any junctions must be made in metal enclosure.

M. Grounding terminals shall be color coded green and yellow and shall be compatible with the other specialty terminals specified above and shall mount on the same DIN rail system. Units shall be arranged so that the wiring connected to them is grounded to the enclosure via the mounting rail. These terminals shall be provided for grounding cable shields at the points where the cables enter a control panel and terminate on the control panel terminal strip. Terminals shall be Entrelec M 4/5.3A.PI or equivalent by Weidmuller, Phoenix, or Allen Bradley.

N. The Department of Housing, Building and Construction's Electrical Division requires that all new lighting control panels, new Building Automation Systems control panels, and new conventional HVAC control panels be certified as being constructed and wired in accordance with NFPA 70 110.3 (a) (1) and article 409.

O. Contractor shall insure control panels have an identification label stating the "Certification Agency" such as UL, CSA, CE, etc. or a label of certification for each control panel by a Professional Engineer (P.E.) registered in the State of Ohio, stating that the design of the control panel was under their direct supervisory control. Include with shop drawings.

P. The Electrical Advisory Council for the State of Ohio requires that only an electrical contractor licensed by the State of Ohio with a licensed Master Electrician and a licensed on-site electrician can install the electrical wiring for lighting controls systems or Building Automation Systems (BAS).

3.7 CABLING

A. Refer to WIRE MANAGEMENT section of this specification for additional requirements.

B. ALL CONTROL WIRING SHALL BE INSTALLED IN A WIRE MANAGEMENT SYSTEM TO INCLUDE CABLE TRAYS, BRIDLE RINGS, & CONDUITS. NO EXCEPTIONS! COORDINATE WITH ELECTRICAL CONTRACTOR TO INSURE A COMPLETE WIRE MANGEMENT SYSTEM.

C. Acceptable cable manufacturers are Belden, West Penn, or Alpha.

D. A complete cabling system shall be furnished and installed, which shall adhere to the highest workmanlike standard of quality and appearance. Cabling shall be installed square with building lines and contained within a wire management system.

E. All sizing of cabling shall be according to manufacturer's recommendations but shall be a minimum of 18 AWG.

F. Furnish a floor plan of the building indicating communication cable labeling and routing as well as addresses and branch wiring from the unitary devices. All cabling shall be labeled on both ends. The type, size and label of all cabling shall be indicated on submittal floor plan drawings.

G. Wall space temperature sensor cabling (from the sensor to the unitary controller) shall have a minimum of four (4) conductors.

H. All cabling shall be stranded. "NO" solid conductors will be accepted. All cabling shall be 100% shielded with appropriate drain wire and insulation.

I. All cable connections shall be continuous run (including shield). Any junctions must be made in a metal enclosure, connections must be soldered, taped and the metal enclosure must be mechanically attached to the nearest ground. No wire nuts or crimped connections will be accepted. Note location of junction boxes on the as built floor plans. All cabling networking unitary controllers, and other networked equipment, shall be in soldered.

J. All shields must be terminated as per manufacturer's recommendation. Shield termination requirements by the manufacturer must be provided with submittals.

K. Wireless controllers are not approved unless specifically mentioned in the sequence of operations or noted on plans.

3.8 SYSTEM SOFTWARE

A. System software will be the latest version available with upgrades provided for full warranty period and shall be fully licensed to the owner for all network controllers and servers. Refer to WARRANTY section of this specification for additional requirements.

B. The BAS shall include trend logging screens accessible from tabs on the home page for building utilities usage.

C. System software shall, at a minimum, provide:
1. Monitor and supervise all control points.
2. Add new points and edit system database.
3. Change control setpoints, timing parameters and loop tuning of PID coefficients in all control loops in all control units.
4. Enter programmed start/stop schedules.
5. View alarm and messages.
6. Modify existing control logic (or sequence of operation) in all control units.
7. Upload/Download programs, databases, control parameters, etc.
8. Modify graphic screens.

D. Sequence of operation programming methodology - The application software shall be user programmable. Application programming shall be (1) Line type programming that uses text programming in a language similar to BASIC or FORTRAN, or (2) graphical block programming - The method of programming shall be by manipulation of graphic icon "blocks." Each block represents a subroutine containing the programming necessary to execute the function of the device that the block represents.

E. Unitary Control Unit Database Archiving - The host software shall provide capability to upload sequence of operation, database, and other control parameters from each controller. Uploaded programs shall be retained on hard disk for system backup. Programs may be modified using Editor functions and downloaded to individual controllers as desired. Downloading of databases shall not interrupt other multi-tasked functions that are ongoing.

F. THIRD PARTY SOFTWARE PACKAGES: The host software shall provide the capacity to run third party software packages for word processing, spreadsheets, or database management programs. Use of third party software shall not suspend operation of background tasks of multi-tasking operating system, such as alarm logging, and report generation.

3.9 GRAPHICS SCREENS AND TRENDS

A. All graphics screens shall be submitted for review by Engineer. Provide the following animated, color graphics screens minimally:

B. Entire floor plan home screen with OAT, Time, and Date displays.
   1. Floor plan showing major zones,
   2. Click major zone displays enlarged floor plan of the zone showing individual heat pump zones & numbers. Include link to respective mechanical room.
   3. Click individual zone shows heat pump graphic. Display all data points from points list, occ/unocc schedule and setpoints, VAV cfm and setpoint, OAT, Time and Date.

C. Color Graphic Screens shall be designed for all mechanical systems and shall include the following:
   1. A graphic shall be the starting page with the building graphically indicated. Break up the floor plan into zones to match Contract Documents. The building shall be the point of reference to enter into the respective building control system.
   2. All terminal equipment including but not limited to VAV boxes, reheat coils, zone dampers, etc.
   3. All AHUs and OA units.
   4. Domestic hot water heaters and pumps.
   5. The summation of all supply OA for each unit shall be displayed on the AHU graphic pages.
   6. All floor plans indicating all actual room numbers, thermostats, and mechanical equipment. Operator shall be capable of clicking on any equipment and pull up the respective graphic screen.

D. Graphics to include floor plans with room numbers (as-built room numbers) and thermostat locations, links to flow diagrams for heat pumps, zone dampers, hydronic loop systems, outside air systems, domestic hot water, and lighting controls.

E. All new graphics shall match the existing system graphics, unless noted otherwise.

F. The graphical programming software shall allow for interactive mouse-driven placement of block icons on the graphic screen and connection of block inputs to block outputs by means of drawing lines to form a graphic logic diagram. The user shall not have to manually input text to assign block input/output interconnections. Blocks shall allow entry of adjustable settings and parameters via pop-up windows.

G. The clarity of sequence shall be such that the user has the ability to verify that the system programming meets the specs without having to learn or interpret a manufacturer's unique programming language. Provide a means for testing and/or debugging the control programs off-line (not communicating with control units) using operator entered values for physical inputs and time. Provide a means for testing and/or debugging the control programs on-line (communicating with control units), showing actual physical inputs land all block outputs in real time.

H. Provide a utility that shall allow the graphic logic diagrams to be directly compiled into application programs. Logic diagrams shall be viewable either off-line, or on-line with real-time output values.

I. All graphic software shall be in the html web browser format and support multiple simultaneous screens to be opened and resizable in a "Windows" type environment. All functions, except text entry, shall be executable with a mouse. Graphic software shall provide for multitasking such that third party programs can be used while the Operator Workstation Software is on-line. Provide the ability to alarm graphically even when operator is in another software package. The software shall allow for Owner to create user defined, color graphic displays of geographic maps, building plans, floor plans, and mechanical and electrical system schematics.

J. The contractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g., fans, coils, filters, dampers, etc.), mechanical system components (e.g., pumps, heat pumps, etc.), complete mechanical systems (e.g., VAV, etc.) and electrical symbols.

K. The graphic development package shall use a mouse or similar pointing device to allow the user to perform the following:
   1. Define symbols
   2. Position items on graphic screens

3. Attach physical or virtual points to a graphic
4. Define background screens
5. Define connecting lines and curves
6. Locate, orient and size descriptive text
7. Define and display colors for all elements
8. Establish correlation between symbols or text and associated system points or other displays.
9. Create hot spots or link triggers to other graphic displays or other functions in the software

L. The TCC shall including programming of 25 point trends as directed by the Engineer. These can be requested at any time during the project including the warranty period. Trend "change of state" for digital inputs. Trend analog points in 30 minute increments. Maintain trend history for 30 days. Include the following:
1. Outside air temperature
2. OA unit leaving air temperatures for each unit
3. Summation of all VAV boxes connected to a unit
4. VFD speeds (OA & EA)
5. Water to water unit main supply and return temperatures (load side)
6. Critical room space temperatures
7. Domestic hot water supply temperatures
8. Freezer/Cooler temperatures
9. Makeup water flow rate
10. Electrical power kW and kWh
11. Others as directed in the field

3.10 TRAINING

A. A formal on-site "Hands On" training session shall be conducted for the owner's maintenance personnel. This session shall be a minimum of three (3) (8) hour days to train the staff on setup, operation, and maintenance of all system(s) and/or devices. This will be at a time and location selected by the owner. One (1) additional eight (8) hour session shall be provided as "opposite season" training – generally 6 months into the warranty period. One (1) additional eight (8) hour session shall be provided at a later date. (This may be requested any time during the warranty period.) All training materials and books shall be provided. Both sessions shall be given by the manufacturers "factory" technical representative. (This is defined as someone other than the installing contractor's representative.) All expenses are to be provided by the TCC. All training sessions shall be scheduled at owner's request.

B. TCC shall conduct training courses for designated personnel in operation and maintenance of system. Training shall be oriented to specific system being installed under his contract and shall be digitally recorded and submitted on DVD by the TCC.

C. Training shall be a mix of, test exercises, and actual keyboard entry and screen viewing at the operator's terminal. A curriculum shall be discussed and implemented based on the level of expertise of the employees. Hands-on experience and problem solving shall be emphasized.

D. If during any training session, the trainer/owner finds more than three (3) items that need repair, the training session will be immediately terminated. The session will be rescheduled for another date. The re-scheduled training session will be carried out at no additional cost to the Owner.

E. The training shall be oriented to making the owner self sufficient in the day-to-day use and operation of the DDC system.

F. Additionally, the training shall include:
1. System start-up, shutdowns, power outage and restart routines, alarms, security levels, changing setpoints, changing schedules and other parameters, overrides, freeze protection, manual operation, return to automatic operation, and resetting equipment.
2. All screens shall be discussed, allowing time for questions.
3. Information specifically focused on showing the owner methods of troubleshooting the mechanical

systems using the DDC.
4. Use of laptop and hand-held operator interface device, if applicable.
5. Creating, modifying, viewing, downloading, and reloading, trend logs.
6. Remote access to the system.
7. The other training sessions shall be oriented toward answering specific questions from Owner's staff.
8. The trainer must be well grounded in both DDC system operation and in mechanical systems service and shall be the programmer.

G. This documentation and process shall be complete, approved and accepted by Engineer and Owner prior to acceptance. This information shall be documented as completed. A copy shall be delivered to the Engineer and Owner and included in the O&M manuals.

3.11 COMMISSIONING & VERIFICATION, FUNCTION PERFORMANCE TESTING & CHECKLISTS:

A. 100% compliance with the requirements of this section is a condition of the Owner's acceptance and start of the warranty period.

B. The TCC shall be responsible for completion of (1) their hardware checkout sheets and test reports, (2) Point-by-point confirmations of ALL points – this includes visual inspection of installed components, and (3) sequence of operation confirmation.

C. This documentation and process shall be complete, approved and accepted by Engineer and Owner prior to acceptance. This information shall be documented as completed. A copy shall be delivered to the Engineer and Owner and included in the O&M manuals. Each subcontractor shall be responsible for completion of their own System Verification Checklists/Manufacturer's Checklists. Sample checklists shall be submitted to the Engineer and Testing Agent for approval.

D. Air and water balancing shall be completed (and discrepancies resolved) before the TCC's final system check and before the acceptance test to be conducted in the presence of the Engineer.

E. This project will be commissioned and the TCC shall be responsible for completing the functional performance testing of the control system sequences and graphics with the Commissioning Agent.

3.12 WARRANTY & SOFTWARE LICENSES

A. Labor and materials for the control system specified shall be warranted free from defects for a period of 12 months after substantial completion and acceptance. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to the Owner.

B. The TCC shall respond to the Owner's request for warranty service within 24 hours during normal business hours. The TCC shall respond to the Owner's request for Emergency service (defined as life-threatening or creating the potential to cause property damage) during the warranty period within 4 hours.

C. The TCC shall provide technical phone support to the owner during the warranty period for warranty related issues and for two years after the warranty period. If the technical support location of the TCC is outside of the toll-free calling area for the customer, the TCC shall have a toll-free number or accept collect calls for the purpose of providing technical support.

D. During the warranty period, standard parts for the DDC system shall arrive at the facility within 48 hours of placing an order. Non-standard parts (requiring re-manufacturing or ordering from another supplier) shall be shipped within 96 hours.

E. Operator workstation software, project-specific software, graphic software, database software, and firmware updates which resolve known software deficiencies as identified by the TCC shall be provided and correctly installed at no charge during the warranty period.

F. Provide licensed electronic copies of all software for each workstation, laptop, server. This includes but is not limited to: project graphic images (editing/modifying/creating), project database, trouble-shooting and debugging programs, project-specific programming code and all other software required to operate and modify the programming code (including software at system level, primary control units, secondary control units, and all communication software). Any hardware devices (cables, protection devices) required to operate the software/hardware shall also be provided.

G. All additional licensing needed for this project shall be supplied by TCC. Software license shall not expire or utilize any sort of protection hardware device for its use. In any case owner shall be free to direct the modification of any software license, regardless of supplier to allow open access to all controllers. Owner shall hold the software and firmware licensing. Software license shall not expire or utilize any sort of protection hardware device for its use.

H. System software shall be the latest version available with upgrades provided at the end of the warranty period and shall be fully licensed to the Owner for the entire system. Supply all software necessary for configuration of, modification, editing or communicating to any of the unitary devices. Software shall be capable of uploading and down-loading the entire unitary data base or any part of the automated system for backup or archiving. Software shall be "IBM compatible".

END OF SECTION 230910

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SECTION 230920 – VARIABLE FREQUENCY MOTOR CONTROL

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractor's attention is directed to Specification Section FACILITY MONTORING SYSTEM.

C. The Contractor's attention is directed to Specification Section INSTRUMENTATION AND CONTROL FOR HVAC.

D. The Contractor's attention is directed to Specification Section SHOP DRAWINGS, MAINTENANCE MANUALS AND PARTS LIST FOR HVAC.

1.2 SCOPE

A. All VFD shall adhere to the latest manufacturers recommended installation, wiring and networking practices.

B. Include all power wiring and cabling for the operation of the VFD. Refer to Electrical Division Specifications for additional requirements.

C. The distributor shall have an established working relationship with the manufacturer of not less than five years and shall have prior approval from the Owner and Engineer and are the only allowed suppliers and/or installing contractors. The distributor shall have a local office within 100 miles of the project site and provide service and/or replacement parts within a 24 hour notification of a control failure.

PART 2 – PRODUCTS:

2.1 VFDs shall be as manufactured by ABB, Danfoss, or Honeywell. These are the only acceptable manufacturers. All VFDs for the project shall be by the same manufacturer (no exceptions).

2.2 VFDs shall be consist of a pulse width modulated (PWM) inverter designed for use on a standard NEMA Design B induction motor.

2.3 The VFD shall be capable of operation form AC voltage in two rages 208–240 VAC ± 10%, or 380–480 VAC ± 10%. 50/60 HZ operation, ± 2 hertz.

2.4 The VFD enclosure shall be rated UL type 1 and shall be UL listed as a plenum rated, suitable operating conditions: $0 – 40^0$ C continuous. Drives that have thermal cut out circuits, or that cannot operate continuously at 40^0 C shall not be acceptable. Altitude 0 to 3300 feet above sea level, up to 95% humidity, non-condensing.

2.5 The VFD shall produce an adjustable AC voltage/frequency output for step less motor speed control utilizing sine wave coded Pulse Width Modulation (PWM) The Drive shall provide automatic power factor correction and a .98 displacement power factor by incorporating a full wave diode bridge rectifier. The VFD shall have an overload rating of 110% of nominal rated current for 1 minute out of every 10 minutes of operation, which is an acceptable overload for centrifugal loads.

2.6 The VFD shall include a built-in first environment RFI/EMI filter and be CE and UL labeled. It shall also meet the CE requirement of EN61800-3 which provides an actual test procedure that shows that the VFD is immune from RFI/EMI interference and at the same time does not emit RFI/EMI noise that would interfere with other sensitive equipment near the VFD.

2.7 The VFD shall include as a minimum a 5% dual DC link or AC line reactor for a clean harmonic signature, which aides in complying with IEEE-519-1992 recommended levels. The VFD manufacturer and representative shall assist in ensuring that the VFD's applied meet IEEE-519-1992 by completing a computer aided Harmonic Analysis of the complete system.

2.8 The VFD shall include as a standard a built in digital keypad/display panel. This panel shall provide "Hand" off "Auto" selection, and a manual speed adjustment via up and down arrows. All faults and warnings shall be provided in "Plain English" for operation without a manual. The drive shall have a complete manual stored in memory that can be accessed with a single keystroke. This display shall be password protected and allow all setup parameters to be adjusted only by authorized personnel.

2.9 The VFD shall include built in Startup, Diagnostic, and Maintenance assistants, which allow for step-by-step startup procedures, troubleshooting, and the ability to indicate when the VFD and the system it is applied to needs preventive maintenance performed.

2.10 The VFD shall include a real time clock with a day/date stamp for troubleshooting purposes. In addition, with the use of this clock the drive shall be capable of stand-alone operation and act as a unitary controller.

2.11 The VFD shall include (2) Analog inputs either 4–20 madc or 0-10 vdc, (6) programmable Digital Inputs, (2) Programmable analog Outputs, (3) Form C Relay output rated 2 amps continuous minimum, and (2) PID Process controllers.

2.12 The VFD keypad shall include a backlit LCD display. The display shall be in complete English words for programming and fault diagnostics (LED and alpha-numeric codes are not acceptable). All VFD faults shall be displayed in English words.

2.13 The drive shall have embedded serial communication capabilities that allow direct connection to Modbus, Johnson Controls, Siemens and BACnet automation systems as part of the drives software suite without the need for extra hardware cards or gateways. The connection shall be tested by the BACnet Testing Labs (BTL) and be BTL Listed. The BACnet interface shall conform to the BACnet standard device type of an Applications Specific Controller (B-ASC).

PART 3 – EXECUTION:

3.1 The work includes all labor, materials, and related items to completely furnish and install, start up and test, and place into service the Variable Frequency Drives (VFDs) indicated and scheduled on the Drawings and described in the Specifications.

3.2 All VFDs shall be provided and installed in strict accordance with the manufacturer's recommendations.

3.3 Factory-authorized startup for each drive is mandatory. Provide a written record of the startup of each unit. Start up and programming by a factory-authorized technician. At startup, lockout any speed with the VFD that does not meet the vibration allowanced of the equipment manufacturers.

3.4 A parts and labor warranty of **3 years from startup and 2 years from the date of substantial completion** shall be included. Warranty shall include travel time and expenses.

END OF SECTION 230920

SECTION 232113 – HYDRONIC PIPING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. Each Contractor's attention is also directed to Specification Section HANGERS, CLAMPS, ATTACHMENTS, ETC.

C. The Contractor's attention is also directed to Specification Section SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS LISTS FOR HVAC.

D. The Contractor's attention is directed to Specification Section INSULATION - MECHANICAL.

E. The Contractor's attention is directed to Specification Section PIPE FILLING, CLEANING, FLUSHING, PURGING AND CHEMICAL TREATMENT.

1.2 SCOPE

A. Unless otherwise indicated, all materials shall be new and of the best grade and quality for the type specified. Materials shall comply with the “Buy American Act”.

B. Where piping is not indicated on the plans, but is obviously or apparently required, contact the Engineer prior to submission of the bid.

C. The piping indicated shall be installed complete and shall be of the size indicated. When a pipe size is not indicated, the Contractor shall request the pipe size from the Engineer. Where a section of piping is not indicated but is obviously required for completion of the system, the Contractor shall provide same at no additional cost to the project.

D. Pay particular attention to conflict of piping with other work. Do not install until conflict is resolved. If in doubt, consult Engineer.

E. Piping materials in each system shall, to the extent practicable, be of the same material. Frequent changes of material (for example, from copper to steel) shall be avoided and in no case shall be accomplished without use of insulating unions and permission of the Engineers.

F. Dielectric couplings or through ways shall be provided at all connections of dissimilar materials.

G. Nipples shall be of the same material, composition, and weight classification as pipe with which installed.

H. Plastic piping or any material with a flame and smoke spread rating not approved for plenum use shall not be permitted in supply, return, relief, or exhaust plenums.

I. Non-metallic piping shall be installed in strict accordance with the manufacturer's instructions. If no such instructions are available, consult Engineer.

J. When connecting to an existing hydronic water system (chilled, hot, etc.), the Contractor shall include cost to drain the existing piping system and refill with water/closed loop chemicals to match existing fluid. If the building is occupied, and the drain down will affect services to these occupied areas, then the systems shall be drained and refilled over a weekend at a time acceptable to the Owner. Refer to Specification.

PART 2 – PRODUCTS

2.1 UNIONS, FLANGES AND WELDED TEES

A. Screwed unions, soldered unions or bolted flanges shall be provided as required to permit removal of equipment, valves, and piping accessories from the piping system. Keep adequate clearances for coil removal, rodding, tube replacement, motor lubrication, filter replacement, etc. Flanged joints shall be assembled with appropriate flanges, gaskets, and bolting. The clearance between flange faces shall be such that the connections can be gasketed and bolted tight without imposing undue strain on the piping system.

B. Dielectric insulating couplings or though ways shall be used wherever the adjoining materials being connected are of dissimilar metals such as connections between copper and steel pipe.

C. Tee connections for welded pipe shall be assembled with welding fittings. Where the size of the side outlet is such that a different connection technique than on the run is required, a weldolet, sockolet, or threadolet type fitting may be used for the branch in place of reducing tees only where the branch is 2/3 the run size or smaller. Weld-o-let and thread-o-let branch connections are acceptable.

2.2 STANDARDS

A. All piping and material shall be new, comply with the “Buy American Act” and shall conform to the following minimum applicable standards:
1. Steel pipe; Schedule 40; ASTM A-53.
2. Copper tube; Type K, L, M; ASTM B88-62; Type DWV ASTM B306-62.
3. Welding fittings; ASA B16.9.
4. Cast brass and wrought copper fittings; ASA B16.18.
5. Cast brass drainage fittings; ASA B16.23.
6. PVC pipe; Schedule 40; ASTM D-1785.

2.3 HVAC PIPING APPLICATIONS

A. HVAC Hydronic Piping

1. System Types:
a) Hot Water
b) Chilled Water

2. 2” and Smaller: Schedule 40 black steel pipe with screwed fittings or Type “L” hard copper tubing with wrought copper fittings and 95/5 solder.

3. 2½” and Larger: Schedule 40 black steel pipe with 125# welded or flanged joints. Weldolets may be used for branch line connections to pipe mains. Type “L” hard copper piping with wrought copper fittings and 95/5 solder may be installed.

4. Schedule 40 Victaulic 107/W07 or approved mechanical grooved pipe couplings and fittings with a minimum 125# rating. Install gaskets as recommended by the manufacturer. Piping system shall be rated for minimum of 250 degrees F water temperature. Mechanical grooved piping may not be used if system water temperature exceeds 250ºF. All grooved components must be of one manufacturer.

B. Air Vent Discharge Lines Type "L" soft copper; wrought copper fittings, 95/5 solder. Pipe to a suitable drainage location.

C. Condensate Drain Lines Type "M" copper tubing with sweat fittings and 95/5 solder.

PART 3 – EXECUTION

3.1 All piping shall be capped or plugged during erection as required to keep clean and debris and moisture free.

3.2 All piping shall be installed straight and true, parallel, or perpendicular to the building construction. Piping shall be installed so as to allow for expansion without damage to the building finishes, structure, pipe, equipment, etc., use offsets, U-bends or expansion joints as required. No mitered joints or field fabricated pipe bends shall be accepted. Pipe shall clear all windows, doors, louvers, and other building openings.

3.3 All pipes shall be supported in a neat and workmanlike manner and wherever possible, parallel runs of horizontal piping shall be grouped together on hangers. Vertical risers shall be supported at each floor line with approved steel pipe riser clamps. Spacing of pipe supports shall not exceed eight (8) foot intervals for pipes 3" and smaller and ten (10) foot intervals on all other piping. Small vertical pipes (1" and less) shall be bracketed to walls, structural members, etc. at four (4) foot intervals so as to prevent vibration or damage by occupants.

3.4 The use of wire or perforated metal to support pipes will not be permitted. Hanging pipes from other pipes shall not be permitted.

3.5 Insulated piping shall be supported on a rigid insulation block at each hanger so as to prevent crushing of insulation by hangers. Hangers shall pass completely around the insulation jacket and a steel protective saddle shall be applied to prevent compression of the insulation.

3.6 In metal buildings or buildings with light gauge trusses, support piping with standard pipe hangers with C-clamp connection to main structural members (not perlins), use angle steel cross pieces between main structural members where required to provide rigid support.

3.7 Where piping rests directly on a hanger, clip, bracket or other means of support, the support element shall be of the same material as the pipe, (e.g., copper to copper, ferrous to ferrous, etc.) or shall be electrically isolated one from the other so as to prevent pipe damage by electrolysis. Pay particular attention and do not allow copper pipe to rest on ferrous structural members, equipment, etc. without electrolytic isolation. This includes temporary support required during Construction.

3.8 In general, piping shall be installed concealed except in mechanical rooms, etc. unless otherwise indicated, and shall be installed underground or beneath concrete slabs only where indicated. All lines at ceilings shall be held as high as possible and shall run so as to avoid conflicts with other trades, and to facilitate the Owner's use and maintenance. Location of pipe in interior partitions shall be carefully coordinated with whoever will construct the partitions after the piping is in place. Where exposed risers occur, they shall be kept as close to walls as possible.

3.9 Pipe shall be cut accurately to measurements established at the building by the Contractor and worked into place without springing or forcing. All pipes shall be reamed to full pipe diameter before joining and before assembling. All lengths of pipe shall be set vertically and tapped with a hammer to remove scale and dust and inspected to ensure that no foreign matter is lodged therein.

3.10 All hot and cold water piping shall be kept a sufficient distance apart so as to prevent heat transfer between them. Cold water piping shall also be kept apart from refrigerant hot gas lines.

3.11 Piping carrying water or other fluids subject to freezing shall not be installed in locations subject to freezing. If in doubt, consult Engineer.

3.12 Apply approved pipe dope for service intended to all male threaded joints. The dope shall be listed for intended use.

3.13 Eccentric reducers shall be used where required to permit proper drainage and venting of pipe lines; bushings shall not be permitted.

3.14 High points of closed loop chilled water, hot water and geothermal systems shall have manual air vents as required unless automatic air vents are specifically indicated. Pipe to suitable drainage point.

3.15 Installation of pipe shall be in such a manner as to provide complete drainage of the system, whether detailed or not on plans. Drain valves shall be provided at all drainage points on pipes. Drain valves shall be ½" size ball valves with 3/4" hose thread end and vacuum breaker. Label each drain valve.

3.16 Where plastic piping penetrates a fire rated assembly, it shall be replaced with a threaded metal adapter and metal pipe or whatever means necessary to maintain the separation rating in accordance with local plumbing and fire codes.

3.17 When running any type of pipe below a footing, perpendicular to the footing, the area underneath the footing and in the zone of influence shall be backfilled with concrete. The zone of influence is the area within a 45 degree angle projecting down from the top edge of footing on all sides of the footing.

3.18 When running any type of pipe below a footing, parallel to the footing, the area underneath the zone of influence shall be backfilled with 4” of crushed stone or sand bedding under the pipe. Each pipe section shall be anchored into unexcavated earth on both ends with deadman anchor system. The remainder of the trench in the zone of influence shall be backfilled with cementitious flowable fill. The zone of influence is the area within a 45 degree angle projecting down from the top edge of the footing on all sides of the footing.

3.19 PIPE TESTING:

A. Piping shall be tested before being insulated or concealed in any manner. Where leaks or defects develop, required corrections shall be made and tests repeated until systems are proven satisfactory.

B. Chilled water piping systems shall be subjected to a hydrostatic test of 250#. The system shall be proven tight after a twenty-four (24) hour test.

C. Hot water and geothermal water piping systems shall be subjected to a hydrostatic test of 150 psi. The system shall be proven tight after a twenty-four (24) hour test.

D. The Contractor shall perform all additional tests that may be required by the Ohio Boiler and Pressure Vessel Rules or other governing agency.

E. Any leaks or imperfections found shall be corrected and a new test run until satisfactory results are obtained. The cost of repair or restoration of surfaces damaged by leaks in any system shall be borne by the Contractor.

3.20 PITCH OF PIPING

A. All piping systems shall be installed so as to drain to a low point. Certain minimum pitches shall be required for this drainage. For proper flow and/or for proper operation, the following pitches shall be required:

B. CONDENSATE DRAIN LINES FROM COOLING EQUIPMENT: Not less than ¼” per foot in direction of flow.

C. ALL OTHER LINES: Provide ample pitch to a low point to allow 100 percent drainage of the system.

END OF SECTION 232113

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SECTION 232113.13 – UNDERGROUND HYDRONIC PIPING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractor’s attention is directed to the following Plans and the Specification Sections:
   1. SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC
   2. TESTING, ADJUSTING AND BALANCING FOR HVAC
   3. HANGERS, CLAMPS, ATTACHMENTS, ETC.
   4. HVAC PIPING INSULATION
   5. PIPE FILLING, CLEANING, FLUSHING, PURGING AND CHEMICAL TREATMENT.
   6. INSULATION - MECHANICAL
   7. INSTRUMENTATION AND CONTROL FOR HVAC
   8. HYDRONIC PUMPS
   9. HVAC WATER TREATMENT
   10. AIR TERMINAL UNITS
   11. INDOOR AIR HANDLING UNITS

1.2 SCOPE

A. Unless otherwise indicated, all materials shall be new and of the best grade and quality for the type specified.

B. Where piping is not indicated on the plans, but is obviously or apparently required, contact the Engineer prior to submission of the bid.

C. The piping indicated shall be installed complete and shall be of the size indicated. When a pipe size is not indicated, the Contractor shall request the pipe size from the Engineer. Where a section of piping is not indicated but is obviously required for completion of the system, the Contractor shall provide same at no additional cost to the project.

D. Pay particular attention to conflict of piping with other work. Do not install until conflict is resolved. If in doubt, consult Engineer.

E. Piping materials in each system shall, to the extent practicable, be of the same material. Frequent changes of material (for example, from copper to steel) shall be avoided and in no case shall be accomplished without use of insulating unions and permission of the Engineers.

F. Dielectric couplings or through ways shall be provided at all connections of dissimilar materials.

G. Nipples shall be of the same material, composition, and weight classification as pipe with which installed.

H. Plastic piping or any material with a flame and smoke spread rating not approved for plenum use shall not be permitted in supply, return, relief, or exhaust plenums.

I. Non-metallic piping shall be installed in strict accordance with the manufacturer's instructions. If no such instructions are available, consult Engineer.

J. When connecting to an existing hydronic water system (chilled water, hot water, etc.), the Contractor shall include cost to drain the existing piping system and refill with water/closed loop chemicals to match existing fluid. If the building is occupied, and the drain down will affect services to these occupied areas, then the systems shall be drained and refilled over a weekend at a time acceptable to the Owner. Refer to Specification.

PART 2 – PRODUCTS

2.1 UNIONS, FLANGES AND WELDED TEES

A. Screwed unions, soldered unions or bolted flanges shall be provided as required to permit removal of equipment, valves, and piping accessories from the piping system. Keep adequate clearances for coil removal, rodding, tube replacement, motor lubrication, filter replacement, etc. Flanged joints shall be assembled with appropriate flanges, gaskets, and bolting. The clearance between flange faces shall be such that the connections can be gasketed and bolted tight without imposing undue strain on the piping system.

B. Dielectric insulating couplings or though ways shall be used wherever the adjoining materials being connected are of dissimilar metals such as connections between copper and steel pipe.

C. Tee connections for welded pipe shall be assembled with welding fittings. Where the size of the side outlet is such that a different connection technique than on the run is required, a weldolet, sockolet, or threadolet type fitting may be used for the branch in place of reducing tees only where the branch is 2/3 the run size or smaller. Weld-o-let and thread-o-let branch connections are acceptable.

2.2 STANDARDS

A. All piping and material shall be new, comply with the "Buy American Act" and shall conform to the following minimum applicable standards:
- Steel pipe; Schedule 40; ASTM A-53.
- Copper tube; Type K, L, ; ASTM B88-62; Type DWV ASTM B306-62.
- Cast iron soil pipe; ASA A-40. l and CS 188-59.
- Cast iron drainage fittings; ASA B16.12.
- Cast iron screwed fittings; ASA B16.4.
- Welding fittings; ASA B16.9.
- Cast brass and wrought copper fittings; ASA B16.18.
- Cast brass drainage fittings; ASA B16.23.

2.3 HVAC PIPING APPLICATIONS

A. HVAC Hydronic Piping
1. System Types:
   a) Chilled Water

B. Underground Double Wall Chilled Water Piping:
1. Contractor shall provide a "Thermacor Thermafab" or approved equivalent pre-insulated pre-fabricated piping system.
2. Insulation shall be foamed polyurethane completely filling annular space and shall be 1 -1/4 inches thick with a uniform density of 1.9-2.1 pounds per cubic foot, and minimum 90% closed cell structure.
3. Jacketing materials shall be PVC with a wall thickness of 0.16 inches.
4. Carrier pipe shall be schedule 40 steel with 125# welded joints. All unloading and handling shall be done so as to protect the outer jacket and bared pipe ends at all times.
5. Joints and fittings shall be insulated in accordance with the manufacturer's specifications. Factory trained personnel for instruction at the job site shall be provided by the piping manufacturer.
6. The trench for buried system shall be a minimum of 18 inches wider than the pre-insulated pipe and a minimum of 2 feet deeper than the top of the pipe. The trench base and all backfill within 6 inches of

the piping system shall be free of any debris. Proper testing shall be carried out before any pipe is buried.

PART 3 – EXECUTION

3.1 All piping shall be capped or plugged during erection as required to keep clean and debris and moisture free.

3.2 All piping shall be installed straight and true, parallel, or perpendicular to the building construction. Piping shall be installed so as to allow for expansion without damage to the building finishes, structure, pipe, equipment, etc., use offsets, U-bends or expansion joints as required. No mitered joints or field fabricated pipe bends shall be accepted. Pipe shall clear all windows, doors, louvers, and other building openings.

3.3 All pipes shall be supported in a neat and workmanlike manner and wherever possible, parallel runs of horizontal piping shall be grouped together on hangers. Vertical risers shall be supported at each floor line with approved steel pipe riser clamps. Spacing of pipe supports shall not exceed eight (8) foot intervals for pipes 3” and smaller and ten (10) foot intervals on all other piping. Small vertical pipes (1” and less) shall be bracketed to walls, structural members, etc. at four (4) foot intervals to prevent vibration or damage by occupants.

3.4 The use of wire or perforated metal to support pipes will not be permitted. Hanging pipes from other pipes shall not be permitted.

3.5 Insulated piping shall be supported on a rigid insulation block at each hanger so as to prevent crushing of insulation by hangers. Hangers shall pass completely around the insulation jacket and a steel protective saddle shall be applied to prevent compression of the insulation.

3.6 In metal buildings or buildings with light gauge trusses, support piping with standard pipe hangers with C-clamp connection to main structural members (not perlins), use angle steel cross pieces between main structural members where required to provide rigid support.

3.7 Where piping rests directly on a hanger, clip, bracket or other means of support, the support element shall be of the same material as the pipe, (e.g., copper to copper, ferrous to ferrous, etc.) or shall be electrically isolated one from the other so as to prevent pipe damage by electrolysis. Pay particular attention and do not allow copper pipe to rest on ferrous structural members, equipment, etc. without electrolytic isolation. This includes temporary support required during Construction.

3.8 In general, piping shall be installed concealed except in mechanical rooms, etc. unless otherwise indicated, and shall be installed underground or beneath concrete slabs only where indicated. All lines at ceilings shall be held as high as possible and shall run so as to avoid conflicts with other trades, and to facilitate the Owner's use and maintenance. Location of pipe in interior partitions shall be carefully coordinated with whoever will construct the partitions after the piping is in place. Where exposed risers occur, they shall be kept as close to walls as possible.

3.9 Pipe shall be cut accurately to measurements established at the building by the Contractor and worked into place without springing or forcing. All pipes shall be reamed to full pipe diameter before joining and before assembling. All lengths of pipe shall be set vertically and tapped with a hammer to remove scale and dust and inspected to ensure that no foreign matter is lodged therein.

3.10 All hot and cold-water piping shall be kept a sufficient distance apart so as to prevent heat transfer between them. Cold water piping shall also be kept apart from refrigerant hot gas lines.

3.11 Piping carrying water or other fluids subject to freezing shall not be installed in locations subject to freezing. If in doubt, consult Engineer.

3.12 Apply approved pipe dope for service intended to all male threaded joints. The dope shall be listed for intended use.

3.13 Eccentric reducers shall be used where required to permit proper drainage and venting of pipelines; bushings shall not be permitted.

3.14 High points of closed loop chilled water, hot water and geothermal systems shall have manual air vents as required unless automatic air vents are specifically indicated. Pipe to suitable drainage point.

3.15 Installation of pipe shall be in such a manner as to provide complete drainage of the system, whether detailed or not on plans. Drain valves shall be provided at all drainage points on pipes. Drain valves shall be ½" size ball valves with 3/4" hose thread end and vacuum breaker. Label each drain valve.

3.16 Where plastic piping penetrates a fire rated assembly, it shall be replaced with a threaded metal adapter and metal pipe or whatever means necessary to maintain the separation rating in accordance with local plumbing and fire codes.

3.17 When running any type of pipe below a footing, perpendicular to the footing, the area underneath the footing and in the zone of influence shall be backfilled with concrete. The zone of influence is the area within a 45 degree angle projecting down from the top edge of footing on all sides of the footing.

3.18 When running any type of pipe below a footing, parallel to the footing, the area underneath the zone of influence shall be backfilled with 4” of crushed stone or sand bedding under the pipe. Each pipe section shall be anchored into unexcavated earth on both ends with deadman anchor system. The remainder of the trench in the zone of influence shall be backfilled with cementitious flowable fill. The zone of influence is the area within a 45 degree angle projecting down from the top edge of the footing on all sides of the footing.

3.19 PIPE TESTING:

A. Piping shall be tested before being insulated or concealed in any manner. Where leaks or defects develop, required corrections shall be made and tests repeated until systems are proven satisfactory.

B. Dual temperature water piping systems shall be subjected to a hydrostatic test of 250#. The system shall be proven tight after a twenty-four (24) hour test.

C. Geothermal water piping systems shall be subjected to a hydrostatic test of 150 psi. The system shall be proven tight after a twenty-four (24) hour test.

D. The Contractor shall perform all additional tests that may be required by all governing agencies.

E. Any leaks or imperfections found shall be corrected and a new test run until satisfactory results are obtained. The cost of repair or restoration of surfaces damaged by leaks in any system shall be borne by the Contractor.

3.20 PITCH OF PIPING

A. All piping systems shall be installed so as to drain to a low point. Certain minimum pitches shall be required for this drainage. For proper flow and/or for proper operation, the following pitches shall be required:

B. ALL OTHER LINES: Provide ample pitch to a low point to allow 100 percent drainage of the system.

END OF SECTION 232113.13

SECTION 232120 - WELDING

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS:

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

1.2 SCOPE:

A. All welding accomplished by any Mechanical Contractor shall comply with provision of the latest revision of applicable codes, whether ASME Boiler and Pressure Vessel Code for pressure piping or such State and Local requirements as may supersede these codes.

B. Welds shall be of sound metal thoroughly fused to the base metal at all points, free from cracks and reasonably free from oxidation blow holes and non-metallic inclusions. No fins or weld metal shall project within the pipe and should they occur, they shall be removed. All pipe beveling shall be done by machine. The surface of all parts to be welded shall be thoroughly cleaned free from paints, oil, rust, or scale at the time of welding, except that a light coat of oil may be used to preserve the beveled surfaces from rust.

PART 2 – PRODUCTS:

2.1 Welding fittings shall conform to ASA B16.9; of the same materials, thickness, etc., as the pipe being jointed; see ASA B36.10.

PART 3 – EXECUTION:

3.1 Welds shall be of sound metal thoroughly fused to the base metal at all points, free from cracks and reasonably free from oxidation blow holes and non-metallic inclusions. No fins or weld metal shall project within the pipe and should they occur, they shall be removed. All pipe beveling shall be done by machine. The surface of all parts to be welded shall be thoroughly cleaned free from paints, oil, rust or scale at the time of welding, except that a light coat of oil may be used to preserve the beveled surfaces from rust.

3.2 Pipe and fittings shall be carefully aligned with adjacent parts and this alignment must be preserved in a rigid manner during the process of welding.

3.3 WELDING QUALIFICATIONS:

A. Pipe welding shall comply with the provisions of the latest revision of the applicable codes, whether ASME Boiler and Pressure Vessel Code, ASA Code for Pressure Piping, or such state or local requirements as may supersede codes mentioned above.

B. Before any pipe welding is performed, submit to the Owner, a copy of the welding procedure specifications, together with proof of its qualification as outlined and required by the most recent issue of the code having jurisdiction.

C. Before any welder shall perform any pipe welding, submit to the Owner the Operator's qualification record in conformance with the provisions of the code having jurisdiction, showing that the operator was tested under the proven procedure specifications submitted.

D. Standard Procedure Specifications and Welders qualified by the National Certified Pipe Welding Bureau shall be considered as conforming to the requirements of these specifications.

3.4 Each Contractor shall be responsible for quality of welding done by his organization and shall repair or replace any work not done in accordance with specifications. If required by the Architect/Engineer, the Contractor shall cut out at least five (5) welds during the job for X-raying and testing. These welds shall be selected at random by the Resident Inspector and shall be tested as a part of the Contractor's Contract. Certifications of these tests and X-rays shall be submitted, in triplicate to the Engineer. In case a faulty weld is discovered, the Contractor shall be required to furnish additional tests.

END OF SECTION 232120

SECTION 232123 – HYDRONIC PUMPS FOR HVAC

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. Electric motors shall be furnished with the pumps and shall be of the size and type scheduled or otherwise specified. All motors shall be UL labeled and shall comply with applicable NEMA standard. Motors to be high efficiency type. Refer to Specification Section – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.

1.2 SCOPE

A. Pumps shall be factory tested, cleaned, and painted prior to shipment. Size, type, capacity, and electrical characteristics are listed in the pump schedule.

B. Insofar as possible, all pumps shall be by the same manufacturer.

PART 2 – PRODUCTS:

2.1 PERMANENTLY LUBRICATED INLINE PUMPS

A. Permanently Lubricated Inline Pumps shall be Series PL as manufactured by Bell & Gossett or equal by Taco, Armstrong, Patterson.

B. The pumps shall be of the horizontal permanently lubricated type, specifically designed for quiet operation. Suitable for 225 degrees F operation at 150 PSIG working pressure.

C. The pumps shall have a solid high-strength alloy steel shaft supported by XL11 permanently lubricated sealed precision bearings. Bearings are to be permanently oil lubricated. Pump shaft shall connect to a non-metallic noryl impeller.

D. Pump shall have integral stainless steel face plate and double sided stainless steel neck rings for increased life and seasonal start-up capabilities.

E. Pump volute shall be of cast bronze. The connection style on bronze pumps shall be flanged with isolation valves.

F. The motor shall be isolated from circulating fluid through use of a carbon/silicone seal attached on a stainless steel shaft sleeve.

G. Motors shall be of an Open Drip-Proof design and shall be non-overloading at any point on the pump curve. Motors shall be UL and CSA listed.

H. Pump shall be of a maintenance free design and be capable of operating in variable speed (varying voltage) applications.

2.2 CLOSED COUPLED INLINE PUMPS

A. Closed Coupled Inline Pump shall be Series 60 as manufactured by Bell & Gossett or equal by Taco, Armstrong, Patterson.

B. The pumps shall be of a vertical or horizontal installation type specifically designed for quiet operation. Suitable for 225° F operation at 175 PSIG working pressure. The pump shall be single stage, vertical split case design, all bronze construction. The pump internals shall be capable of being serviced without disturbing piping connections.

C. The pumps shall have a solid SAE1045 steel shaft that is integral to the motor. A non-ferrous shaft sleeve shall be employed to completely cover the wetted area under the seal.

D. The motor bearings shall support the shaft via heavy-duty grease lubricated ball bearings.

E. Pump shall be equipped with a mechanical seal assembly. Seal assembly shall have a brass housing, BUNA bellows and seat gasket, stainless steel spring, and be of a carbon ceramic design with the carbon face rotating against a stationary ceramic face.

F. Pump shaft shall connect to a brass impeller. Impeller shall be hydraulically and dynamically balanced, keyed to the shaft and secured by a locking capscrew or nut.

G. Pump should be designed to allow for true back pull-out access to the pump's working components for ease of maintenance.

H. Pump volute shall be of cast iron design for heating systems or cast brass for domestic water systems. The connection style on cast iron and bronze pumps shall be flanged. Volute shall include gauge ports at nozzles.

I. Motors shall meet scheduled horsepower, speed, voltage, and enclosure design. Motors shall have heavy-duty grease lubricated ball bearings to offset the additional bearing loads associated with the closed coupled pump design. Motors shall be non-overloading at any point on the pump curve and shall meet NEMA specifications.

J. Pump shall be of a maintainable design and for ease of maintenance should use machine fit parts and not press fit components.

K. Each pump shall be factory tested and name-plated before shipment.

L. Pumps shall conform to ANSI/HI 9.6.3.1 standard for Preferred Operating Region (POR).

2.3 SPLIT COUPLED INLINE PUMPS

A. Split Coupled Inline Pump shall be Series KS as manufactured by Taco or equal by Bell & Gossett, Armstrong, or Patterson.

B. The pumps shall be of a vertical or horizontal installation type specifically designed for quiet operation. Suitable for 225°F operation at 175 PSIG working pressure. The pump shall be single stage, vertical split case design, all bronze construction. The pump internals shall be capable of being serviced without disturbing piping connections.

C. The pumps shall have a solid Type 416 stainless steel shaft that is integral to the motor. A non-ferrous shaft sleeve shall be employed to completely cover the wetted area under the seal.

D. The motor bearings shall support the shaft via heavy-duty grease lubricated ball bearings.

E. Pump shall be equipped with a mechanical seal assembly. Seal assembly shall have a brass housing, BUNA bellows and seat gasket, stainless steel spring, and be of a carbon ceramic design with the carbon face rotating against a stationary ceramic face.

F. Pump shaft shall connect to a brass impeller. Impeller shall be hydraulically and dynamically balanced, keyed to the shaft and secured by a locking capscrew or nut.

G. Pump should be designed to allow for true back pull-out access to the pump's working components for ease of maintenance.

H. Pump volute shall be of cast iron design for heating systems or cast brass for domestic water systems. The connection style on cast iron and bronze pumps shall be flanged. Volute shall include gauge ports at nozzles.

I. Motors shall meet scheduled horsepower, speed, voltage, and enclosure design. Motors shall have heavy-duty grease lubricated ball bearings to offset the additional bearing loads associated with the closed coupled pump design. Motors shall be non-overloading at any point on the pump curve and shall meet NEMA specifications.

J. Pump shall be of a maintainable design and for ease of maintenance should use machine fit parts and not press fit components.

K. Each pump shall be factory tested and name-plated before shipment.

L. Pumps shall conform to ANSI/HI 9.6.3.1 standard for Preferred Operating Region (POR).

PART 3 – EXECUTION:

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PUMP INSTALLATION

A. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

B. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

C. Equipment Mounting: Install in-line pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases.
   1. Coordinate sizes and locations of concrete bases with actual equipment provided.
   2. Construct bases to withstand, without damage to equipment, seismic force required by code.

3. Construct concrete bases 4 inches high and extend base not less than 6 inches in all directions beyond the maximum dimensions of base-mounted pumps unless otherwise indicated or unless required for seismic-anchor support.
4. Minimum Compressive Strength: 5000 psi at 28 days.

E. Equipment Mounting: Install in-line pumps mounted to concrete maintenance pad with angle stands and neoprene vibration isolation of size required to support weight of in-line pumps.
1. Comply with requirements for seismic-restraint devices specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
2. Comply with requirements for hangers and supports specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

3.3 ALIGNMENT

A. Engage a factory-authorized service representative to perform alignment service.

B. Comply with requirements in Hydronics Institute standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.

C. Comply with pump and coupling manufacturers' written instructions.

D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.4 CONNECTIONS

A. Comply with requirements for piping specified in Division 23 Section "Steam and Condensate Heating Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to pump, allow space for service and maintenance.

C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

E. Install check, shutoff, and throttling valves; check valve and throttling valve with memory stop; or triple-duty valve as detailed on discharge side of pumps as detailed.

F. Install Y-type strainer or suction diffuser as detailed and shutoff valve on suction side of pumps.

G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

H. Install pressure gages on pump suction and discharge or at integral pressure-gage tapping or install single gage with multiple-input selector valve.

I. Install check valve and gate or ball valve on each condensate pump unit discharge.

J. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

K. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping.
4. Perform the following startup checks for each pump before starting:
   a. Verify bearing lubrication.
   b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
   c. Verify that pump is rotating in the correct direction.
5. Prime pump by opening suction valves and closing drains and prepare pump for operation.
6. Start motor.
7. Open discharge valve slowly.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION 232123

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SECTION 232300 – REFRIGERANT PIPING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. Each Contractor's attention is also directed to Specification Section HANGERS, CLAMPS, ATTACHMENTS, ETC.

C. The Contractor's attention is also directed to Specification Section SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS LISTS FOR HVAC.

D. The Contractor's attention is directed to Specification Section INSULATION - MECHANICAL.

1.2 SCOPE

A. Unless otherwise indicated, all materials shall be new and of the best grade and quality for the type specified. Materials shall comply with the “Buy American Act”.

B. Where piping is not indicated on the plans, but is obviously or apparently required, contact the Engineer prior to submission of the bid.

C. The piping indicated shall be installed complete and shall be of the size as recommended by the equipment vendor. Where a section of piping is not indicated but is obviously required for completion of the system, the Contractor shall provide same at no additional cost to the project.

D. Pay particular attention to conflict of piping with other work. Do not install until conflict is resolved. If in doubt, consult Engineer.

PART 2 – PRODUCTS

2.1 SPECIFICATIONS STANDARDS

A. All piping and material shall be new, comply with the “Buy American Act” and shall conform to the following minimum applicable standards:
- Copper tube; Type L, ASTM B88-62.

2.2 HVAC PIPING APPLICATIONS

A. Refrigerant Piping Type "L" copper tubing with forged or wrought copper fittings and silver soldered joints. Solder must have a minimum of 15% silver content.

PART 3 – EXECUTION

3.1 All piping shall be capped or plugged during erection as required to keep clean and debris and moisture free.

3.2 All piping shall be installed straight and true, parallel, or perpendicular to the building construction. Piping shall be installed so as to allow for expansion without damage to the building finishes, structure, pipe, equipment, etc., use offsets, U-bends or expansion joints as required. No mitered joints or field fabricated pipe bends shall be accepted. Pipe shall clear all windows, doors, louvers and other building openings.

3.3 All pipes shall be supported in a neat and workmanlike manner and wherever possible, parallel runs of horizontal piping shall be grouped together on hangers. Vertical risers shall be supported at each floor line with approved steel pipe riser clamps. Spacing of pipe supports shall not exceed eight (8) foot intervals for pipes 3" and smaller. Small vertical pipes (1" and less) shall be bracketed to walls, structural members, etc. at four (4) foot intervals so as to prevent vibration or damage by occupants.

3.4 The use of wire or perforated metal to support pipes will not be permitted. Hanging pipes from other pipes shall not be permitted.

3.5 Hangers shall pass completely around the insulation jacket and a steel protective saddle shall be applied to prevent compression of the insulation.

3.6 In metal buildings or buildings with light gauge trusses, support piping with standard pipe hangers with C-clamp connection to main structural members (not perlins), use angle steel cross pieces between main structural members where required to provide rigid support.

3.7 Where piping rests directly on a hanger, clip, bracket or other means of support, the support element shall be of the same material as the pipe, (e.g., copper to copper, ferrous to ferrous, etc.) or shall be electrically isolated one from the other so as to prevent pipe damage by electrolysis. Pay particular attention and do not allow copper pipe to rest on ferrous structural members, equipment, etc. without electrolytic isolation. This includes temporary support required during Construction.

3.8 In general, piping shall be installed concealed except in mechanical rooms, etc. unless otherwise indicated, and shall be installed underground or beneath concrete slabs only where indicated. All lines at ceilings shall be held as high as possible and shall run so as to avoid conflicts with other trades, and to facilitate the Owner's use and maintenance. Location of pipe in interior partitions shall be carefully coordinated with whoever will construct the partitions after the piping is in place. Where exposed risers occur, they shall be kept as close to walls as possible.

3.9 Pipe shall be cut accurately to measurements established at the building by the Contractor and worked into place without springing or forcing. All pipes shall be reamed to full pipe diameter before joining and before assembling. All lengths of pipe shall be set vertically and tapped with a hammer to remove scale and dust and inspected to ensure that no foreign matter is lodged therein.

3.10 PIPE TESTING:

A. Piping shall be tested before being insulated or concealed in any manner. Where leaks or defects develop, required corrections shall be made and tests repeated until systems are proven satisfactory.

B. Any leaks or imperfections found shall be corrected and a new test run until satisfactory results are obtained. The cost of repair or restoration of surfaces damaged by leaks in any system shall be borne by the Contractor.

3.11 Refrigerant piping must be installed to meet the HVAC equipment manufacturer's requirements. A refrigerant piping schematic shall be obtained from the equipment manufacturer which indicates pipe sizes, valves, traps, sight glasses and other required refrigerant specialties. While installing or soldering refrigerant lines, the piping system must be continuously purged with nitrogen. After the piping system is installed, the refrigerant system must be evacuated to 25 microns for eight hours. Contact Engineer 36 hours prior to installation of refrigerant lines or evacuation of refrigerant system.

END OF SECTION 232300

SECTION 232500 – PIPE HVAC WATER TREATMENT

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. Review the Specification Section – REQUIRED SHOP DRAWINGS, ETC., and provide all documentations called for therein.

1.2 Through coordination with other Contractors, Vendors and Suppliers associated with this Project, this Contractor shall insure a complete, 100% functional, tested, inspected, and approved systems. Claims for additional cost or change orders will immediately be rejected.

1.3 Maintain a water treatment program for the closed loop piping systems. It is the Contractor’s responsibility to contact the engineer 2 weeks in advance to any treatments performed on the systems. It is the Engineer’s discretion whether or not this process should be monitored after notification.

1.4 A pre-installation meeting shall be held with the Owner, Architect, Engineer, Construction Manager, HVAC Contractor, Pipe Fitter Foreman, Geothermal Contractor, and Chemical Treatment Contractor to discuss goals and expectations for cleaning, flushing, purging and chemical treatment.

1.5 Chemicals, equipment, testing services, and chemical application shall be supplied by a single water treatment company for undivided responsibility. The water treatment company shall be a recognized specialist, active in the field of commercial/industrial water treatment for at least 5 years. The water treatment company shall have regional water analysis laboratories, service department, and full time representatives located within the area of the job site or facility.

1.6 Prior to any construction, the Contractor shall sample the existing closed loop chemicals and provide chemical treatment water quality analysis. Provide levels for all items noted in paragraph “Water Quality Minimum Performance Requirements for Closed Loops”. Provide a report to the Engineer.

1.7 Be advised the existing loop contains an anti-freeze mixture. Prior to any construction, the Contractor shall sample the existing closed loop and provide anti-freeze mixture data.

1.8 Furnish initial supply of the closed loop chemicals for each system. This contractor shall retest the systems after 3, 6, 9 and 12 months upon substantial completion to verify the proper dosage is in each system. Provide all closed loop chemicals and anti-freeze for the first year. The Contractor shall determine the appropriate chemical volumes for each system. Each system’s water shall be tested for proper chemical parameters, clarity, and biological activity. If needed, provide chemical addition, including anti-freeze. Provide any laboratory and technical assistance required to achieve a successful program.

1.9 As a condition of acceptance and project closeout, a summary of water quality and treatment shall be provided in writing to the Owner and/or Engineer after the water treatment services have been successfully completed. The closeout documentation shall include dates for warranty testing.

1.10 Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or the environment. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

1.11 WATER QUALITY MINIMUM PERFORMANCE REQUIREMENTS FOR CLOSED LOOPS:

A. Closed hydronic systems shall maintain a pH value within 9 – 10.5 pH for iron and copper piping loops.

B. Total Anaerobic Plate Count - Maintain a maximum value of 100 organisms/ml.

C. Nitrate Reducers (Denitrifying Bacteria) - Maintain below a maximum value of 10,000 organisms/ml.

D. Sulfate Reducers - Maintain below a maximum value of 200 organisms/ml.

E. Iron Bacteria - Maintain below a maximum value of 100 organisms/ml.

F. Slime Bacteria - Maintain below a maximum value of 1,000 organisms/ml.

PART 2 – PRODUCTS:

2.1 REFER TO PLANS FOR EQUIPMENT REQUIREMENTS.

PART 3 – EXECUTION:

3.1 CLEANING AND FLUSHING OF HYDRONIC PIPING:

A. This project consists of the following Hydronic Piping Loops:
1. Hot Water
2. Chilled Water

B. There are several precautions which must be observed during piping installation. This contractor is advised to read all of the manufacturer's instructions prior to commencing the installation. This cleaning and flushing of the systems must be accomplished.

C. All water circulating systems for the project shall be thoroughly cleaned before placing in operation to rid the system of dirt, piping compound, mill scale, oil and any and all other material foreign to the water. During construction, extreme care shall be exercised to prevent all dirt and other foreign matter from entering the pipe or other parts of the system. Pipe stored on the project shall have the open ends capped and equipment shall have all openings fully protected. Before erection, each piece of pipe, fitting or valve shall be visually examined, and all dirt removed.

D. After the piping is complete:
1. The Contractor shall first fill the piping loops and all runouts with clear water. The loop water shall be circulated for one hour with make-up water open and boiler drain open to accomplish initial flushing of the system.
2. After initial flushing, all strainers shall be cleaned, and the individual terminal devices and coils shall be connected permanently to the supply and return runouts conditions and then add trisodium phosphate in an aqueous solution to the system at the proportion of one pound per fifty gallons of water in the system.
3. After the system is filled with this solution, the loop shall be allowed to circulate for 24 hours.
4. The Chemical Treatment Contractor shall be given notice by the Contractor of scheduling this cleaning and, if the Engineer's representative deems it necessary, the operation shall be repeated.
5. After the system has been completely cleaned as specified herein, it shall be tested by litmus paper or other dependable method and shall be left on the slightly alkaline side.
6. If the system is found to be still on the acid side, the cleaning by use of Trisodium Phosphate shall be repeated.
7. After the cleaning including all strainers and flushing is complete, and approved by CMTA, the Contractor shall provide the proper water treatment for the system.

3.2 CLOSED LOOP CHEMICAL TREATMENT:

A. Provide a 3/4" valved and capped port for injection of the closed loop chemicals into the system.

B. After the system is complete it shall be thoroughly cleaned before placing in operation to rid the system of dirt, biological contamination, piping compound, loose mill scale, oil, and any and all other material foreign to the water as previously specified.

C. Before chemical cleaning and sterilization of the entire system, the field and hydronic loop and mains shall be individually flushed and purged until free of dirt, debris, and air. During the flushing/purging and chemical cleaning processes the supply and return runouts shall be temporarily placed in bypass operation. See SYSTEM FILLING & PURGING PLAN for additional information.

D. After chemical cleaning, the entire system shall be sterilized with a biocide added at recommended dosage to effectively kill any present microorganisms. Add glutaraldehyde to achieve 60 – 200 ppm of active ingredient or isothiazoline to achieve 10 – 13 ppm active. Do not flush biocide from system. Corrosion inhibitors shall be installed in closed loop systems containing metal piping, fittings, accessories, etc.

E. A bacteria analysis shall be performed to ascertain biological cleanliness of system. If bacteria counts are above set parameters, then sterilization process shall be repeated until bacteria counts are at or below acceptable levels. Microbiological limits are listed under “Water Quality Minimum Performance Requirements” elsewhere in this Specification Section.

F. Within 48 hours of the completion of the sterilization and confirmation that bio-levels are within the specified parameters, implement a water treatment program to passivate all metal surfaces.

END OF SECTION 232500

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SECTION 233100 - SHEET METAL

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractor's attention is directed to Specification Section SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS LISTS FOR HVAC.

1.2 SCOPE

A. This branch of the work includes all materials, labor and accessories for the fabrication and installation of all sheet metal work as shown on the drawings and/or as specified herein. Where construction methods for various items are not indicated on the drawings or specified herein, all such work shall be fabricated and installed in accordance with the recommended methods outlined in the latest edition of SMACNA's Duct Manual and Sheet Metal Construction for Low Velocity Ventilating and Air Conditioning Systems. All equipment furnished by manufacturers shall be installed in strict accord with their recommended methods.

B. Ductwork shall be constructed and installed per the latest edition of the International Mechanical Code.

C. Ductwork shall be kept clean at all times. Ductwork stored on the job site shall be placed a minimum of 4" above the floor and shall be completely covered in plastic. Installed ductwork shall be protected with plastic. Do not install the ductwork if the building is not "dried-in". If this is required, the entire lengths of duct shall be covered in plastic to protect. The Owner/Engineer shall periodically inspect that these procedures are followed. If deemed unacceptable, the Contractor shall be required to clean the duct system utilizing a NADCA certified Contractor.

D. Prior to purchase and fabrication of ductwork (shop fabricated or manufactured), the Contractor shall coordinate installations with new and existing conditions. Notify the Engineer if there are any discrepancies for resolution.

E. For healthcare projects, provide a SMACNA duct cleanliness level "C" per the latest SMACNA standards.

PART 2 – PRODUCTS:

2.1 LOW VELOCITY DUCTWORK

A. Ductwork, plenums, and other appurtenances shall be constructed of one of the following: Steel sheets, zinc coated, Federal Specification 00-S-775, Type I, Class E & ASTM A93-59T with G-90 zinc coating. Aluminum alloy sheets 3003, Federal Specification AA-A-359, Temper H-14. Utilize Aluminum in MRI Scan Rooms.

B. Ductwork, plenums, and other appurtenances shall be constructed of the materials of the minimum weights or gauges as required by the latest SMACNA 2" W.G. Standard or below table. When gauge thickness differs, the heavier gauge shall be selected. The below table shall serve as a minimum.

Round Diameter	Duct Gauge	Rectangular Width	Duct Gauge
3-12 Inches	26 Ga.	3-12 inches	26 Ga,
12-18 Inches	24 Ga.	13-30 inches	24 Ga.
19-28 Inches	22 Ga.	31-54 inches	22 Ga.
29-36 Inches	20 Ga.	55-84 inches	20 Ga.

37-52 Inches	18 Ga.	85 inches and up	18 Ga.

C. All ductwork connections, fittings, joints, etc., including longitudinal and transverse joints, seams and connections shall be sealed. Seal with high velocity, smooth-textured, water based duct sealant. Sealant shall be UL 181B-M listed, UL 723 classified, NFPA 90A & 90B compliant, permanently flexible, non-flammable, and rated to 15”wg. Apply per manufacturer's recommendations. Contractors shall insure no exposed sharp edges or burrs on ductwork.

D. Duct dimensions indicated are required inside clear dimensions. Plan duct layouts for adequate insulation and fitting clearance.

E. All angular turns shall be made with the radius of the center line of the duct equivalent to 1.5 times the width of the duct.

F. Cross-break all ducts where either cross sectional dimension is 18" or larger.

G. Ducts shall be hung by angles, rods, 18 ga. minimum straps, trapezes, etc., in accordance with SMACNA's recommended practices. Duct supports shall not exceed 12 ft intervals. There shall be no less than one set of hangers for each section of ductwork. Where ductwork contains filter sections, coils, fans or other equipment or items, such equipment or items shall be hung independently of ductwork with rods or angles. Do not suspend ducts from purlins or other weak structural members where no additional weight may be applied. If in doubt, consult the Structural Engineer.

H. Double turning vanes shall be installed in square turns and/or where indicated.

I. Provide a “high efficiency” type take-off with round damper (Flexmaster STOD-B03 or approved equal) for all round duct branches from a rectangular main to a GRD. Refer to the detail on the drawings for all installation requirements.

J. Air volume dampers shall be installed in each duct branch takeoffs and/or where indicated, whichever is more stringent. All such dampers shall be accessible without damage to finishes or insulation and shall be provided where required for proper system balance.

K. Miscellaneous accessories such as test openings with covers, latches, hardware, locking devices, etc., shall be installed as recommended by SMACNA and/or as indicated. Test openings shall be placed at the inlet and discharge of all centrifugal fans, VAV boxes, fan sections of air handling units, at the end and middle of all main trunk ducts and where indicated. All such openings shall be readily accessible without damage to finishes.

L. INSULATED FLEXIBLE AIR DUCT: Thermaflex G-KM or equal. Flexible air duct shall be two (2) inch thick fiberglass insulation with CPE liner permanently bonded to a coated spring steel wire helix supporting a fiberglass scrim and fiberglass insulating blanket. Flexible air duct shall be listed under UL Standard 181 as a Class I flexible air duct complying with NFPA 90A and 90B. Maximum flame spread = 25 and maximum smoke developed = 50. Minimum insulating value is R-6.0. Flexible duct shall be used only for GRD runouts, and no section shall be more than five feet in length.

2.2 HIGH VELOCITY DUCTWORK

A. High velocity ductwork shall be utilized for all supply ductwork between air handling units and VAV/CAV boxes. Provide Eastern Sheet Metal Model “CB” or equal takeoff fitting for each VAV/CAV off high velocity main. Shop or field fabricated takeoffs are not acceptable. Straight tees are not allowed.

B. Prior to purchase/shipment of the ductwork, manufacturer shall provide as part of the submittal process scaled, field coordinated Autocad drawings of the complete system to be furnished. Drawings will indicate all system components including fittings, ductwork and manifolds. Drawings shall be available in an electronic format.

C. All round and oval high velocity ductwork for systems above 1.5" W.G. shall be Eastern Sheet Metal, United McGill or Semco or equal as required by the latest SMACNA 10" W.G. Standard.

D. Ductwork shall be spiral, lock-seam construction fabricated from galvanized steel meeting ASTM-527 standard. Any ductwork exposed to view shall be constructed of galvanized steel. Galvanized metal shall be prepped and clean prior to painting. Coordinate with General Contractor. Ductwork shall be constructed of the following minimum gauges:

Round Diameter	Duct Gauge	Flat Oval Major Axis	Duct Gauge
3-14 Inches	26 Ga.	10-24 inches	24 Ga,
15-26 Inches	24 Ga.	25-48 inches	22 Ga.
27-36 Inches	22 Ga.	49-71 inches	20 Ga.
37-50 Inches	20 Ga.	71 inches and up	18 Ga.
52-84 Inches	18 Ga.		

E. All high velocity duct fittings shall be fabricated by the same manufacturer as the spiral pipe. Contractor or field fabricated fittings shall not be accepted. Duct fittings shall be constructed per the latest SMACNA 10" WG standard with continuous welds. Take-off fittings shall be combination type tees (Eastern Sheet Metal Model "CB" or equal). Straight or angle tees are not acceptable. Fittings shall be constructed of the following minimum gauges.

Round Diameter	Duct Gauge	Flat Oval Major Axis	Duct Gauge
3-50 Inches	20 Ga.	10-36 inches	20 Ga.
52-60 Inches	18 Ga.	37-60 inches	18 Ga.
61-84 Inches	16 Ga.	71 inches and up	16 Ga.

F. All single wall ductwork will be furnished with factory installed flanges equal to Eastern Sheet Metal Flange on all ductwork greater than 24 inches in size.

G. Duct dimensions indicated are required inside clear dimensions.

H. All ductwork connections, fittings, joints, etc., shall be sealed. Seal with high velocity, smooth-textured, water based duct sealant. Sealant shall be UL 181B-M listed, UL 723 classified, NFPA 90A & 90B compliant, permanently flexible, non-flammable, and rated to 15" wg. Apply per manufacturer's recommendations.

I. Ductwork shall be installed per the latest SMACNA Medium or High Pressure Manual, whichever is applicable.

J. All hanger straps shall be 18 ga. minimum with reinforcement angles installed in strict accordance with SMACNA. Flat oval ducts shall be installed with 2"x2"x¼" angles on top and bottom ducts 18" wide and larger. Use 1"x1"x3/16" angles on ducts under 18" wide.

K. Miscellaneous accessories such as test openings with covers, latches, hardware, locking devices, etc., shall be installed as recommended by SMACNA or the duct manufacturer, and/or as indicated. Test openings shall be placed at the discharge of all air handling units and at the end and middle of all main trunk ducts and where indicated. All such openings shall be readily accessible without damage to finishes.

L. Whether indicated or not, provide code approved, full sized fire dampers at all locations where ductwork penetrates fire rated walls. Fire stop rating shall meet or exceed the rating of the wall. Provide an approved access panels at each fire damper located and sized so as to allow hand reset of each fire damper. All such fire dampers and access panels shall be readily accessible without damage to finishes. Refer to Architectural Plans for locations of fire rated walls. Where access doors are installed in insulated ductwork, the access door shall be the insulated type.

2.3 EXPOSED ROUND DUCTWORK IN MEDIA CENTER

A. Prior to purchase/shipment of the ductwork, manufacturer shall provide as part of the submittal process scaled, field coordinated Autocad drawings of the complete system to be furnished. Drawings will indicate all system components including fittings, ductwork, and manifolds. Drawings shall be available in an electronic format.

B. Furnish and install where indicated double wall duct. The double wall duct shall be Eastern Sheet Metal, United McGill, Semco or approved equivalent. The duct shall have an inner shell, a 1-inch layer of fiberglass insulation and an outer pressure shell.

C. Ductwork outer shell shall be spiral, lock-seam construction fabricated from galvanized steel meeting ASTM-527 standard. Any ductwork exposed to view shall be constructed of G90 galvanized steel, 20 gauge, and shall be supported as required with aircraft cables and self-tightening locks. Exposed metal shall be prepped and cleaned prior to painting. Coordinate with General Contractor. Ductwork shall be constructed as specified in LOW VELOCITY DUCTWORK.

D. Inner shell for spiral pipe shall be 26 gauge solid galvanized steel, as noted on drawings. Ductwork shall have 3 intermediate reinforcing ribs and be constructed of the minimum gauge specified.

E. Inner shell for fittings shall be galvanized steel. All fittings shall be manufactured by the same manufacturer as the spiral pipe. Fittings shall be constructed a minimum of 22 Ga.

F. The fiberglass liner shall have a maximum thermal conductivity (k) factor of 0.27 btu per hour per square foot per degree Fahrenheit per inch thickness at 75 degree F ambient temperature.

G. All double wall ductwork will be furnished with factory installed flanges equal to Eastern Sheet Metal Flange which shall consist of a 1-1/2" outer flange and an inner secondary flange which shall keep the inner flange concentric and eliminate inner wall connections. Flanges requiring inner couplings will not be allowed, no insulation shall be exposed to the airstream at the connections.

2.4 KITCHEN RANGE HOOD EXHAUST DUCT:

A. Ducts shall be constructed of 18 gauge stainless steel with liquid tight continuous external weld of all seams and joints where exposed. Where ducts are concealed, they shall be constructed of 16 gauge carbon steel with liquid-tight continuous weld of all seams and joints. Inside laps on duct joints shall project in a direction against the air flow.

B. Ducts shall be so constructed and sloped as to provide suitable drainage of grease to a collection point.

C. Hand holes for inspection and cleaning purposes, equipped with tight fitting sliding or swinging doors and latches, shall be provided in horizontal sections of exhaust ducts. Such openings shall be at the sides of the horizontal run in order to prevent dripping of residue. Spacing of such openings shall not exceed 20 feet and shall be located at all offsets. Openings shall have a minimum dimension of 20" in width with a height equivalent to the duct height minus one inch.

D. At the base of each vertical riser, a residue trap shall be provided with provisions for cleanout.

E. The Contractor shall install the kitchen rangehood exhaust duct systems and maintain the minimum code required clearances to combustibles. The use of UL listed, and approved enclosure system of fire wraps/blankets installed per the manufacturer’s instructions are acceptable when required to achieve the clearance to combustibles requirements.

F. At the Contractor's option, a UL2221 Pre-manufactured Duct System equal to Metal Fab 3G shall be acceptable. Duct shall have a stainless steel inner liner, aluminized outer liner and one or three inch liner as required to comply with requirements of clearance to combustibles.

G. Shop drawings of the kitchen rangehood exhaust ductwork shall be made and submitted to the appropriate reviewing agency. Any fees associated with this submittal shall be borne by this Contractor.

2.5 DISHWASHER EXHAUST DUCT

A. All exposed exhaust duct shall be 22 gauge stainless steel duct with liquid tight continuous external weld of all seams and joints. All concealed exhaust duct shall be 24 gauge aluminum with liquid tight joints. Provide dielectric connection between steel and aluminum ductwork.

2.6 DOMESTIC WATER HEATER COMBUSTION VENT PIPING

A. Schedule 80 CPVC with pressure rated fittings and solvent weld joints. Pipe size, routing, slope, and termination shall be installed per the manufacturer's recommendations. Provide hangers every four feet to properly support the piping.

2.7 DOMESTIC WATER HEATER COMBUSTION AIR INTAKE PIPING

A. Schedule 40 PVC with pressure rated fittings and solvent welde joints. Pipe size, routing, slope, and termination shall be installed per the manufacturer's recommendations. Provide hangers every four (4) feet to properly support piping.

2.8 BOILER FLUE STACK

A. POSITIVE PRESSURE FLUE STACK:

a. Metal-Fab Type "Corr/Guard Model FCG" or Heat Fab double wall, factory-built type for use on condensing appliances or pressurized venting systems serving Category II, III or IV appliances or as specified by the equipment manufacturer. Vent shall be listed for an internal static pressure of 6" w.g. and tested to 15" w.g. Vent shall be constructed with an inner and outer wall, with a 1" annular insulating air space. The inner wall (vent) shall be constructed of AL29-4C superferritic stainless steel, .015 thickness for 6"-12" diameters and .024 thickness for 14"-24" diameters. The outer wall (casing) shall be constructed of aluminized steel, .018 thickness for 6"-12" diameters and .024 thickness for 14"-24" diameters. Inner and outer walls shall be connected by means of spacer clips that maintain the concentricity of the annular space and allow unobstructed differential thermal expansion of the inner and outer walls. All parts exposed to the weather shall be protected by one (1) coat of corrosion and heat resistant base primer and one (1) coat of heat resistant paint. All supports, roof or wall penetrations, terminations, appliance connectors and drain fittings, required to install the vent system shall be included. Roof penetration pieces shall be UL listed and provided by the vent manufacturer. Roof curbs shall be required on roofs greater than 12:12 pitch. All inner vent connections shall be secured by means of profiled connector bands with gear clamp tighteners. Joints shall be sealed with P077 Sealant. Where exposed to weather, the outer closure band shall be sealed to prevent rainwater from entering the space between inner and outer walls. Vent shall terminate in accordance with installation instructions and local codes. Provide with factory fittings such as elbows, tees, tee cap, cap, tall cone flashing, support plate, increaser, etc., as required for a complete project. Shop drawings by the Flue Manufacturer shall be submitted for Engineer's review. The Flue Manufacturer shall confirm flue size, configuration, fittings, etc. based on site specific measurements.

2.9 DRYER VENT DUCTWORK

A. All dryer ducting shall be a minimum of 4" in diameter. Refer to the drawings for exact duct sizing.

B. Dryer vent ductwork shall be rigid metal 20-gauge aluminum duct. Duct joints shall be installed so that the male end of the duct points in the direction of the airflow. Joints shall be secured with metal tape (not duct tape). Do not use rivets or screws in the joints or anywhere else in the duct as these will incur lint collection.

C. Length of concealed rigid metal ducting shall not exceed the allowable length of 35 feet. Deduct 5 feet from the allowable length for every 4" 90 degree elbow and 4" 2.5 feet for every 45 degree fitting. These lengths may vary per local codes and dryer manufacturer's recommendations. Install per 2012 IMC Section 504 Clothes Dryer Exhaust. Provide a complete, working in-line booster fan system, including power, if the maximum allowable duct length is exceeded.

D. Flexible transition hose connection at the dryer shall be the aluminum flexible duct type. Do not use the plastic or vinyl.

E. Termination of dryer venting shall be to the exterior with a proper hood or roof jack equipped with a backdraft damper. Hood/jack shall be painted with suitable exterior grade paint and color per the Owner's direction. Small orifice metal screening shall not be part of the hood or roof jack as this will trap lint and block the opening. The hood opening shall point down and maintain a minimum of 12 inches of clearance between the bottom of the hood and the ground or other obstruction.

PART 3 – EXECUTION:

3.1 Unless otherwise dimensioned on the drawings, all diffusers, registers, and grilles shall be located aesthetically and symmetrically with respect to lighting, ceiling patterns, doors, masonry bond, etc. Locate all supply, return, and exhaust diffusers and grilles in the locations shown on the architectural reflected ceiling plan.

3.2 The interior surface of the ductwork connecting to return/exhaust air grilles shall be painted flat black. The ductwork shall be painted a minimum of 24" starting from the grille.

3.3 Provide approved flexible connectors at inlet and outlet of each item of heating and cooling equipment whether indicated or not. Install so as to facilitate removal of equipment as well as for vibration and noise control.

3.4 All fans and other vibrating equipment shall be suspended by independent vibration isolators.

3.5 Miscellaneous accessories such as test openings with covers, latches, hardware, locking devices, etc., shall be installed as recommended by SMACNA and/or as indicated. Test openings shall be placed at the inlet and discharge of all centrifugal fans, VAV boxes, fan sections of air handling units, at the end and middle of all main trunk ducts and where indicated. All such openings shall be readily accessible without damage to finishes.

3.6 Low Velocity Ductwork: Whether indicated or not, provide code approved, full sized fire dampers at all locations where ductwork penetrates fire rated walls. Fire stop rating shall meet or exceed the rating of the wall. Provide an approved access panel at each fire damper located and sized so as to allow hand reset of each fire dampers. All such fire dampers and access panels shall be readily accessible without damage to finishes. Refer to Architectural Plans for locations of fire rated walls. All access doors shall be 16"x16" or as high as ductwork permits and 16" in length.

3.7 The Contractor who installs the sheet metal shall furnish to the Air Balancing Contractor, a qualified person to assist in testing and balancing the system.

3.8 All grille and register taps shall be factory manifolded. Field installed taps will not be allowed. Manifolded taps may be tack welded and caulked for appearance. Only taps for grilles and registers may be provided this way. All other fittings shall be full body welded.

3.9 AIR LEAKAGE TESTING OF THE DUCTWORK SYSTEMS

A. It is the intent of this section to ensure the ductwork installed has minimal air leakage. Air leakage testing shall be accomplished by an AABC certified company. Refer to the Test & Balance specifications. Whenever the systems are being leak tested by the Test & Balance Contractor, a representative from the Mechanical Contractor shall be present to assist.

B. Carefully select the ductwork construction requirements and the type of duct sealant to be used as required to meet the leakage allowances. The sheet metal duct pressure classification is a minimum only. The Contractor shall select the appropriate sheet metal pressure classification, duct sealant class and duct sealant materials to meet the project air leakage allowances.

C. The entire supply air ductwork system shall be tested with some exceptions. On VAV systems, the high velocity ductwork upstream of the VAV boxes shall only be tested. Cap the duct at the inlet to the VAV box. On low velocity reheat system, all ductwork upstream of the hot water reheat coil shall be tested. The air volume damper and access door upstream of the reheat coil shall be included in the tested system.

D. All return and exhaust air sheet metal ductwork associated with the system shall be tested. Flexible ductwork shall not be tested. Cap the main duct prior to the central equipment fan connection. Also cap the branch ducts which serve the diffusers, after the round branch air volume with sheet metal caps. Seal caps well to damper to avoid air loss at this location. This air loss, from the caps, is included in the noted leakage rate.

E. A duct pre-installation conference shall be held prior to the installation of the ductwork. Present should be the Owner, Engineer, Test & Balance Contractor, General Contractor, Mechanical Contractor, Sheet Metal Contractor, and Insulation Contractor. At this meeting, the Contractor shall advise all of the duct materials and sealant materials to be used to meet the air leakage allowances.

F. It is the intent to test all ductwork. The duct systems which will require testing are as follows:
   1. All supply air duct systems.
   2. All return air duct systems.
   3. All exhaust air duct systems.

G. Do not insulate the supply air systems prior to testing.

H. The maximum allowable supply air leakage rate is 2.5% of the systems design CFM when the ductwork is pressurized to 2.5" WG. Therefore, if a supply air system is tested, and the supply air fan rated capacity is 10,000 CFM, the allowable leakage is 250 CFM. The maximum allowable return air and exhaust air leakage rate is 2.5% of the system design when the ductwork is pressurized to 1.50" WG.

I. The noted allowable leakage rate is the total allowable. It shall include leakage associated with the following:
   1. All ductwork as described in above paragraphs.
   2. Access doors
   3. Volume dampers
   4. Relief air doors
   5. Smoke dampers
   6. Fire dampers
   7. Fire smoke dampers
   8. End caps used to seal ducts

J. If any duct system fails a test, the Contractor shall reseal the system. It shall than be retested until the duct system meets the leakage allowment at no additional cost to the Owner.

3.10 DISHWASHER EXHAUST DUCT

A. All ductwork shall be sloped so as to drain back toward the dishwasher.

END OF SECTION 233100

SECTION 233300 – AIR DUCT ACCESSORIES

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractor's attention is directed to Specification Section SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS LISTS FOR HVAC.

1.2 SCOPE

A. This branch of the work includes all materials, labor and accessories for the fabrication and installation of all sheet metal work as shown on the drawings and/or as specified herein. Where construction methods for various items are not indicated on the drawings or specified herein, all such work shall be fabricated and installed in accordance with the recommended methods outlined in the latest edition of SMACNA's Duct Manual and Sheet Metal Construction for Low Velocity Ventilating and Air Conditioning Systems. All equipment furnished by manufacturers shall be installed in strict accord with their recommended methods.

B. Ductwork accessories shall be constructed and installed per the latest edition of the International Mechanical Code.

C. Ductwork accessories shall be kept clean at all times. Ductwork stored on the job site shall be placed a minimum of 4" above the floor and shall be completely covered in plastic. Installed ductwork shall be protected with plastic. Do not install the ductwork if the building is not "dried-in". If this is required, the entire lengths of duct shall be covered in plastic to protect. The Owner/Engineer shall periodically inspect that these procedures are followed. If deemed unacceptable, the Contractor shall be required to clean the duct system utilizing a NADCA certified Contractor.

D. Prior to purchase and fabrication of ductwork (shop fabricated or manufactured), the Contractor shall coordinate installations with new and existing conditions. Notify the Engineer if there are any discrepancies for resolution.

E. For healthcare projects, provide a SMACNA duct cleanliness level "C" per the latest SMACNA standards.

PART 2 – PRODUCTS:

2.1 LOW VELOCITY DUCTWORK ACCESSORIES

A. Provide a "high efficiency" type take-off with round damper (Flexmaster STOD-B03 or approved equal) for all round duct branches from a rectangular main to a GRD. Refer to the detail on the drawings for all installation requirements.

B. Miscellaneous accessories such as test openings with covers, latches, hardware, locking devices, etc., shall be installed as recommended by SMACNA and/or as indicated. Test openings shall be placed at the inlet and discharge of all centrifugal fans, VAV boxes, fan sections of air handling units, at the end and middle of all main trunk ducts and where indicated. All such openings shall be readily accessible without damage to finishes.

C. FLEXIBLE CONNECTORS: Duro-Dyne, Ventfabrics, Inc., U.S. Rubber or equivalent; conforming to NFPA No. 90A; neoprene coated glass fabric; 20 oz. for low velocity ducts secured with snap lock.

D. TURNING VANES: Fabricated as recommended by SMACNA: noiseless when in place without mounting projections in ducts. All turning vanes shall be double blade type.

E. ACCESS DOORS IN DUCTWORK: Flexmaster TBSM, Air Balance, Vent Products or equal. Access doors for rectangular ducts shall be 16"x16" where possible. Otherwise install as large an access door as height permits by 16" in length. Door shall be 2" thick double wall insulated with continuous hinge and cam lock. Provide in ducts where indicated or where required for servicing equipment whether indicated or not. Provide a hinged access door in duct adjacent to all fire, smoke, and control dampers for the purpose of determining position. Access doors shall also be provided on each side of duct coils and downstream side of VAV boxes and CAV boxes.

F. ARCHITECTURAL ACCESS DOORS IN CEILINGS OR WALLS: Provide Kees D Panel, Cesco, Milcor or equal. Panels shall be 24"x24" in size and constructed with 16 gauge galvannealed steel for door and frame. Provide with primer finish to accept specified finish. Door shall include three (3) screwdriver operated cam latches and concealed continuous pivoting rod hinge. Door shall open 175 degrees. For masonry construction, furnish frames with adjustable metal masonry anchors. For fire rated units, provide manufacturer's standard insulated flush panel/doors with continuous piano hinge and self-closing mechanism. The Contractor shall include all required access doors in the bid and shall coordinate with the General Contractor prior to the bid to insure a complete project.

G. VOLUME DAMPERS (RECTANGULAR): Ruskin MD35 or Air Balance, Pottorff, rectangular volume dampers. Frames shall be 16 gauge galvanized steel. Blades shall be opposed blade 16 gauge galvanized steel with triple crimped blades on 6" centers. Linkage shall be concealed in jamb. Bearings shall be ½" nylon. Maximum single section size shall be 48" wide and 72" high. Provide with Ventfabrics 2" high elevated dial regulator to avoid damper handle from conflicting with duct insulation. Provide permanent mark on dial regulator to mark air balance point.

H. VOLUME DAMPERS (ROUND): Ruskin MDRS25 or Air Balance, Pottorff round volume dampers. Dampers shall be butterfly type consisting of circular blade mounted to axle. Frames shall be 20 gauge steel and 6" long. Damper blades shall be 20 gauge crimped galvanized steel. Axle shall be 3/8"x6" square plated steel. Bearing shall be 3/8" nylon. Provide with Ventfabrics 2" high elevated dial regulator to avoid damper handle from conflicting with duct insulation. Provide permanent mark on dial regulator to mark air balance point.

I. FIRE DAMPERS: Fire dampers shall be Ruskin 1BD2 1½ hour rating U-215B vertical 1½ hour rating or United Air Type U-255B for a 3 hour vertical rating. Other acceptable manufacturers are Air Balance or Pottorff. Fire dampers shall be constructed and tested in accordance with UL Safety Standard 555. Each fire damper shall have a 1½ or 3 hour fire protection rating as required by fire wall. Damper shall have a 165 degrees F fusible link and shall include a UL label in accordance with established UL labeling procedures. Fire damper shall be equipped for vertical or horizontal installation as required by the location shown. Fire dampers shall be installed in wall and floor openings utilizing minimum 20 gauge steel sleeves, angles, other materials, practices required to provide an installation to that utilized by the manufacturer when dampers were tested at UL. Blade and frame thickness shall be a minimum of 24 gauge. Installation shall be in accordance with the damper manufacturer's instructions. The blades shall be out of the air stream. Provide an access door for fire damper reset at all fire damper locations. Label access door as "FIRE DAMPER ACCESS" and provide red dot tape on ceiling grid to indicate access location. Provide factory supplied caulked sleeve, gauge as required to meet manufacturer UL installation requirements.

J. MOTOR DRIVEN SMOKE DAMPERS – AIR FOIL BLADE: Provide Ruskin SD60 smoke damper where required by the locations of smoke partitions or as shown on the plans, whichever is more stringent. Other acceptable manufacturers are Air Balance or Pottorff. All smoke dampers shall be three inches larger than HVAC duct in each direction. Frame shall be a minimum of 18 gauge galvanized steel formed into a structural hat channel shaper with tabbed corners for reinforcement. The blade shall be airfoil shaped, constructed of a dual skinned galvanized steel, 14 gauge equivalent thickness, on 6" maximum centers.

Bearings shall be stainless steel sleeve turning in an extruded hole in the frame. Jamb seal shall be stainless steel flexible metal compression type. Each smoke damper shall be classified by Underwriters Laboratories as a Leakage Rated Damper for use in smoke control systems under the latest version of UL555S and bear a UL label attesting to same. As part of the UL qualification, dampers shall have demonstrated a capacity to operate (to open and close under HVAC system operating conditions) with pressures of at least the maximum possible of the HVAC system in the closed position, and the system maximum duct air velocity in the open position. In addition to the leakage ratings already specified herein, the dampers and their actuators shall be qualified under UL555S to an elevated temperature of 350 degrees F. Appropriate electric actuators shall be installed by the damper manufacturer. Refer to building fire alarm and controls for exact type. Actuator to be mounted outside of air stream. The pressure drop shall not be greater than .16" wg @ 2500 FPM when tested by an independent laboratory. Provide factory supplied caulked sleeve, gauge as required to meet manufacturer UL installation requirements.

K. MOTOR DRIVEN FIRE/SMOKE DAMPERS – AIR FOIL BLADE: Fire damper shall be constructed and tested in accordance with UL Safety Standard 555. The damper shall be Ruskin FSD60. Other acceptable manufacturers are Air Balance or Pottorff. The blade shall be airfoil shaped, constructed of a dual skinned galvanized steel, 14 gauge equivalent thickness, on 6" maximum centers. Frame is to be a minimum of 16 gauge galvanized steel, rollformed into a structural hat shape channel. Frame seals shall consist of flexible, compression type stainless steel. The damper and actuator electric shall be rated to an elevated temperature or 250 degrees F or 350 degrees F. In addition, the damper must be factory supplied with actuator and sleeve to comply with the requirements of UL 555S. These dampers shall have been constructed and tested in compliance with U.L. Standard 555 and U.L. Standard 555S, current editions. The pressure drop shall not be greater than .25 in.wg. At 2500 fpm when tested by an independent laboratory. Each damper shall bear an approved U.L. label identifying its classification as a Dynamic Rated fire Damper (Static Rated dampers are not acceptable) and shall further be classified by U.L. as a Leakage Rated Damper for use in Smoke Control Systems. Each damper shall have a 1-1/2 hour fire protection rating, 212EF U.L. Listed fusible link and a leakage class I. In addition to the leakage ratings already specified herein, the dampers and their actuators shall be qualified under UL555S to an elevated temperature of 350 degrees F. Appropriate electric actuators shall be installed by the damper manufacturer. Refer to building fire alarm and controls for exact type. Provide factory supplied caulked sleeve, 20 gauge on dampers through 84” wide and 18 gauge above 84" wide. Actuator to be mounted outside of air stream. Provide factory supplied caulked sleeve, gauge as required to meet manufacturer UL installation requirements.

2.2 HIGH VELOCITY DUCTWORK ACCESSORIES

A. FLEXIBLE CONNECTORS: Duro-Dyne, Ventfabrics, Inc., U.S. Rubber or equivalent; conforming to NFPA No. 90A; neoprene coated glass fabric. Provide flexible connectors at inlet and outlet of air handling equipment to accommodate a minimum of three times the operating pressure of the system.

B. PRESSURE RELIEF DOORS: Provide a pressure relief door in the supply air ductwork at each air handling unit. It shall be located where shown on the drawings. It shall be sized to relieve the duct air pressure below the rated pressure construction of the ductwork and above the working pressure of the fan. The supply air relief door shall be Ruskin PRD18 or equal. Provide a vacuum relief door in the return air ductwork at each return air fan. It shall be located where shown on the drawings. It shall be sized to relieve the duct vacuum below the rated construction of the ductwork and above the working negative pressure of the fan. The return air relief door shall be Ruskin NRD18 or equal. Automatic fan shutdown upon damper closure shall not be an acceptable protection for either overpressure or vacuum conditions. All duct relief dampers shall be of the automatic resetting type.

C. ARCHITECTURAL ACCESS DOORS IN CEILINGS OR WALLS: Provide Kees D Panel, Cesco, Milcor or equal. Panels shall be 24”x24” in size and constructed with 16 gauge galvannealed steel for door and frame. Provide with primer finish to accept specified finish. Door shall include three (3) screwdriver operated cam latches and concealed continuous pivoting rod hinge. Door shall open 175 degrees. For masonry construction, furnish frames with adjustable metal masonry anchors. For fire rated units, provide manufacturer’s standard insulated flush panel/doors with continuous piano hinge and self-closing

mechanism. The Contractor shall include all required access doors in the bid and shall coordinate with the General Contractor prior to the bid to insure a complete project.

D. ACCESS DOORS; IN DUCTWORK: All access doors in round or oval high velocity ductwork shall be screw and gasketed type. Screws shall be maximum 4 inches on centers.

DUCT DIAMETER	OPENING SIZE
3-4 inches	4"x10"
5-6 inches	6"x10"
7-24 inches	10"x16"
26-36 inches	16"x16"
Over 36 inches	16"x22"

E. FIRE DAMPERS: Fire dampers shall be Ruskin 1BD2 1½ hour rating U-215B vertical 1½ hour rating or United Air Type U-255B for a 3 hour vertical rating. Other acceptable manufacturers are Air Balance or Pottorff. Fire dampers shall be constructed and tested in accordance with UL Safety Standard 555. Each fire damper shall have a 1½ or 3 hour fire protection rating as required by fire wall. Damper shall have a 165 degrees F fusible link and shall include a UL label in accordance with established UL labeling procedures. Fire damper shall be equipped for vertical or horizontal installation as required by the location shown. Fire dampers shall be installed in wall and floor openings utilizing minimum 20 gauge steel sleeves, angles, other materials, practices required to provide an installation equipment to that utilized by the manufacturer when dampers were tested at UL. Blade and frame thickness shall be a minimum of 24 gauge. Installation shall be in accordance with the damper manufacturer's instructions. The blades shall be out of the air stream. Provide an access door for fire damper reset at all fire damper locations. Label access door as “FIRE DAMPER ACCESS” and provide red dot tape on ceiling grid to indicate access location. Provide factory supplied caulked sleeve, gauge as required to meet manufacturer UL installation requirements.

F. MOTOR DRIVEN SMOKE DAMPERS – AIR FOIL BLADE: Provide Ruskin SD60 smoke damper where required by the locations of smoke partitions or as shown on the plans, whichever is more stringent. Other acceptable manufacturers are Air Balance or Pottorff. All smoke dampers shall be three inches larger than HVAC duct in each direction. Frame shall be a minimum of 18 gauge galvanized steel formed into a structural hat channel shaper with tabbed corners for reinforcement. The blade shall be airfoil shaped, constructed of a dual skinned galvanized steel, 14 gauge equivalent thickness, on 6" maximum centers. Bearings shall be stainless steel sleeve turning in an extruded hole in the frame. Jamb seal shall be stainless steel flexible metal compression type. Each smoke damper shall be classified by Underwriters Laboratories as a Leakage Rated Damper for use in smoke control systems under the latest version of UL555S and bear a UL label attesting to same. As part of the UL qualification, dampers shall have demonstrated a capacity to operate (to open and close under HVAC system operating conditions) with pressures of at least the maximum possible of the HVAC system in the closed position, and the system maximum duct air velocity in the open position. In addition to the leakage ratings already specified herein, the dampers and their actuators shall be qualified under UL555S to an elevated temperature of 350 degrees F. Appropriate electric actuators shall be installed by the damper manufacturer. Refer to building fire alarm and controls for exact type. Actuator to be mounted outside of air stream. The pressure drop shall not be greater than .16" wg @ 2500 FPM when tested by an independent laboratory. Provide factory supplied caulked sleeve, gauge as required to meet manufacturer UL installation requirements.

G. MOTOR DRIVEN FIRE/SMOKE DAMPERS – AIR FOIL BLADE: Fire damper shall be constructed and tested in accordance with UL Safety Standard 555. The damper shall be Ruskin FSD60. Other acceptable manufacturers are Air Balance or Pottorff. The blade shall be airfoil shaped, constructed of a dual skinned galvanized steel, 14 gauge equivalent thickness, on 6" maximum centers. Frame is to be a minimum of 16 gauge galvanized steel, rollformed into a structural hat shape channel. Frame seals shall consist of flexible; compression type stainless steel. The damper and actuator electric shall be rated to an elevated temperature or 250 degrees F or 350 degrees F. In addition, the damper must be factory supplied with actuator and sleeve to comply with the requirements of UL 555S. These dampers shall have been constructed and tested in compliance with U.L. Standard 555 and U.L. Standard 555S, current editions. The pressure drop shall not be greater than .25 in.wg. At 2500 fpm when tested by an independent laboratory. Each damper shall

bear an approved U.L. label identifying its classification as a Dynamic Rated fire Damper (Static Rated dampers are not acceptable) and shall further be classified by U.L. as a Leakage Rated Damper for use in Smoke Control Systems. Each damper shall have a 1-1/2 hour fire protection rating, 212EF U.L. Listed fusible link and a leakage class I. In addition to the leakage ratings already specified herein, the dampers and their actuators shall be qualified under UL555S to an elevated temperature of 350 degrees F. Appropriate electric actuators shall be installed by the damper manufacturer. Refer to building fire alarm and controls for exact type. Provide factory supplied caulked sleeve, 20 gauge on dampers through 84 wide and 18 gauge above 84" wide. Actuator to be mounted outside of air stream. Provide factory supplied caulked sleeve, gauge as required to meet manufacturer UL installation requirements.

PART 3 – EXECUTION:

3.1 Unless otherwise dimensioned on the drawings, all diffusers, registers, and grilles shall be located aesthetically and symmetrically with respect to lighting, ceiling patterns, doors, masonry bond, etc. Locate all supply, return, and exhaust diffusers and grilles in the locations shown on the architectural reflected ceiling plan.

3.2 All ductwork connections, fittings, joints, etc., shall be sealed. Seal with high velocity, smooth-textured, water based duct sealant. Sealant shall be UL 181B-M listed, UL 723 classified, NFPA 90A & 90B compliant, permanently flexible, non-flammable, and rated to 15”wg. Apply per manufacturer's recommendations.

3.4 Miscellaneous accessories such as test openings with covers, latches, hardware, locking devices, etc., shall be installed as recommended by SMACNA or the duct manufacturer, and/or as indicated. Test openings shall be placed at the discharge of all air handling units and at the end and middle of all main trunk ducts and where indicated. All such openings shall be readily accessible without damage to finishes.

3.5 The interior surface of the ductwork connecting to return/exhaust air grilles shall be painted flat black. The ductwork shall be painted a minimum of 24" starting from the grille.

3.6 Provide approved flexible connectors at inlet and outlet of each item of heating and cooling equipment whether indicated or not. Install so as to facilitate removal of equipment as well as for vibration and noise control.

3.7 Double turning vanes shall be installed in square turns and/or where indicated.

3.8 Air volume dampers shall be installed in each duct branch takeoffs and/or where indicated, whichever is more stringent. All such dampers shall be accessible without damage to finishes or insulation and shall be provided where required for proper system balance.

3.9 All fans and other vibrating equipment shall be suspended by independent vibration isolators.

3.10 Miscellaneous accessories such as test openings with covers, latches, hardware, locking devices, etc., shall be installed as recommended by SMACNA and/or as indicated. Test openings shall be placed at the inlet and discharge of all centrifugal fans, VAV boxes, fan sections of air handling units, at the end and middle of all main trunk ducts and where indicated. All such openings shall be readily accessible without damage to finishes.

3.11 Low Velocity Ductwork: Whether indicated or not, provide code approved, full sized fire dampers at all locations where ductwork penetrates fire rated walls. Fire stop rating shall meet or exceed the rating of the wall. Provide an approved access panel at each fire damper located and sized so as to allow hand reset of each fire dampers. All such fire dampers and access panels shall be readily accessible without damage to finishes. Refer to Architectural Plans for locations of fire rated walls. All access doors shall be 16"x16" or as high as ductwork permits and 16" in length.

3.12 High Velocity Ductwork: Whether indicated or not, provide code approved, full sized fire dampers at all locations where ductwork penetrates fire rated walls. Fire stop rating shall meet or exceed the rating of the wall. Provide an approved access panels at each fire damper located and sized so as to allow hand reset of each fire damper. All such fire dampers and access panels shall be readily accessible without damage to finishes. Refer to Architectural Plans for locations of fire rated walls. Where access doors are installed in insulated ductwork, the access door shall be the insulated type.

3.13 The Contractor who installs the sheet metal shall furnish to the Air Balancing Contractor, a qualified person to assist in testing and balancing the system.

3.14 All grille and register taps shall be factory manifolded. Field installed taps will not be allowed. Manifolded taps may be tack welded and caulked for appearance. Only taps for grilles and registers may be provided this way. All other fittings shall be full body welded.

END OF SECTION 233300

SECTION 233423- HVAC POWER VENTILATORS

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. Each Contractor's attention is also directed to Specification Section SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC, and provide all documentation called for therein.

C. Each Contractor's attention is also directed to Specification Section INSTRUMENTATION AND CONTROLS FOR HVAC to determine controls, including variable frequency drives, to be furnished. Where manufacturer's temperature controls are specified, they shall be in full compliance with NFPA 90A including automatic smoke shut down provisions.

D. Each Contractor's attention is also directed to Specification Section VARIABLE FREQUENCY MOTOR CONTROLLER to determine, VFDs to be furnished by the contractor.

E. Each Contractor's attention is also directed to Specification Section TESTING, ADJUSTING, AND BALANCING FOR HVAC. For all belt driven equipment, provide final fan and motor sheaves as determined by the air balance contractor during project balancing phase. The mechanical contractor shall install any new sheaves and belts as required for balancing.

1.2 The Contractor shall provide in complete working order the heating, ventilation and air conditioning equipment located as indicated and installed, connected, and placed in operation in strict accordance with the manufacturer's recommendations. All equipment shall be factory painted and, where applicable, factory insulated and shall, where such standards exist, bear the label of the Underwriters Laboratory.

1.3 All Contractors and Vendors providing a bid for this project shall review the Plans and Specifications and determine any modifications and/or adjustments necessary relative to the proposed equipment and materials with specific manufacturer's installation requirements. Include in the bid any necessary installation methods, features, options, accessories, etc. necessary to install the proposed equipment and materials, regardless of whether used as basis of design or being offered as a substitution in accordance with the specific manufacturer's installation requirements whether specifically detailed or not within the Plans and Specifications.

1.4 All equipment, material and labor warranties shall be furnished by the equipment supplier/vendor. All warranties begin on the date of Substantial Completion.

1.5 Refer to Specification Section COMMON WORK RESULTS FOR HVAC for minimum required Schedule of Values breakdown and special warranty requirements.

1.6 All HVAC equipment shall comply with the latest provisions of ASHRAE Standard 90.1 and all provisions of the International Energy Conservation Code.

PART 2 – PRODUCTS:

2.1 Roof exhaust fans shall be of the direct drive centrifugal type, Model DCRD or DCRU, as manufactured by Twin City Fan & Blower, Minneapolis, Minnesota or equivalent by Greenheck, Penn, ACME or Cook.

2.2 Fans shall be tested in accordance with AMCA 211 and AMCA 311 test codes for air moving devices and shall be guaranteed by the manufacturer to deliver rated published performance levels. Fans shall be licensed to bear the AMCA certified ratings seal for both sound and air. Models shall be UL 705 listed. Refer to the schedule for more details.

2.3 Fans shall be constructed of aluminum for durability and appearance. Fan spinnings shall have a rolled bead edge for rigidity. Units shall have a deep venturi inlet to prevent snow and rain entry into the building. The curb cap shall include prepunched mounting holes for ease of installation. A conduit chase constructed of electrical metallic tubing shall be provided to the motor compartment. The curb base shall have continuously welded corners for maximum leak protection. Lifting lugs shall be provided inside the motor compartment for ease of handling and installation. Fans shall bear a permanently attached nameplate displaying model and serial number of the unit for future identification.

2.4 Motor assembly shall be mounted on vibration isolators to eliminate vibration and noise transmission into the ductwork. Motors shall be mounted out of the exhaust airstream.

2.5 No tools shall be needed to access motor compartment for inspection of motor and drive components.

2.6 Fan wheels shall be of the centrifugal backward inclined type, constructed of aluminum and containing a matching inlet venturi for optimum unit performance. Wheels shall be statically and dynamically balanced.

2.7 Motors shall be heavy-duty ball bearing type, closely matched to the fan load. All single-phase motors shall contain thermal overload protection. All motors shall be UL and/or CSA recognized. Motors for use with speed control shall provide good speed controllability without any objectionable noise.

2.8 A NEMA 3R disconnect switch shall be supplied with wiring leading from the motor to the junction box.

2.9 When scheduled, accessories such as backdraft damper, roof curb, curb hinge, retaining chain, security hasp, variable speed controller, NEMA-4 disconnect switch, 2-speed switch, firestat, aluminum bird screen, aluminum insect screen, and special coatings shall be provided by the approved fan manufacturer to maintain one source responsibility. Refer to schedule remarks for specified accessories.

PART 3 – EXECUTION:

3.1 Each subcontractor shall be responsible for their own completion of System Verification Checklists/Manufacturer's Checklists. Factory startup is required for all HVAC equipment. In general, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians and shall complete and submit start-up reports/checklists.

3.2 Ensure that the equipment that is proposed to be furnish may be installed, connected, placed in operation, and easily maintained at the location and in the space allocated for it.

3.3 The contractor and vendor shall confirm connection sides for each piece of equipment specific to this project.

3.4 Determine from the Bid Documents the date of completion of this project and ensure that equipment delivery schedules can be met so as to allow this completion date to be met.

3.5 EQUIPMENT START-UP: Prior to utilization of equipment, start-up service shall be performed by factory authorized representative. Utilize startup sheets included in the Specification Section COMMON WORK RESULTS FOR HVAC. Refer to Specification Section COMMON WORK RESULTS FOR HVAC for additional requirements.

END OF SECTION 237000

SECTION 233600 – VARIABLE AIR VOLUME TERMINAL BOXES

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. Each Contractor's attention is also directed to Specification Section SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC, and provide all documentation called for therein.

C. Each Contractor's attention is also directed to Specification Section INSTRUMENTATION AND CONTROLS FOR HVAC to determine controls, including variable frequency drives, to be furnished. Where manufacturer's temperature controls are specified, they shall be in full compliance with NFPA 90A including automatic smoke shut down provisions.

D. Each Contractor's attention is also directed to Specification Section TESTING, ADJUSTING, AND BALANCING FOR HVAC. For all belt driven equipment, provide final fan and motor sheaves as determined by the air balance contractor during project balancing phase. The mechanical contractor shall install any new sheaves and belts as required for balancing.

1.2 SCOPE

A. The Contractor shall provide in complete working order the heating, ventilation and air conditioning equipment located as indicated and installed, connected, and placed in operation in strict accordance with the manufacturer's recommendations. All equipment shall be factory painted and, where applicable, factory insulated and shall, where such standards exist, bear the label of the Underwriters Laboratory.

B. All Contractors and Vendors providing a bid for this project shall review the Plans and Specifications and determine any modifications and/or adjustments necessary relative to the proposed equipment and materials with specific manufacturer's installation requirements. Include in the bid any necessary installation methods, features, options, accessories, etc. necessary to install the proposed equipment and materials, regardless of whether used as basis of design or being offered as a substitution in accordance with the specific manufacturer's installation requirements whether specifically detailed or not within the Plans and Specifications.

C. All equipment, material and labor warranties shall be furnished by the equipment supplier/vendor. All warranties begin on the date of Substantial Completion.

D. All HVAC equipment shall comply with the latest provisions of ASHRAE Standard 90.1 and all provisions of the International Energy Conservation Code.

PART 2 – PRODUCTS:

2.1 ACCEPTABLE MANUFACTURERS: ETI, Trane, Titus, Carrier, JCI/York, Price.

2.2 Terminals shall be certified by ARI and bear the ARI 880 seal.

2.3 Terminals shall be constructed of not less than 22 gauge galvanized steel, able to withstand a 125 hour salt spray test per ASTM B-117. The terminal casing shall be mechanically assembled (spot-welded casings are not acceptable). Terminal shall include control enclosure and hanger brackets. The terminal shall be provided with a removable bottom access panel.

2.4 Casing shall be insulated with ½" thick fiberglass insulation, rated for a maximum air velocity of 5000 f.p.m. Maximum thermal conductivity shall be 0.24 (BTU · in) / (hr · ft² · °F). Insulation must meet all requirements of ASTM C1071 (including C665), UL 181 for erosion, and carry a 25/50 rating for flame spread/smoke developed per ASTM E-84, UL 723 and NFPA 90A. Raw insulation edges on the discharge of the unit must be covered with metal liner to eliminate flaking of insulation during field duct connections. Simple "buttering" of raw edges with an approved sealant is not acceptable. Insulation shall be covered with scrim backed foil facing. All insulation edges shall be covered with foil or metal nosing. Insulation shall meet ASTM C1136 for mold, mildew, and humidity resistance. All appurtenances including control assemblies and control enclosures, shall not extend beyond the top and bottom of the unit casing. At an inlet velocity of 2000 f.p.m., the static pressure drop across the basic terminal shall not exceed .08" W.G. for all unit sizes.

2.5 The air terminals shall be single wall with 1/2" foil faced insulation.

2.6 The primary air valve shall consist of a minimum 22 gauge cylindrical body that includes embossment rings for rigidity. The damper blade shall be connected to a solid shaft by means of an integral molded sleeve which does not require screw or bolt fasteners. The shaft shall be manufactured of a low thermal conducting composite material and include a molded damper position indicator visible from the exterior of the unit. The damper shall pivot in self lubricating bearings. The damper acturator shall be mounted on the exterior of the terminal for ease of service. The valve assembly shall include internal mechanical stops for both full open and closed positions. The damper blade seal shall be secured without use of adhesives. The air valve leakage shall not exceed 1% of maximum inlet rated airflow at 3" W.G. inlet pressure.

2.7 The differential pressure airflow sensor shall traverse the duct along two perpendicular diameters. Cylindrically shaped inlets shall utilize the equal cross sectional area or log-linear traverse method. Single axis sensor shall not be acceptable. A minimum of 12 total pressure sensing points shall be utilized. The total pressure inputs shall be averaged using a pressure chamber located at the center of the sensor. A sensor that delivers the differential pressure signal from one end of the sensor is not acceptable. The sensor shall output an amplified differential pressure signal that is at least 2.5 times the equivalent velocity pressure signal obtained from a conventional pitot tube. The sensor shall develop a differential pressure of 0.03" W.G. at an air velocity of <450 FPM. Brass balancing taps and airflow calibration charts shall be provided for field airflow measurements. Terminal shall have access door for inspection and cleaning.

2.8 Terminal shall include an integral, 2-row (minimum), hot water coil where indicated on the plans. The coil shall be manufactured by the terminal unit manufacturer and shall have a minimum 22 gauge galvanized sheet metal casing. Coil to be constructed of pure aluminum fins with full fin collars to assure accurate fin spacing and maximum tube contact. Fins shall be spaced with a minimum of 10 per inch and mechanically fixed to seamless copper tubes for maximum heat transfer. Each coil shall be hydrostatically tested at a minimum of 450 PSIG under water, and rated for a maximum 300 PSIG working pressure at 200°F.

PART 3 – EXECUTION:

3.1 Each subcontractor shall be responsible for their own completion of System Verification Checklists/Manufacturer's Checklists. Factory startup is required for all HVAC equipment. In general, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians and shall complete and submit start-up reports/checklists.

3.2 A 100% complete mockup installation shall be required for a typical unit. This mockup shall be inspected/reviewed by the Engineer prior to installation of other units.

3.3 Any mechanical closet dimension modifications or access requirements due to the manufacturer specifics shall be the burden of the approved manufacturer.

3.4 Ensure that the equipment that is proposed to be furnish may be installed, connected, placed in operation, and easily maintained at the location and in the space allocated for it.

3.5 The contractor and vendor shall confirm connection sides for each piece of equipment specific to this project.

3.6 Provide eight (8) hours of onsite training for this system. All training shall occur after building completion. Systems shall function properly, and O&M staff shall be able to operate the system prior to turnover.

3.7 Determine from the Bid Documents the date of completion of this project and ensure that equipment delivery schedules can be met so as to allow this completion date to be met.

3.8 EQUIPMENT START-UP: Prior to utilization of equipment, start-up service shall be performed by factory authorized representative.

END OF SECTION 233600

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SECTION 233713 – DIFFUSERS, REGISTERS & GRILLES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contactor’s attention is directed to Specification Section HVAC.

PART 2 – PRODUCTS

2.1 REGISTERS, GRILLES, AND DIFFUSERS

A. Acceptable R, G & D manufacturers are Krueger, Anemostat, Nailor Industries, Titus, and Tuttle & Bailey. Shop drawings shall identify and list all characteristics of each device exactly as scheduled herein. Finishes for specified devices shall be selected by the Architect. Factory color samples shall be submitted with shop drawings. Devices shall be white unless noted otherwise. Aluminized steel devices are not acceptable. Steel devices are not acceptable unless specifically noted otherwise.

2.2 Refer to drawings for schedule.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated on drawings, or as directed, before starting air balancing.

END OF SECTION 233713

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SECTION 233813 – COMMERCIAL-KITCHEN HOODS

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. Each Contractor’s attention is also directed to Specification Section SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC, and provide all documentation called for therein.

C. Each Contractor’s attention is also directed to Specification Section INSTRUMENTATION AND CONTROLS FOR HVAC to determine controls, including variable frequency drives, to be furnished. Where manufacturer’s temperature controls are specified, they shall be in full compliance with NFPA 90A including automatic smoke shut down provisions.

D. Each Contractor’s attention is also directed to Specification Section VARIABLE FREQUENCY MOTOR CONTROLLER to determine, VFDs to be furnished by the contractor.

E. Each Contractor’s attention is also directed to Specification Section TESTING, ADJUSTING, AND BALANCING FOR HVAC. For all belt driven equipment, provide final fan and motor sheaves as determined by the air balance contractor during project balancing phase. The mechanical contractor shall install any new sheaves and belts as required for balancing.

1.2 SCOPE

A. The Contractor shall provide in complete working order kitchen range hood, make up air and exhaust system equipment located as indicated and installed, connected, and placed in operation in strict accordance with the manufacturer's recommendations. All equipment shall be factory painted and, where applicable, factory insulated and shall, where such standards exist, bear the label of the Underwriters Laboratory.

B. All Contractors and Vendors providing a bid for this project shall review the Plans and Specifications and determine any modifications and/or adjustments necessary relative to the proposed equipment and materials with specific manufacturer’s installation requirements. Include in the bid any necessary installation methods, features, options, accessories, etc. necessary to install the proposed equipment and materials, regardless of whether used as basis of design or being offered as a substitution in accordance with the specific manufacturer’s installation requirements whether specifically detailed or not within the Plans and Specifications.

C. All equipment, material and labor warranties shall be furnished by the equipment supplier/vendor. All warranties begin on the date of Substantial Completion.

D. All HVAC equipment shall comply with the latest provisions of ASHRAE Standard 90.1 and all provisions of the International Energy Conservation Code.

PART 2 – PRODUCTS:

2.1 ACCEPTABLE MANUFACTURERS: Greenheck, Captive Aire or equal.

2.2 The Contractor shall submit shop drawings for the kitchen range hood system(s) along with all required supporting documentation and review fees to the Department of Housing, Buildings and Construction.

2.3 Through coordination with other Contractors, Vendors and Suppliers associated with this Project, this Contractor shall insure a complete, 100% functional, tested, inspected, and approved system. Claims for additional cost or change orders will immediately be rejected. Refer to Specification Section - ELECTRIC MOTORS, ETC. for additional requirements.

2.4 Hood shall be furnished and installed to comply with NFPA-96, IMC Chapter 5 and local/state regulating governing same. Refer to drawings for sizes, locations, etc.

2.5 Hoods shall all be constructed of 18 gauge, Type 304 stainless steel and Number 3 finish. Grind and polish all exposed welds. Joints other than welded will not be accepted. All joints shall be internally welded.

2.6 Hood shall be furnished complete with all required concentric ductwork, plenums, curbs, and controls. The rangehood supply and exhaust duct collars shall each be provided. Provide 8" minimum between supply and exhaust collars.

2.7 Provide 20” minimum height insulated roof curb for rangehood exhaust fans. Coordinate roof curb requirements with roofing system.

2.8 Hoods shall be equipped with vapor proof fluorescent light fixtures with an average lamp output of 15 watts per foot of hood. Light Fixtures shall be UL-listed, surface-mounted, with lenses sealed vaportight.

2.9 TYPE I EXHAUST HOODS – GREASE LADEN VAPORS: Weld all joints exposed to grease with continuous welds and make grease removal devices and makeup air diffusers easily accessible for cleaning. Hood(s) shall be listed and labeled, according to UL 710, by a testing agency acceptable to authorities having jurisdiction. Grease Removal Devices shall be removable, aluminum, filter/baffle grease filters. They shall be fabricated with a minimum of 0.0781-inch- (1.98-mm-) thick aluminum for filter frame and removable collection cup and trough. Exposed surfaces shall be pitched to drain to collection cup. Filters/baffles shall comply with UL 1046, “Grease Filters for Exhaust Ducts. Hood Discharge Plenums shall be Type 304 Stainless Steel Plenums at the vertical face of both hoods. Plenum shall cover entire face.

2.10 FIRE CONTROL SYSTEM: Furnish and install a fire control system for each Type I Exhaust Hood. This system shall be a wet chemical, pre-engineered, piped, fixed nozzle, cartridge operated, non-pressurized type. It shall be specifically UL listed for the hazard involved and installed in accordance with National Fire Protection Association Standard No. 96 latest revision, "Standard for the Installation of Equipment for the Removal of Smoke and Grease Laden Vapors from Commercial Cooking Equipment". The system shall also conform to all local and/or state codes and standards. The design of the fire control system shall be by the vendor and provide for protection for duct systems, grease removal devices and hoods. Cooking equipment such as ranges and steam kettle, which may be source of ignition of grease in hood or duct shall be protected. The system shall be capable of automatic (connected to a suitable listed system of detection and actuation) and manual mechanical operation. Install manual operator 48” maximum feet above floor where indicated on the plans. All components, including the pressure container and the remote emergency fire station, shall be furnished by the hood manufacturer, and installed by the contractor. Include equipment for the automatic shutdown of any electric heating equipment under the hood. Coordinate with Electrical/Fire Alarm Contractor.

2.11 CONTROLS: Provide a complete controls system for the range hoods, exhaust fans, and makeup air unit. This shall include all wiring between indoor and outdoor equipment, sensors, audible alarms, VFDs, start/stopping of fans and other components. Unit shall be wired for a single point connection to a NEMA-1 stainless steel control panel complete with all required controls, starters, and fusing. Control panel shall be factory-mounted to the hood unless noted otherwise on the drawings. Each motor shall have its own power disconnect. Panel shall be NEMA 3R for outdoor use, rain-tight.

2.11.1 Provide backlit, full color touchscreen user interface configured to push fit into a junction box with no visible/exposed screws. Provide the following minimum functionality:

A. All controls, hood system (lights, fans) will be controlled via touchscreen UI.
   a. Touchscreen shall have capability to control all fans and lights connected to the control panel with a single button.
   b. Balancing interfacing for proper kitchen fan balancing.
B. Capable of displaying the following information:
   a. Fans on/off
   b. Lights on/off
   c. Heat or cooling on/off
   d. Flame failure
   e. Freeze stat fault
   f. Push button switch labeled “afterhours” to override the time schedule
C. Programmable schedule in the system settings
   a. Program override option on to override any scheduled run times
D. Alarms/fault codes, including but not limited to:
   a. High temperature alarm
   b. VFD failure
   c. Temperature sensor failure
   d. Flame failure

2.11.2 Kitchen controls shall utilize resistive type temperature sensors that are mounted in the capture tank of the hood to monitor exhaust air temperatures.

2.11.3 Auto start-up operation shall be controlled by an excess offset temperature (10°F, adj.) between the hood temperature and the constant, preset room temperature (75°F, adj.). If any fan(s) are activated through the auto start-up operation, the fan(s) will not shut off automatically until the measured hood temperature(s) remain below the room temperature for the length of the hysteresis timer (5°F, 5 minutes, adj.).

2.11.4 After fan initiation, either manually, through the touchscreen or through auto start-up, the controller shall operate the associated exhaust and supply fan(s) at their design speeds via motor starters, VFDs, or analog signals. Control system shall be fully compatible with 24VAC coil motor starters.

2.11.5 In a fire condition, the control panel shall be capable of forcing the exhaust fan to maximum speed, shutting down the supply air, and shutting down hood lights regardless of current fan speeds via integration with the fire control system.

2.12 KITCHEN EXHAUST FANS:

A. Acceptable Manufacturers: Twin City, Greenheck, Cook.

B. Units shall be UL 76 certified for grease removal and selected in conjunction with the hoods.

C. Provide with totally enclosed motor and grease box with drain.

D. Disconnect Switch: Where scheduled, a NEMA 3R disconnect switch shall be supplied with wiring leading from the motor to the junction box (TEFC motors).

E. Provide motor with shaft grounding and thermal overload protection for variable speed application. Variable frequency drive shall be located in the associated kitchen hood control panel.

F. Accessories: 20” vented roof curb, curb hinge with retaining chain. Refer to the drawings for additional requirements.

G. For all belt-driven fans provide with auto belt tensioner and four (4) sets of belts for the Owner’s use upon Substantial Completion.

PART 3 – EXECUTION:

3.1 Each subcontractor shall be responsible for their own completion of System Verification Checklists/Manufacturer's Checklists. Factory startup is required for all HVAC equipment. In general, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians and shall complete and submit start-up reports/checklists.

3.2 Any mechanical closet dimension modifications or access requirements due to the manufacturer specifics shall be the burden of the approved manufacturer.

3.3 Ensure that the equipment that is proposed to be furnish may be installed, connected, placed in operation, and easily maintained at the location and in the space allocated for it.

3.4 The contractor and vendor shall confirm connection sides for each piece of equipment specific to this project.

3.5 Provide eight (8) hours of onsite training for this system. All training shall occur after building completion. Systems shall function properly, and O&M staff shall be able to operate the system prior to turnover.

3.6 Determine from the Bid Documents the date of completion of this project and ensure that equipment delivery schedules can be met so as to allow this completion date to be met.

3.7 EQUIPMENT START-UP: Prior to utilization of equipment, start-up service shall be performed by factory authorized representative. Utilize startup sheets included in the Specification Section COMMON WORK RESULTS FOR HVAC. Refer to Specification Section COMMON WORK RESULTS FOR HVAC for additional requirements.

3.8 BALANCING: Hoods supply and exhaust fan shall have the final air balance supervised by factory authorized personnel to obtain maximum performance. Submit air balance report to engineer stating CFM of exhaust and supply fans.

3.9 EQUIPMENT START-UP: Prior to utilization of equipment, start-up service shall be performed by factory authorized representative. Refer to Specification Section COMMON WORK RESULTS FOR HVAC for additional requirements.

3.10 DUCT LEAKAGE TESTING:

A. Prior to the use or concealment of any portion of the duct system, a duct leakage test shall be performed in the presence of the Code Official. Ducts shall be considered concealed where installed in shafts or covered by coatings or wraps that prevent the ductwork from being visually inspected on all sides. The Contractor shall be responsible to provide the necessary equipment and perform the duct leakage test. A light test or an approved equivalent test method shall be performed to determine that all welded and brazed joints are liquid tight. A light test shall be performed by passing a lamp having a power rating of not less than 100 watts through the entire section of the ductwork to be tested. The lamp shall be open so as to emit light equally in all directions perpendicular to the duct walls. A test shall be performed for the entire duct system, including the hood-to-duct connection. The Contractor, Owner, Architect, Engineer, Test and Balance Contractor and the Equipment Manufacturer shall all be present during the Code Official Inspection(s).

B. Prior to the Code Official Inspection(s), the Contractor and the Equipment Manufacturer shall perform a pre-test on all duct systems to include a flashlight test of the ductwork. Any deficiencies shall be corrected and re-tested prior to the formal inspection(s) by the Code Official.

3.11 HOOD PERFORMANCE TESTING:

A. Performance test(s) shall be conducted by the Contractor and witnessed by the Code Official upon completion and before final approval of the installation of the ventilation system serving the commercial

kitchen appliances. The test(s) shall verify the rate of exhaust airflow and makeup airflow as required as well as the proper operation of the system. The Contractor shall be responsible to provide the necessary equipment and perform the test including 45 second white smoke candles. The test(s) shall emulate actual cooking conditions with all appliances in operation. The test(s) shall also include validation of the automatic controls systems. The Contractor, Owner, Architect, Engineer, Test and Balance Contractor and the Equipment Manufacturer shall all be present during the Code Official Inspection(s).

B. Prior to the Code Official Inspection(s), the Contractor and the Equipment Manufacturer shall perform pre-test(s) on all hood systems to include smoke bomb testing with 45 second white smoke candles. The pre-test(s) shall emulate actual cooking conditions with all appliances in operation. The test(s) shall also include validation of the automatic controls systems. Any deficiencies shall be corrected and re-tested prior to the formal inspection(s) by the Code Official.

END OF SECTION 233800

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SECTION 235216- CONDENSING BOILERS

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. Each Contractor’s attention is also directed to Specification Section SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC, and provide all documentation called for therein.

C. Each Contractor’s attention is also directed to Specification Section INSTRUMENTATION AND CONTROLS FOR HVAC to determine controls, including variable frequency drives, to be furnished. Where manufacturer’s temperature controls are specified, they shall be in full compliance with NFPA 90A including automatic smoke shut down provisions.

D. Each Contractor’s attention is also directed to Specification Section VARIABLE FREQUENCY MOTOR CONTROLLER to determine, VFDs to be furnished by the contractor.

E. Each Contractor’s attention is also directed to Specification Section TESTING, ADJUSTING, AND BALANCING FOR HVAC. For all belt driven equipment, provide final fan and motor sheaves as determined by the air balance contractor during project balancing phase. The mechanical contractor shall install any new sheaves and belts as required for balancing.

1.2 SCOPE

A. The Contractor shall provide in complete working order the heating, ventilation and air conditioning equipment located as indicated and installed, connected, and placed in operation in strict accordance with the manufacturer's recommendations. All equipment shall be factory painted and, where applicable, factory insulated and shall, where such standards exist, bear the label of the Underwriters Laboratory.

B. All Contractors and Vendors providing a bid for this project shall review the Plans and Specifications and determine any modifications and/or adjustments necessary relative to the proposed equipment and materials with specific manufacturer’s installation requirements. Include in the bid any necessary installation methods, features, options, accessories, etc. necessary to install the proposed equipment and materials, regardless of whether used as basis of design or being offered as a substitution in accordance with the specific manufacturer’s installation requirements whether specifically detailed or not within the Plans and Specifications.

C. All equipment, material and labor warranties shall be furnished by the equipment supplier/vendor. All warranties begin on the date of Substantial Completion.

D. All HVAC equipment shall comply with the latest provisions of ASHRAE Standard 90.1 and all provisions of the International Energy Conservation Code.

PART 2 – PRODUCTS - HIGH EFFICIENCY CONDENSING BOILERS:

2.1 ACCEPTABLE MANUFACTURERS: Laars, Lochinvar, Harsco/Patterson-Kelley.

2.2 CONSTRUCTION: Boiler modules shall be natural gas fired, condensing fire tube design with a modulating forced draft power burner and positive pressure vent discharge.

2.3 MODULATING AIR/FUEL VALVE and BURNER: The Boiler burner shall be capable of a 20 to 1 turndown ratio of the firing rate without loss of combustion efficiency or staging of gas valves. The burner shall be nozzle mix design, with spark ignition and flame rectification. The burner head shall be cast stainless steel. All burner material exposed to the combustion zone shall be of stainless steel construction. There shall be no moving parts within the burner itself. A modulating air/fuel valve shall meter the air and natural gas input. The modulating motor must be linked to both the gas valve body and air valve body with a single linkage. The linkage shall not require any field adjustment.

2.4 PRESSURE VESSEL/HEAT EXCHANGER:

A. The boiler shall be capable of handling return water temperatures down to 40 F without any failure due to thermal shock or fireside condensation. The heat exchanger shall be ASME stamped for a working pressure not less than 150 psig. The pressure vessel shall have a maximum water volume of 30 gallons. The boiler water pressure drop shall *not exceed* 2 psig at 180 gpm. The boiler water connections shall be 4" flanged 150 lb. ANSI rated. The pressure vessel is constructed of SA53 carbon steel, with a 0.25 in. thick wall and 0.50 in. thick upper head. Inspection openings in the pressure vessel & shall be in accordance with ASME Section IV pressure vessel code.

B. The boiler shall be designed so that the thermal efficiency increases as the boiler firing rate decreases. The heat exchanger shall be constructed entirely of 316L stainless steel fire tubes and tube sheets with a one-pass combustion gas flow design. Hybrid designs or heat exchangers utilizing dissimilar metals or any non-ferrous metals shall not be acceptable. The fire tubes shall be 5/8 in. OD with no less than 0.065 in. wall thickness. The upper and lower stainless steel tubesheet shall be no less than 0.313 in. thick. The pressure vessel/heat exchanger shall be welded construction. The heat exchanger shall be ASME stamped for a working pressure not less than 150 psig. Access to the tubesheets and heat exchanger is available by burner and exhaust manifold removal. Minimum access opening shall be no less than 13.5 in. diameter.

2.5 EXHAUST MANIFOLD: Refer to Specification Section SHEETMETAL positive pressure venting specification. The exhaust manifold shall have a gravity drain for the elimination of the condensation with collecting reservoir.

2.6 BOILER CONTROLS: The boiler control system shall be segregated into three components: Control Panel, Power Box, and Input/Output Connection Box. The entire system shall be Underwriters Laboratories Recognized.

A. The control panel shall consist of 6 individual circuit boards utilizing surface-mount technology, in a single enclosure. These circuit boards shall be defined as follows: display board incorporating LED display to read temperature, and a VFD display module for all message annunciations; CPU board which houses all control functions; electric low water cutoff board with test and manual reset functions; power supply board; ignition /stepper board incorporating flame safeguard control; and connector board. Each board shall be individually field replaceable. The combustion safeguard/flame monitoring system shall utilize spark ignition and a rectification type flame sensor. The control panel hardware shall support both RS-232 and RS-485 remote communications. The controls shall annunciate boiler & sensor status and include extensive self-diagnostic capabilities that incorporates a minimum of 8 separate status messages and 34 separate fault messages.

B. The control panel shall incorporate three self-governing features designed to enhance operation in modes where it receives an external control signal by eliminating nuisance faults due to over-temperature, improper external signal, or loss of external signal. These features are called: Setpoint High Limit, Setpoint Low Limit, and Failsafe Mode. Setpoint High Limit allows for a selectable maximum boiler outlet temperature and acts as temperature limiting governor. It is a PID function that automatically limits firing rate to maintain outlet temperature within a 0 to10 degree selectable band from the desired maximum boiler outlet temperature. Setpoint Low Limit allows for a selectable minimum operating temperature.

C. Failsafe Mode allows the boiler to switch its mode to operate from an internal setpoint if its external control signal is lost, rather than shut off. This is a selectable mode; hence the control can be set to shut off the unit upon loss of external signal if so desired.

D. The boiler control system shall incorporate the following features for system interface: system start temperature feature; pump delay timer; auxiliary start delay timer; auxiliary temperature sensor; mA output feature which allows for simple monitoring of either temperature setpoint, outlet temperature, or fire rate; remote interlock circuit; delayed interlock circuit; and fault relay for simple remote fault alarm.

E. Each boiler shall utilize an electric single seated safety shutoff valve with proof of closure switch in its gas train and incorporate dual over-temperature protection with manual reset in accordance with ASME Section IV and CSD-1.

F. TEMPERATURE CONTROL MODES:
1. The boilers shall operate in the control modes listed below:
   - Indoor/Outdoor Reset
   - Boiler Management System (BMS)
2. The first six control modes refer to independent boiler settings, while the last two control modes refer to banks of boilers operated as a system by supplied BMS. The BMS shall be programmed to operate the entire bank of boilers in either of the first four control modes.

G. INDOOR/OUTDOOR RESET:
1. Boiler shall include integral factory wired operating controls to control all operation and energy input of the boiler plant. The system shall be comprised of a microprocessor-based control utilizing pulse width modulation for bumpless transfer of header temperature. The controller shall have the ability to vary boiler input throughout its full range to maximize the condensing capability of the boiler and without header temperature swings.
2. The boiler will operate to vary header temperature setpoint on an inverse ratio in response to outdoor temperature to control discharge temperature +2ºF. Unit shall operate with an Inverse Efficiency Curve, with known Part Load Value Efficiencies. Maximum efficiency shall be achieved at minimum firing input. Reset ratio shall be fully field adjustable from 0.3 to 3.0 in operation. The boiler shall have LCD display for monitoring of all sensors and interlocks.
3. The outdoor air sensor and supply water temperature sensor shall be furnished with the boiler package and installed by the Contractor.

H. BOILER MANAGEMENT SYSTEM (BMS):
1. The Boiler Manufacturer shall supply as part of the boiler package a completely integrated Boiler Management System to control all operation and energy input of the multiple boiler heating plant. The Boiler Management System shall be comprised of a microprocessor-based control. The BMS controller shall have the ability to operate up to 32 boilers per BMS panel.
2. The controller shall have the ability to vary the firing rate and energy input of each individual boiler throughout its full modulating range to maximize the condensing capability and thermal efficiency output of the entire heating plant. The BMS shall control the boiler outlet header temperature within +2ºF. The controller shall be a PID type controller for accurate temperature control with excellent variable load response. The BMS controller shall provide contact closure for auxiliary equipment such as system pumps and combustion air inlet dampers based upon outdoor air temperature.
3. When set on Internal Setpoint Mode, temperature control setpoint on the BMS shall be fully field adjustable from 50ºF to 190ºF in operation. When set on Indoor/Outdoor Reset Mode, the BMS will operate on an adjustable inverse ratio in response to outdoor temperature to control the main header temperature. Reset ratio shall be fully field adjustable from 0.3 to 3.0 in operation.
4. The BMS controller shall have a LCD display for monitoring of all sensors and interlocks. Non-volatile memory backup of all control parameters shall be internally provided as standard. The controller will automatically balance the sequence of operating time on each module by a first-on first-off mode and provide for setback and remote alarm contacts. Connection between central BMS system

and individual modules shall be twisted pair low voltage wiring, with the boilers 'daisy-chained' for ease of installation.

I. CONTROLS INTEROPERABILITY: The control panel and the BMS shall utilize a BACnet gateway, however the manufacturer shall coordinate the details of this interface with the Temperature Controls Contractor prior to bid and prior to the shipment of the boilers. This coordination shall be documented in writing to the Owner and Engineer.

PART 3 – EXECUTION:

3.1 All aspects of installation of Boiler Plant shall be in strict accordance with manufacturer's instructions. The vent and air intake system must conform to all manufacturers' recommendations and shall utilize UL listed stainless steel AL-29-4C Positive Pressure for the vent and PVC for the intake. The vent must be sized in accordance with boiler manufacturer's recommendations. Prior to the bid, the boiler manufacturer and Contractor shall confirm the appropriate vent and intake sizes according to the manufacturer's recommendation. Change orders will not be accepted for increases in sizes after the bid.

3.2 Boiler plant piping shall be field constructed of materials as specified. Each boiler shall have individually isolating shutoff valves for service and maintenance. Each boiler shall require a minimum gas pressure of 7"W.C. (FM gas train) at 2,000 scfh (full load rated capacity). Each boiler shall be provided with an individual supply gas regulator for proper gas regulation with a 2" NPT connection.

3.3 WARRANTY:

A. The boiler manufacturer shall provide a complete unit parts and labor warranty for one year from substantial completion.

B. Beginning at the expiration of the one year parts and labor, the Owner shall be provided with a non-prorated 7 year warranty against failure due to condensate corrosion, thermal stress, mechanical defects or workmanship. The six individual circuit boards of the control panel assembly shall carry a 2 year warranty against failure due to defective materials or workmanship.

3.4 EQUIPMENT START-UP: Prior to utilization of equipment, start-up service shall be performed by factory authorized representative. Utilize start-up sheets provided by the manufacturer. Refer to Specification Section COMMON WORK RESULTS FOR HVAC for additional requirements.

3.5 Provide eight (8) hours of onsite training for this system. All training shall occur after building completion. Systems shall function properly, and O&M staff shall be able to operate the system prior to turnover.

END OF SECTION 235216

SECTION 236423- AIR-COOLED WATER CHILLERS

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. Each Contractor's attention is also directed to Specification Section SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC, and provide all documentation called for therein.

C. Each Contractor's attention is also directed to Specification Section INSTRUMENTATION AND CONTROLS FOR HVAC to determine controls, including variable frequency drives, to be furnished. Where manufacturer's temperature controls are specified, they shall be in full compliance with NFPA 90A including automatic smoke shut down provisions.

D. Each Contractor's attention is also directed to Specification Section VARIABLE FREQUENCY MOTOR CONTROLLER to determine, VFDs to be furnished by the contractor.

E. Each Contractor's attention is also directed to Specification Section TESTING, ADJUSTING, AND BALANCING FOR HVAC. For all belt driven equipment, provide final fan and motor sheaves as determined by the air balance contractor during project balancing phase. The mechanical contractor shall install any new sheaves and belts as required for balancing.

1.2 SCOPE

A. The Contractor shall provide in complete working order the heating, ventilation and air conditioning equipment located as indicated and installed, connected, and placed in operation in strict accordance with the manufacturer's recommendations. All equipment shall be factory painted and, where applicable, factory insulated and shall, where such standards exist, bear the label of the Underwriters Laboratory.

B. All Contractors and Vendors providing a bid for this project shall review the Plans and Specifications and determine any modifications and/or adjustments necessary relative to the proposed equipment and materials with specific manufacturer's installation requirements. Include in the bid any necessary installation methods, features, options, accessories, etc. necessary to install the proposed equipment and materials, regardless of whether used as basis of design or being offered as a substitution in accordance with the specific manufacturer's installation requirements whether specifically detailed or not within the Plans and Specifications.

C. All equipment, material and labor warranties shall be furnished by the equipment supplier/vendor. All warranties begin on the date of Substantial Completion.

D. All HVAC equipment shall comply with the latest provisions of ASHRAE Standard 90.1 and all provisions of the International Energy Conservation Code.

PART 2 – PRODUCTS – AIR-COOLED SCROLL WATER CHILLER:

2.1 ACCEPTABLE MANUFACTURERS: Trane, Carrier, JCI/York.

2.2 Equipment shall minimally meet efficiency standards of ASHRAE Standard 90.1, refer to the chiller schedule for efficiency requirements.

2.3 Chillers shall be delivered to the job site completely assembled and charged with refrigerant and oil by the manufacturer. Comply with the manufacturer's instructions for rigging and handling equipment.

2.4 DRAWINGS: Each bidder will submit a layout drawing showing location of chiller on pads and necessary water piping. Also, submit control prints and parts breakdown.

2.5 Provide air cooled chillers with efficiency and capacity as scheduled on the drawings. The chiller shall be constructed in accordance with the following specifications. The chiller shall also be provided with the following options: (1) Provide factory installed non-fused disconnect switch, (2) Control Transformer.

2.6 REGULATORY REQUIREMENTS FOR CAPACITY AND EFFICIENCY:

2.6.1 Only packaged chillers with AHRI certification shall be accepted. Chiller shall conform to AHRI Standard 550/590 Air-Cooled Water-Chilling Packages.

2.6.2 All proposals for chiller performance must include an AHRI approved selection method. Verification of date and version of computer program selection or catalog must be available.

2.6.3 Conform to ANSI/UL 465 code for construction of water chillers and provide UL label.

2.6.4 Conform to ANSI/ASME SEC 8 Boiler and Pressure Vessel Code for construction and testing of water chillers.

2.6.5 Conform to ANSI/ASHRAE 15 code for construction and operation of water chillers.

2.7 Minimum full load and part load efficiencies are specified on the drawings. DO NOT SUBMIT CHILLERS THAT DO NOT MEET THE SPECIFIED PERFORMANCE REQUIREMENTS.

2.8 COMPRESSOR (SCROLL): The scroll compressor is fully hermetic, direct drive, with intermediate discharge valve, rolling element bearings, differential refrigerant pressure oil pump and oil heater. The motor is a suction gas cooled, hermetically sealed, two pole squirrel cage induction motor. Oil separator and filtration devices are provided separate from the compressor. Check valves in the compressor discharge and lube oil system and a solenoid valve in the lube system are provided. The compressor shall have an hour meter installed on the load side of the compressor contactor. Chiller shall start in unloaded condition. Factory installed hot gas bypass is an acceptable option.

2.9 MOTOR: Provide a hermetic motor selected to operate at 480 volt, 3 phase, 60 hertz, 1750 RPM. The motor shall include the following minimum design standards and accessories: (1) Refrigerant gas cooled, (2) 3-phase inherent overload protection, (3) Motor terminal box above crankcase level to prelude leakage and fouling of electrical connections, (4) Compressor motor assembly factory run and tested prior to shipment.

2.10 EVAPORATOR: Provide high efficiency brazed plate-to-plate type heat exchanger consisting of parallel plates. Braze plates shall be stainless steel with copper braze material. The cooler is to be factory insulated with fiberglass insulation protected with a steel jacket. The cooler shall include the following minimum design standards and accessories: (1) Design working pressure of the cooler water side at 150 psig with 5" IPS raised flanged chilled water piping connector, (2) Design working pressure of the cooler refrigerant side at 460 psig, (3) Thermostat controlled electric heater cable to provide freeze-up protection down to minus 20 degrees Fahrenheit ambient.

2.11 CONDENSER COIL: Provide condenser coils constructed of seamless copper tubes mechanically expanded into aluminum fins. Condenser coil shall include the following minimum design standards and accessories: (1) Design working pressure of the coil at 650 psig, (2) Refrigerant sub-cooling for proper expansion valve operation, (3) Unit to have liquid receiver with pump-down valves.

2.12 CONDENSER FANS: Direct coupling to independent fan motors with vertical air discharge, heavy gauge fan guards, vinyl coated, resilient mounting for vibration free operation. Ultra quiet condenser fans. See scheduled sound performance requirements. Condenser fans shall be single speed.

2.13 CONDENSER FAN MOTORS: Provide totally enclosed air over fan motors with the following minimum design standards and accessories: (1) Squirrel cage type 3-phase motors, (2) permanent split capacitor type single phase motor, (3) inherent motor protection, (4) ball bearing construction, (5) permanent lubrication. Condenser fan motors shall be single speed.

2.14 REFRIGERANT CIRCUIT: Provide a minimum of two independent refrigerant circuits constructed of copper tubing with braised joints and completely insulated suction and liquid lines. The refrigeration circuit shall include the following minimum design standards and accessories: (1) liquid line shut-off valve, (2) charging connection, (3) filter dryer with 100% shut-off valves on inlet and outlet of dryer, use replaceable core type dryer shells (by-pass piping around shell) with gauge access port on dryer shell.

2.15 CONTROL CENTER:

2.15.1 Provide controls and motor staring equipment factory wired and mounted in a fully enclosed cabinet. Provide controls wired to the terminal box suitably marked for field interlock connection. Controls shall include the following minimum design standards and accessories:

2.15.2 Manufacturer to provide interface to TCC specified in Specification Section CONTROLS. Interface to include all hardware necessary to communicate with N2 or BacNet IP protocol. Provide hardware and software identifiers for the interface points, values, units, etc. Provide on-site technical personnel to facilitate the interface with TCC. If the successful chiller vendor elects to utilize BacNet IP, then include in the bid complete installation of CAT5 cabling to the chiller and an IP address- No exceptions!

2.15.3 Additional Control Requirements:

- Suction, discharge, and oil pressure gauges for each refrigerant circuit that can be valved off.
- Oil pressure cutout, with manual reset.
- High pressure cutout, with manual reset.
- Low pressure cutout.
- Freeze protection control with manual reset.
- Cooler heater thermostat.
- Low ambient lock-out temperature control - adjustable (55 degree range).
- Non-recycling pump-down control.
- Provisions for remote alarm.
- On/Off stop switch.
- Control fuses (one box of spare fuses for every fuse in control panel).
- Lead/lag control and system selector switch.
- Control voltage transformer.
- Inlet and outlet thermometers.

2.16 COIL GUARD: Furnish factory installed protective FULL UNIT louvered panels. Painted steel to match unit panels, to protect condenser coils from incidental damage, screen internal components visually, and prevent unauthorized access to internal components.

2.17 CAPACITY CONTROL SYSTEM AND STARTING SEQUENCE:

2.17.1 Each unit shall contain two microcomputer control centers. All controls shall be contained in a NEMA 3R cabinet with hinged outer door including: an attractive inner protective panel with "user-friendly" instructions for unit start-up sequence, data display codes, water cooling range codes, system monitoring or diagnosis and fault codes. Rotary wheel switches shall be provided to select chilled water temperature,

water cooling range, and data to be displayed. Toggle switches shall be provided to select: system 1 or system 2 on-off and Lead/Lag.

2.17.2 Microprocessor control circuitry shall include a large, easy to read 4-digit hexadecimal display capable of displaying the following: return chilled water temperature; leaving chilled water temperature; low leaving water temperature cutout setting, chilled water setpoint; low ambient temperature cutout setting, outside air temperature, System 1 and 2 full load motor current (%), suction pressure, oil pressure, discharge pressure, suction pressure cutout setting; eight (8) water cooling range temperature codes; (11) unit fault codes, three possible System 1 and 2 ten-minute anti-recycle status conditions; remote device (time clock etc.) malfunction; and unit ready to operate status.

2.18 UNIT CONSTRUCTION:

2.18.1 Provide weatherized unit casings for outdoor installation constructed of heavy gauge, zinc coated or galvanized steel, zinc phosphate bonderized with a baked enamel finish. Access panels shall provide complete accessibility to all parts of the unit. Unit panels, control boxes, and structural base shall be baked on powder paint. All painted surfaces shall be coated with baked on powder paint in compliance with ASTMB 117, 1,000 hours, 5% salt spray test yielding a minimum ASTM 1654 rating of 6.

2.18.2 Chilled water flow switch.

2.18.3 Refrigerant R-454B and oil charge with sight glass and moisture indicator.

2.18.4 Low noise sound package to enclose compressors, oil separators and discharge lines. Refer to drawings for sound requirements.

PART 3 – EXECUTION:

3.1 Manufacturer to supply maintenance manuals, troubleshooting guide, parts list, wiring diagrams, all fact sheets on after market problems, and procedures and process for repairing or replacing printed circuit boards for microprocessors. Tools, software keys, hardware and software required to service the units to be supplied and delivered to the Owner. Any manufacturer unwilling to supply this information will be unacceptable.

3.2 SOUND PERFORMANCE VERIFICATION: The chiller shall be installed to meet the sound requirements scheduled on the drawings. The sound levels will be field measured one time by the Test and Balance Contractor. Any additional field modifications require to meet the sound requirements will be at the Contractor’s expense. The Contractor shall also pay the Test and Balance Contractor for any additional expenses necessary to confirm sound compliance.

3.3 WARRANTY:

A. The chiller manufacturer shall provide a complete unit parts and labor warranty for five (5) years from substantial completion.

3.4 EQUIPMENT START-UP: Prior to utilization of equipment, start-up service shall be performed by factory authorized representative. Utilize start-up sheets provided by the manufacturer. Refer to Specification Section COMMON WORK RESULTS FOR HVAC for additional requirements.

3.5 Provide eight (8) hours of onsite training for this system. All training shall occur after building completion. Systems shall function properly, and O&M staff shall be able to operate the system prior to turnover.

END OF SECTION 236423

SECTION 237000 - HVAC EQUIPMENT

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. Each Contractor’s attention is also directed to Specification Section SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC, and provide all documentation called for therein.

C. Each Contractor’s attention is also directed to Specification Section INSTRUMENTATION AND CONTROLS FOR HVAC to determine controls, including variable frequency drives, to be furnished. Where manufacturer’s temperature controls are specified, they shall be in full compliance with NFPA 90A including automatic smoke shut down provisions.

D. Each Contractor’s attention is also directed to Specification Section VARIABLE FREQUENCY MOTOR CONTROLLER to determine, VFDs to be furnished by the contractor.

E. Each Contractor’s attention is also directed to Specification Section TESTING, ADJUSTING, AND BALANCING FOR HVAC. For all belt driven equipment, provide final fan and motor sheaves as determined by the air balance contractor during project balancing phase. The mechanical contractor shall install any new sheaves and belts as required for balancing.

1.2 The Contractor shall provide in complete working order the heating, ventilation and air conditioning equipment located as indicated and installed, connected, and placed in operation in strict accordance with the manufacturer's recommendations. All equipment shall be factory painted and, where applicable, factory insulated and shall, where such standards exist, bear the label of the Underwriters Laboratory.

1.3 All Contractors and Vendors providing a bid for this project shall review the Plans and Specifications and determine any modifications and/or adjustments necessary relative to the proposed equipment and materials with specific manufacturer’s installation requirements. Include in the bid any necessary installation methods, features, options, accessories, etc. necessary to install the proposed equipment and materials, regardless of whether used as basis of design or being offered as a substitution in accordance with the specific manufacturer’s installation requirements whether specifically detailed or not within the Plans and Specifications.

1.4 All equipment, material and labor warranties shall be furnished by the equipment supplier/vendor. All warranties begin on the date of Substantial Completion.

1.5 Refer to Specification Section COMMON WORK RESULTS FOR HVAC for minimum required Schedule of Values breakdown and special warranty requirements.

1.6 All HVAC equipment shall comply with the latest provisions of ASHRAE Standard 90.1 and all provisions of the International Energy Conservation Code.

PART 2 – PRODUCTS:

2.1 Not applicable.

PART 3 – EXECUTION:

3.1 Each subcontractor shall be responsible for their own completion of System Verification Checklists/Manufacturer's Checklists. Factory startup is required for all HVAC equipment. In general, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians and shall complete and submit start-up reports/checklists.

3.2 A 100% complete mockup installation shall be required for a typical unit. This mockup shall be inspected/reviewed by the Engineer prior to installation of other units.

3.3 Any mechanical closet dimension modifications or access requirements due to the manufacturer specifics shall be the burden of the approved manufacturer.

3.4 Ensure that the equipment that is proposed to be furnish may be installed, connected, placed in operation, and easily maintained at the location and in the space allocated for it.

3.5 The contractor and vendor shall confirm connection sides for each piece of equipment specific to this project.

3.6 Provide eight (8) hours of onsite training for this system. All training shall occur after building completion. Systems shall function properly, and O&M staff shall be able to operate the system prior to turnover.

3.7 Determine from the Bid Documents the date of completion of this project and ensure that equipment delivery schedules can be met so as to allow this completion date to be met.

3.8 EQUIPMENT START-UP: Prior to utilization of equipment, start-up service shall be performed by factory authorized representative. Utilize startup sheets included in the Specification Section COMMON WORK RESULTS FOR HVAC. Refer to Specification Section COMMON WORK RESULTS FOR HVAC for additional requirements.

END OF SECTION 237000

SECTION 237313 – INDOOR AIR HANDLING UNITS

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. Each Contractor's attention is also directed to Specification Section SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC, and provide all documentation called for therein.

C. Each Contractor's attention is also directed to Specification Section INSTRUMENTATION AND CONTROLS FOR HVAC to determine controls, including variable frequency drives, to be furnished. Where manufacturer's temperature controls are specified, they shall be in full compliance with NFPA 90A including automatic smoke shut down provisions.

D. Each Contractor's attention is also directed to Specification Section VARIABLE FREQUENCY MOTOR CONTROLLER to determine, VFDs to be furnished by the contractor.

E. Each Contractor's attention is also directed to Specification Section TESTING, ADJUSTING, AND BALANCING FOR HVAC. For all belt driven equipment, provide final fan and motor sheaves as determined by the air balance contractor during project balancing phase. The mechanical contractor shall install any new sheaves and belts as required for balancing.

1.2 SCOPE

A. The Contractor shall provide in complete working order the heating, ventilation and air conditioning equipment located as indicated and installed, connected, and placed in operation in strict accordance with the manufacturer's recommendations. All equipment shall be factory painted and, where applicable, factory insulated and shall, where such standards exist, bear the label of the Underwriters Laboratory.

B. All Contractors and Vendors providing a bid for this project shall review the Plans and Specifications and determine any modifications and/or adjustments necessary relative to the proposed equipment and materials with specific manufacturer's installation requirements. Include in the bid any necessary installation methods, features, options, accessories, etc. necessary to install the proposed equipment and materials, regardless of whether used as basis of design or being offered as a substitution in accordance with the specific manufacturer's installation requirements whether specifically detailed or not within the Plans and Specifications.

C. All equipment, material and labor warranties shall be furnished by the equipment supplier/vendor. All warranties begin on the date of Substantial Completion.

D. All HVAC equipment shall comply with the latest provisions of ASHRAE Standard 90.1 and all provisions of the International Energy Conservation Code.

PART 2 – PRODUCTS:

2.1 ACCEPTABLE MANUFACTURERS: Carrier, JCI/York, Trane.

2.2 Provide factory built and factory tested air handling units of sizes, capacities and configurations as scheduled and as specified herein. Unit layout shall be dual path, providing one path for outside air with all

components arranged in series as specified and providing one path for exhaust air with all components arranged in series as specified.

2.3 Provide factory installed external support kit on the base of the unit. Unit mounting devices not constructed of galvanized steel shall be chemically cleaned, coated with rust-inhibiting primer, and finished with rust inhibiting enamel.

2.4 CASINGS:

A. Unit shall be double wall foam injected constructed in all sections. Foil facing on insulation shall not be acceptable as a substitute for double wall construction. Insulate all sections with 2" thick foam injected insulation, 1 ½ lb per cubic foot density. All panels shall be solid on the interior and exterior. Insulation shall comply with NFPA 90A. Fiberglass insulation shall not be acceptable.

B. Unit shall be constructed of a complete structural frame with removable panels. Removal of all exterior panels shall not affect the structural integrity of the unit. Installing Contractor shall be responsible to provide connection flanges and all other framework that is needed on unit to ensure that removals of unit's panels shall not affect structural integrity.

C. All exterior panels and structural frames shall be constructed of G90-U galvanized steel. Casings not constructed of G90-U galvanized steel, casings with welds on interior and exterior surfaces that have burned through to exterior surfaces shall be chemically cleaned, coated with rust inhibiting primer, and finished with rust inhibiting enamel.

D. Construct casing sections located upstream of the supply fan for operation at 4 inches water gauge negative static pressure and casing sections located downstream of the supply fan for operation at 6 inches water gauge positive static pressure.

E. All joints between exterior panels and structural frames shall have seals and gaskets with closed-cell foam gasketing for air seal and acoustical break.

F. As required for routine service access, unit shall be supplied with full height, galvanized, double wall, hinged, removable access doors. Access door shall have a full perimeter automotive type gasket to prevent air leakage, and Ventlock style handle that can be opened from unit interior. Doors shall open against system pressure. If access doors open against unit operating pressure, provide safety latches that allow access doors to partially open after the first handle movement and fully open after second handle movement. All handles shall operate easily without special tools.

2.5 FAN SECTIONS:

A. Provide fan sections with fan type as specified on drawings designed and suitable for class or service indicated. Fan sections shall have full height, double wall hinged, removable access doors on drive side for inspection and maintenance of internal components. Fan sections with plug fans shall have galvanized expanded metal access door guards to prevent unauthorized entry into fan sections when access doors are opened.

B. Provide variable speed direct drive fans. Design fan shafts so as not to pass through first critical speed when unit comes up to rated RPM. Statically and dynamically balance fan assemblies in fan housing after final assembly.

C. Mount fans on isolation bases. Internally mount motors on same isolation bases and internally isolate fans and motors with a minimum of 2-inch spring isolators. Provide adjustable motor base, adjusted with mounting bolts, to provide variation in center distance. Provide locking nuts, or similar devices, to secure base in proper position. Install flexible canvas ducts between fan and casings to ensure complete isolation. Flexible canvas ducts shall comply with NFPA 90A. Fan and motor assembly shall be weighed at the manufacturer's factory for isolator selection. Vibration shall be measured at each fan shaft bearing in

horizontal, vertical, and axial directions. All fans shall have pillow block bearings with minimum L-50 200,000 hour rating. Provide grease lubricated fan bearings with externally accessible fittings for lubrication. Extend both grease lubrication fittings to drive side of unit with plastic tubes and zerk fittings rigidly attached to drive side bearing support.

D. Motors shall be 3 phase ODP with NEMA frame and 1.15 service factor. Motor base shall be adjustable. Motor brake horsepower shall not exceed scheduled values. Fan brake horsepower shall not exceed 85% of motor horsepower. All motors shall comply with EPACT efficiency requirements. Refer to Specification Section – ELECTRIC MOTORS, ETC. for more requirements. Fan sections controlled by variable frequency drives and shall be factory installed. Refer to Specification Section - CONTROLS for all VFD specification requirements.

2.6 COIL SECTIONS AND DRAIN PANS:

A. Provide double wall casing for coil sections. Inside surfaces of chilled water coil sections exposed to the air stream shall be constructed of stainless steel. Design internal structure of coil section to allow for removal of coils. Provide suitable baffles to assure no air bypass around coils. Condensate drain pans and chilled water coil casing and all fasteners shall be constructed of stainless steel. Insulate coil section casings and drain pans as prior specified.

B. All coils shall be tested at 200 psig air pressure while submerged in water. Coil performance shall be certified in accordance with ARI Standard 410. All coils shall have chilled water coils stainless steel casings. Hot water coils shall have mill galvanized casings. Construct coil headers of round copper pipe or cast iron. Clearly label supply and return headers on the outside of the units such that the direction of coil water flow is counter to the direction of air flow. If two or more coils are stacked in the unit, install intermediate drain pan channels between the coils to drain condensate to main drain pans without flooding lower coils or passing condensate through the air stream.

C. Provide type 304 sealed stainless steel drain pans. Encase insulation between exterior and interior walls. Drain pans shall be sloped in two planes; cross break interior pans and pitch toward drain connections to ensure complete condensate drainage. Drain pans shall be installed under the complete cooling coil section. Units with heating coils shall have a drain pan under the complete heating coil segment to ensure proper drainage during cleaning. All drain pan connections will be to the side of the unit to ensure proper trapping. All drain pan connections will be to the side of the unit to ensure proper trapping. Units without 2-way sloped drain pans shall coat drain pans with anti-microbial treatment.

2.7 FILTERS: Filters shall be 2” thick, 30% efficient Merv 8, pleated and disposable. The filter pressure drop shall be 0.28” at 500 fpm face velocity. Each filter shall consist of a non-woven cotton and synthetic fabric media, media support grid and enclosing frame. The filter shall be listed by Underwriters’ Laboratories as Class 2. Provide filter boxes with either hinged access doors at each end. Provide racks to receive filters in either flat or angle type pattern. Provide air filters to fit in filter box of the type scheduled on the drawings. Sizes and quantities shall be per the manufacturer’s recommendations. Refer to Specification Section COMMON WORK RESULTS FOR HVAC for Temporary Use of Equipment Requirements and filter quantities.

2.8 DAMPERS: Provide internally mounted ultra low leak outside air dampers as specified on drawings. Dampers shall be double-skin airfoil design. Construct damper blades and damper frames of galvanized steel. Blades shall rotate on stainless steel sleeve bearings. Leakage rate shall not exceed 5 CFM/square foot at one inch water gauge and 9 CFM/square foot at 4 inches water gauge.

2.9 FACE AND BYPASS SECTION: Face and bypass section shall include hot and chilled water coil. A horizontal blank off wall shall be factory installed to bypass coil when damper is in the bypass position.

2.10 AIR BLENDER: The air blender shall be constructed of the rotary design with radial blades. Blender shall have the proper distances upstream and downstream to provide minimum mixing effectiveness of 75%

when mixing 50% outdoor air and 50% return air at 50 degree F initial inlet temperature differential. Unit shall mix two or more air streams of different temperatures to within a range of 6 degrees F standard deviation of theoretical mixed air temperature and provide a more uniform air velocity contour entering a downstream filter or coil bank. Construct blender of aluminum. Unit panels shall be double wall construction as specified in the CASINGS paragraph of this section. A hinged access door shall be provided in the air blender section, downstream of the actual blender. The door shall be full height, insulated double-wall, with baked-on enamel dogged fasteners to provide airtight compression of the perimeter gasket. The door shall be lift-off type, removable at hinge pin to provide maximum service access.

PART 3 – EXECUTION:

3.1 Each subcontractor shall be responsible for their own completion of System Verification Checklists/Manufacturer's Checklists. Factory startup is required for all HVAC equipment. In general, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians and shall complete and submit start-up reports/checklists.

3.2 Any mechanical closet dimension modifications or access requirements due to the manufacturer specifics shall be the burden of the approved manufacturer.

3.3 Ensure that the equipment that is proposed to be furnish may be installed, connected, placed in operation, and easily maintained at the location and in the space allocated for it.

3.4 The contractor and vendor shall confirm connection sides for each piece of equipment specific to this project.

3.5 Provide eight (8) hours of onsite training for this system. All training shall occur after building completion. Systems shall function properly, and O&M staff shall be able to operate the system prior to turnover.

3.6 Determine from the Bid Documents the date of completion of this project and ensure that equipment delivery schedules can be met so as to allow this completion date to be met.

3.7 EQUIPMENT START-UP: Prior to utilization of equipment, start-up service shall be performed by factory authorized representative.

END OF SECTION 237313

INDEX

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SECTION 260010 - GENERAL REQUIREMENTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Contractors to reference all design guidelines, standards, and specifications provide by Wake County Public Schools.

B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

C. The Instructions to Bidders, General and Special Conditions, and all other contract documents shall apply to the Contractor's work as well as to each Sub Contractor's work. Each Contractor is directed to familiarize themself in detail with all documents pertinent to this Contract. In case of conflict between these General Provisions and the General and/or Special Conditions, the affected Contractor shall contact the Engineer for clarification and final determination.

D. Each Contractor shall be governed by any alternates, unit prices and Addenda or other contract documents insofar as they may affect their part of the work.

1.2 SUMMARY

A. Section Includes general requirements applicable to work specified in Divisions 26, 27, and 28.

B. The work included in this division consists of the furnishing of all labor, equipment, transportation, supplies, material, and appurtenances and performing all operations necessary for the satisfactory installation of complete and operating Electrical Systems indicated on the drawings and/or specified herein.

C. Any materials, labor, equipment, or services not mentioned specifically herein which may be necessary to complete or perfect any part of the Electrical Systems in a substantial manner, in compliance with the requirements stated, implied, or intended in the drawings and specifications, shall be included as part of this Contract. The Contractor shall give written notice of any materials or apparatus believed inadequate or unsuitable; in violation of laws, ordinances, rules, or regulations of authorities having jurisdiction; and any necessary items of work omitted a minimum of ten days prior to bid. In the absence of such written notice and by the act of submitting a bid, it shall be understood that the Contractor has included the cost of all required items in their bid, and that they will be responsible for the approved satisfactory functioning of the entire system without extra compensations.

D. It is not the intent of this section of the specifications (or the remainder of the contract documents) to make any specific Contractor, other than the Contractor holding the prime contract, responsible to the Owner, Architect and Engineer. All transactions such as submittal of shop drawings, claims for extra costs, requests for equipment or materials substitution, shall be done through the Contractor to the Architect (if applicable), then to the Engineer.

E. This section of the Specifications or the arrangement of the contract documents shall not be construed as an attempt to arbitrarily assign responsibility for work, material, equipment or services to a particular trade Contractor or Sub-Contractor. Unless stated otherwise, the subdivision and assignment of work under the various sections shall be the responsibility of the Contractor holding the prime contract.

F. Any reference within these specifications to a specific entity, i.e., "Electrical Contractor" is not to be construed as an provide to limit or define the scope of work for that entity or assign work to a specific trade

or contracting entity. Such assignments of responsibility are the responsibility of the Contractor holding the prime contract, unless otherwise provided herein.

G. In each of the specifications and drawings referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears.

H. Intent and Interpretation

1. It is the intent of these specifications and all associated drawings that the Contractor provide finished work, tested, and ready for operation. Wherever the word "provide" is used, it shall mean "furnish and install complete, tested and ready for operation."
2. Minor details not usually shown or specified, but necessary for the proper installation and operation, shall be included in the work, the same as if herein specified or shown.
3. It is the intention of the Contract Documents to call for a complete and operational system, including all components, accessories, finish work, etc. as necessary for trouble free operation, tested and ready for operation. Anything that may be required, implied, or inferred by the Contract Documents shall be provided and included as part of the Bid.
4. All Contractors and Vendors providing a bid for this project shall review the Plans and Specifications and determine any modifications and/or adjustments necessary relative to the proposed equipment and materials with specific manufacturer's installation requirements. Include in the bid any necessary installation methods, features, options, accessories, etc. necessary to install the proposed equipment and materials, regardless of whether used as basis of design or being offered as a substitution in accordance with the specific manufacturer's installation requirements whether specifically detailed or not within the Plans and Specifications.
5. The Bidder/Proposer shall completely review the Contract Documents. Any interpretation as to design intent or scope shall be provided by the Engineer/ Architect. Should an interpretation be required, the Bidder/Proposer shall request a clarification not less than ten days prior to the submission of the proposal so that the condition may be clarified by Addendum. In the event of any conflict, discrepancy, or inconsistency develops; the interpretation of the Engineer shall be final.
6. The Contractor shall give written notice of any materials or apparatus believed inadequate or unsuitable; in violation of laws, ordinances, rules, or regulations of authorities having jurisdiction; and any necessary items of work omitted a minimum of ten days prior to bid. In the absence of such written notice and by the act of submitting a bid, it shall be understood that the Contractor has included the cost of all required items in the bid, and that will be responsible for the approved satisfactory functioning of the entire system without extra compensations.

I. Drawings and Specifications

1. The drawings are diagrammatic only and indicate the general arrangement of the systems and are to be followed insofar as possible. If deviations from the layouts are necessitated by field conditions, detailed layouts of the proposed departures shall be submitted in writing to the Engineer for approval before proceeding with the work. The Contract Drawings are not intended to show every vertical or horizontal offset which may be necessary to complete the systems. Contractors shall, however, anticipate that additional offsets may be required and submit their bid accordingly.
2. The drawings and specifications are intended to supplement each other. No Contractor, bidder, proposer, or supplier shall take advantage of conflict between them, or between parts of either, but should this condition exist, the Contractor or supplier shall request a clarification of the condition at least ten days prior to the submission of bids so that the condition may be clarified by Addendum. In the event that such a condition arises after work is started, the interpretation of the Engineer shall be the determining factor. In all instances, unless modified in writing and agreed upon by all parties thereto, the Contract to accomplish the work shall be binding on the affected Contractor.
3. The drawings and specifications shall be considered to be cooperative and complimentary and anything appearing in the specifications which may not be indicated on the drawings or conversely, shall be considered as part of the Contract and must be executed the same as though indicated by both.

4. This Contractor shall make all their own measurements in the field and shall be responsible for correct fitting. They shall coordinate this work with all other branches of work in such a manner as to cause a minimum of conflict or delay.
5. The Engineer shall reserve the right to make minor adjustments in location of conduit, fixtures, outlets, switches, etc., where they consider such adjustments desirable in the interest of concealing work or presenting a better appearance.
6. Each Contractor shall evaluate ceiling heights called for on Architectural Plans and ensure that these heights may be maintained after all mechanical and electrical equipment is installed. Where the location of Electrical equipment may interfere with ceiling heights, the Contractor shall call this to the attention of the Engineer in writing prior to making the installation. Any such changes shall be anticipated and requested sufficiently in advance so as to not cause extra work on the part of the Contractor or unduly delay the work.
7. Should overlap of work between the various trades become evident, this shall be called to the attention of the Engineer. In such an event, neither trade shall assume that he is to be relieved of the work which is specified under his branch until instructions in writing are received from the Engineer.
8. The Electrical drawings are intended to show the approximate location of equipment, materials, etc. Dimensions given in figures on the drawings shall take precedence over scaled dimensions and all dimensions whether given in figures or scaled shall be verified in the field. In case of conflict between small- and large-scale drawings, the larger scale drawings shall take precedence.
9. The Electrical Contractor and their Sub-Contractors shall review all drawings in detail as they may relate to his work (structural, architectural, site survey, mechanical, etc.). Review all drawings for general coordination of work, responsibilities, ceiling clearances, wall penetration points, chase access, fixture elevations, etc. Make any pertinent coordination or apparent conflict comments to the Engineers at least ten days prior to bids, for issuance of clarification by written addendum.
10. Where on any of the drawings a portion of the work is drawn out and the remainder is indicated in outline, or not indicated at all, the parts drawn out shall apply to all other like portions of the work. Where ornament or other detail is indicated by starting only, such detail shall be continued throughout the courses or parts in which it occurs and shall also apply to all other similar parts of the work, unless otherwise indicated.

1.3 COST BREAKDOWN AND PAY APPLICATIONS

A. Within thirty days after acceptance of the Contract, each Contractor is required to furnish to the Engineer one copy of a detailed cost breakdown on each respective area of work. These cost breakdowns shall be made on forms provided or approved by the Engineer or Architect. Payments will not be made until satisfactory cost breakdowns are submitted. Refer to Division 00 and 01 specification sections for additional requirements.

B. In addition to cost breakdowns by specification section, the following shall also be provided: Material and labor shall be listed separately. These items are in addition to items listed in Division 01 specifications. Pay special attention to required withholding percentages for startup, testing, documentation, acceptance, owner training, etc. The breakdown shall be minimally as follows:

1. Permitting
2. Mobilization
3. Electrical Submittals
4. Electrical Coordination Drawings
5. Temporary Power
6. Interior Lighting Materials & Labor
7. Exterior Lighting Materials & Labor
8. Lighting Controls Materials & Labor
9. Lighting and Lighting Controls Startup, Testing, & Verification (equal to 2.5% of Equipment Value)
10. Electrical Distribution Equipment Materials & Labor
11. Electrical Distribution Equipment Startup, Testing, & Verification (equal to 2.5% of Equipment Value)

12. Electrical Distribution Equipment Power System Study & Field Adjusting
13. Feeders Materials & Labor
14. Branch Circuiting Materials & Labor
15. Service Grounding Materials & Labor
16. Surge Suppression Materials & Labor
17. Electrical Devices Materials & Labor
18. Cable Trays Materials & Labor
19. Underground Duct Banks Materials & Labor
20. Fire Alarm Materials & Labor
21. Fire Alarm System Startup, Testing, & Verification (equal to 5% of Equipment Value)
22. Low-Voltage Data/Voice Cabling Materials & Labor
23. Low-voltage Data/Voice Equipment Materials & Labor
24. Audio/Video Equipment and Cabling Materials & Labor
25. Access Controls Equipment and Cabling Materials & Labor
26. CATV Equipment and Cabling Materials & Labor
27. Security Equipment and Cabling Materials & Labor
28. Video Surveillance Equipment and Cabling Materials & Labor
29. Low Voltage Systems Startup, Testing, & Verification (equal to 5% of Equipment Value)
30. Engine Generator System Materials & Labor
31. Automatic Transfer Switches Materials & Labor
32. Engine Generator Systems Startup, Testing, & Verification (equal to 2.5% of Equipment Value)
33. Owner Training
34. Punchlist
35. As-Built/Record Drawings
36. O&M Manuals
37. Warranty
38. Demobilization

1.4 REFERENCES

A. Abbreviations and Acronyms

1. A, AMP: Ampere
2. ADA: Americans with Disabilities Act.
3. AFF: Above Finished Floor
4. AFG: Above Finished Grade
5. AHJ: Authority Having Jurisdiction
6. AHU: Air Handling Unit
7. AIC: Amps Interrupting Capacity
8. ANSI: American National Standards Institute.
9. ASA: American Standards Association.
10. ASTM: American Society for Testing Materials.
11. ASHRAE: American Society of Heating, Refrigeration and Air Conditioning Engineers.
12. ATS: Automatic Transfer Switch
13. A/V: Audio/Visual
14. AWG: American Wire Gauge
15. BAS: Building Automation System
16. BFG: Below Finished Grade
17. BICSI: Building Industry Consulting Services International
18. C: Conduit
19. CB: Circuit Breaker
20. CFCI: Contractor Furnished, Contractor Installed
21. CFOI: Contractor Furnished, Owner Installed
22. CKT: Circuit
23. CLG: Ceiling

24. CT: Current Transformer
25. CM: Construction Manager
26. DDC: Direct Digital Building Controls
27. DOAS: Dedicated Outdoor Air System
28. DWG: Drawing
29. EC: Electrical Contractor
30. ELEV: Elevator
31. EM: Emergency
32. EPO: Emergency Power Off
33. FA: Fire Alarm
34. FAA: Fire Alarm Annunciator
35. FACP: Fire Alarm Control Panel
36. FCC: United States Federal Communications Commission
37. FFE: Finished Floor Elevation
38. FLA: Full Load Amps
39. G, GND: Ground
40. GFCI: Ground Fault Circuit Interrupter
41. GC: General Contractor
42. HOA: Hands Off Auto
43. HP: Horsepower
44. IDF: Intermediate Distribution Frame
45. IECC: International Energy Conservation Code
46. ISO: International Standards Organization.
47. IT: Information Technology
48. KVA: Kilovolt-Amperes
49. KW: Kilowatt
50. KWH: Kilowatts Hours
51. LRA: Locked Rotor Amps
52. LTG: Lighting
53. MC: Mechanical Contractor
54. MCA: Minimum Circuit Ampacity
55. MCB: Main Circuit Breaker
56. MDF: Main Distribution Frame
57. MDP: Main Distribution Panel
58. MLO: Main Lugs Only
59. MOCP: Maximum Overcurrent Protection
60. MSB: Main Switchboard
61. N/A: Not Applicable
62. NEC: National Electrical Code
63. NECA: Standards for Installation.
64. NEMA: National Electrical Manufacturers Association.
65. NESC: National Electrical Safety Code.
66. NFPA: National Fire Protection Association.
67. NIC: Not in Contract
68. NRTL: Nationally Recognized Testing Laboratory
69. NTS: Not to Scale
70. N/A: Not Applicable
71. OFCI: Owner Furnished, Contractor Installed
72. OFOI: Owner Furnished, Owner Installed
73. OSHA: Office of Safety and Health Administration.
74. P: Pole, Poles
75. PC: Plumbing Contractor
76. PIR: Passive Infrared
77. RFI: Request for Information
78. RIO: Rough-in Only
79. RM: Room

80. SPD: Surge Protection Device
81. SS: Stainless Steel
82. SWBD: Switchboard
83. TIA: Telecommunications Industry Association
84. TYP: Typical
85. UL: Underwriters Laboratories, Inc.
86. UON or UNO: Unless otherwise noted.
87. UG: Underground
88. V: Volt, Volts
89. VFD: Variable Frequency Drive
90. W: Watts
91. WG: Wire Guard
92. WP: Weather Proof
93. XFMR: Transformer

B. Definitions

1. Architect: The Architect of Record for the project, if applicable.
2. Basis of Design (BOD): Documentation of primary thought processes and assumptions behind design decisions made to meet design intent. Describes systems, components, conditions, and methods chosen to meet intent.
3. Bidder/Proposer: Any person, agency or entity submitting a proposal to any person, agency, or entity for any part of the work required under this contract.
4. Contract Documents: All documents pertinent to the quality and quantity of work to be performed on this project. Includes, but not limited to: Plans, Specifications, Instructions to Bidders, General and Special Conditions, Addenda, Alternates, Lists of Materials, Lists of Sub-Contractors, Unit Prices, Shop Drawings, Field Orders, Change Orders, Cost Breakdowns, Schedules of Value, Periodical Payment Requests, Construction Manager's Assignments, Architect's Supplemental Instructions, Construction Contract with Owner, etc.
5. Contractor: Any Contractor whether bidding, proposing, or working independently or under the supervision of a General Contractor, Prime Contractor, or Construction Manager and who installs any type of Electrical Work as specified in the Contract Documents.
6. Electrical Contractor: Any Contractor whether bidding or working independently or under the supervision of the entity holding the Prime Contract and who installs any type of Electrical work, such as: power, lighting, television, telecommunications, data, fiber optic, intercom, fire detection and alarm, security, video, underground or overhead electrical, etc.
7. Electrical Sub-Contractor: Each or any Contractor contracted to, or employed by, the Electrical Contractor for any work required by the Electrical Contractor.
8. Engineer: The Consulting Mechanical-Electrical Engineer consulting to the Owner, Architect, or Other, etc.
9. Indicated: Listed in the Specifications, shown on the Plans or Addenda thereto.
10. Install: Install equipment furnished by others in complete working order.
11. Installer: Contractor or another entity engaged by Contractor as an employee, subcontractor, or sub-subcontractor, to perform a particular construction operation, including installation, erection, application, assembly, and similar operations.
12. Furnish: Deliver to the site in good condition and turn over to the Contractor who is to install.
13. Prime Contractor: The Contractor who has been engaged by the Owner in a contractual relationship to accomplish the work.
14. Project: All of the work required under this Contract.
15. Provide: Furnish and install complete, tested, and ready for operation.
16. Start-Up: The activities where systems or equipment are initially tested and operated. Start-up is completed prior to functional testing.
17. Typical: Where indicated repeat this work, method or means each time the same or similar condition occurs whether indicated or not.
18. Vendor: Supplier of equipment.

C. Reference Standards: Contractor is responsible for knowledge and application of current versions of all applicable standards and codes. Contractor shall adhere to the most recent revisions or version adopted by the Authorities Having Jurisdiction, including all relevant changes or addenda at the time of installation.

1. IEEE – Institute of Electrical and Electronics Engineers.
   a. IEEE C2, National Electrical Safety Code
2. NECA – National Electrical Contractors Association.
   a. NECA 1, Standard for Good Workmanship in Electrical Construction
3. NFPA - National Fire Protection Association.
   a. NFPA 70, National Electrical Code (NEC)
4. OSHA - The Occupational Safety and Health Act

1.5 COORDINATION

A. Utility Company Requirements

1. Contact the utility company for specifics on construction of pads, conduit, etc., prior to bidding the work and determine all their requirements. All work shall be in accordance with their standards.
2. Each contractor, prior to bidding the work, is to contact the utility companies (electric and telecommunications) and determine the exact points of extension of all underground services in the field with a representative of each utility company. Also, obtain construction details on manholes, transformer pads, pedestal stub-ups, etc., from each utility company as applicable. Extension points indicated on the plans are approximate and are given for the bidder's information only.
3. The Contractor shall provide the local utility company with a drawing produced by a licensed Land Surveyor or a licensed Engineer and acceptable to the utility that locates the centerline of the service and connection point. Coordinate further requirements with utility company.
4. The Contractor is responsible for all fees, permit costs, etc., from the electrical utility, data, telephone, and cable TV companies. This includes any cost associated with the underground electrical service extension.

B. Coordination with Existing Utilities and Structures

1. The locations of all piping, conduits, cables, utilities, and manholes existing, or otherwise, that are present within the contract construction site, shall be subject to continuous uninterrupted maintenance with no exception unless the Owner of the utility grants permission for temporary interruption.
2. Known utilities and structures as available to the Engineer are shown on the drawings. However, it is additionally required that, prior to any excavation being performed, each Contractor ascertain and mark all utilities or lines that would be endangered by the excavation. Contractor shall bear costs of repairing damaged utilities.
3. If utilities or structures are installed within the construction project boundary, the Contractor shall first probe and make every effort to locate the lines prior to excavating in the respective area.
4. Cutting into existing utilities and services shall be done in coordination with and as designated by the Owner of the utility. The Contractor shall work continuously to restore service(s) upon deliberate or accidental interruption, providing premium time and materials as needed without extra claim to the Owner.
5. The Contractor shall repair to the satisfaction of the Engineer any surface or subsurface improvements damaged during the course of the work unless such improvement is shown to be abandoned or removed.
6. Machine excavation shall not be permitted within ten feet of existing gas or fuel lines. Hand excavate only in these areas, in accord with utility company, agency or other applicable laws, standards or regulations.
7. Protect all new or existing lines from damage by traffic, etc. during construction.

8. Protect existing trees, indicated to remain with fencing or other approved method. Hold all new subsurface lines outside the drip line of trees, offsetting as necessary to protect root structures. Refer to planting or landscaping plans, or in their absence, consult with the Architect.

C. Coordination Between Trades

1. The Contractor is expressly directed to read the General Conditions and all detailed sections of these specifications for all other trades and to study all drawings applicable to their work, including Architectural, Mechanical, Structural, and other pertinent Drawings, to the end that complete coordination between trades will be affected.
2. The Contractor is responsible for the correct location of all rough-in and connections at every piece of equipment. Work not correctly located shall be relocated at the Contractor's expense.
3. It shall be the responsibility of each Contractor to leave the necessary room for other trades. No extra compensation or time will be allowed to cover the cost of removing fixtures, devices, conduit, ducts, etc. or equipment found encroaching on space required by others.
4. Where any work is to be installed in close proximity to, or will interfere with work of other trades, each shall cooperate in working out space conditions to make a satisfactory adjustment. If directed by the Engineer, the Contractor shall prepare composite working drawings and sections at a suitable scale not less than ¼ inch = 1 Foot, clearly indicating how his work is to be installed in relation to the work of other trades, or so as not to cause any interference with work of other trades. The Contractor shall make the necessary changes in his work to correct the condition without extra charge.
5. The Contractor shall furnish to other trades, as required, all necessary templates, patterns, setting plans, and shop details for the proper installation of work and for the purpose of coordinating adjacent work.

D. Temporary Services

1. The Contractor shall arrange for temporary electrical and other services required to accomplish the work. In the absence of other provisions in the contract, the Contractor shall provide for temporary services of all types, including the cost of connections, utility company fees, construction, removal, etc., in their bid.
2. All temporary services shall be removed by Contractor prior to acceptance of work.

E. Temporary Use of Equipment

1. The permanent electrical equipment, when installed, may be used for temporary services, subject to an agreement among the Contractors involved, the Owner, and with the consent of the Engineer. Should the permanent systems be used for this purpose, each Contractor shall pay for all temporary connections required and any replacements required due to damage without additional cost to the Owner, leaving the equipment and installation in "as new" condition. The Contractor may be required to bear utility costs, user fees, etc.
2. Permission to use the permanent equipment does not relieve the Contractors who utilize this equipment from the responsibility for any damages to the building construction and/or equipment which might result from its use.

F. Preinstallation Conference

1. Conduct a preinstallation conference at project site before each construction activity when required by other Sections and when required for coordination with other construction.
2. Attendees: Installer and representatives of manufacturers and fabricators involved in or affected by the installation and its coordination or integration with other materials and installations that have preceded or will follow, shall attend the meeting. Advise Architect and Engineer of scheduled meeting dates.
3. Agenda: Review progress of other construction activities and preparations for the particular activity under consideration, including any possible conflicts, requirements, limitations, and coordination with other work.

4. Record significant conference discussions, agreements, and disagreements, including required corrective measures and actions.
5. Reporting: Distribute minutes of the meeting to each party present and to other parties requiring information.
6. Do not proceed with installation if the conference cannot be successfully concluded. Initiate whatever actions are necessary to resolve impediments to performance of the Work and reconvene the conference at earliest feasible date.

1.6 SUBMITTALS

A. Review of submittals by the Engineer applies only to conformance with the design intent of the project and general compliance with the information given in the contract documents. In all cases, the installing Contractor alone shall be responsible for furnishing the proper quantity of equipment and/or materials required, for seeing that all equipment fits the available space in a satisfactory manner and that piping, electrical and all other connections are suitably located.

B. The Engineer's review of submittals, schedules or other required submittal data shall not relieve the Contractor from responsibility for the adaptability of the equipment or materials to the project, compliance with applicable codes, rules, regulations, information that pertains to fabrication and installation, dimensions and quantities, electrical characteristics, and coordination of the work with all other trades involved in this project.

C. If a submittal deviates from the drawings or specifications because of Contractor’s standard practice, approved substitution request, or any other reason, the submittal shall notify the designer of the deviation.

D. Prior to the start of work the contractor shall submit the following. Work shall not proceed without the Engineer’s and Owner’s completed review of the submitted items.

E. Product Data: Collect information into a single submittal for each element of construction and type of product or equipment.

1. If information must be specially prepared for submittal because standard published data are unsuitable for use, submit as Shop Drawings, not as Product Data.
2. Clearly and precisely mark red notations and yellow highlights on the submittal to show which products and options are applicable.
3. Include the following information, as applicable:
    a. Manufacturer's catalog cuts.
    b. Manufacturer's product specifications.
    c. Standard color charts.
    d. Statement of compliance with specified referenced standards.
    e. Testing by recognized testing agency.
    f. Application of testing agency labels and seals.
    g. Notation of coordination requirements.
    h. Rated capacities, operating characteristics, and electrical characteristics,
    i. Wiring diagrams that show factory-installed wiring and interface points.
    j. Clearances required to other construction, if not indicated on accompanying Shop Drawings.
4. Format and Organization: submit bookmarked electronic PDF files complying with the following:
    a. Cover: Clearly display the following information: Owner name, Project name, Submittal name, project submittal number, Contractor name and contact information, and applicable specification section numbers.
    b. Table of Contents: Include a TOC that lists materials by section number, with a brief product description, manufacturer, and part number, and list the submittal page number per product
    c. Product Information

F. Product Schedules: As required in individual Specification Sections, prepare a written summary indicating types of products required for the Work and their intended location. Include the following information in tabular form:

1. Type of product. Include unique identifier for each product indicated in the Contract Documents or assigned by Contractor if none is indicated.
2. Manufacturer and product name, and model number if applicable.
3. Number and name of room or space.
4. Location within room or space.

G. Shop Drawings: Prepare Project-specific information, drawn accurately to scale.

1. Shop Drawings that are reproductions of the Contract Documents are not permitted and will be rejected.
2. Preparation: Fully illustrate requirements in the Contract Documents. Include the following information, as applicable:

a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
b. Mounting Details
c. Wiring diagrams and installation details
d. Identification of products.
e. Schedules.
f. Compliance with specified standards.
g. Notation of coordination requirements.
h. Notation of dimensions established by field measurement.
i. Seal and signature of professional engineer if specified.

H. Coordination Drawings:

1. Detailed electronic coordination drawings shall be required for this project. The Engineer and the Engineer's Construction Administrator shall closely monitor progress and quality of the preparation of the electronic coordination drawings and may withhold pay requests as deemed appropriate.
2. Coordination Drawings shall be provided on this project by each Trade. Drawings shall be 30x42 sheet size and shall be at ¼-inch scale and shall match the drawing setup as included in the Architectural Drawings. Drawings shall be prepared in electronic format utilizing AutoCad software. The Architect and Engineer will supply electronic drawings files of the Contract Documents upon the Contractor's request and release.
3. The basis for the Coordination Drawings shall be the sheet metal ductwork fabrication shop drawings, all electrical feeder conduits, groupings of branch circuit conduits, other conduits 2" and larger, and pneumatic tube system piping and components in ceiling spaces. These drawings shall indicate all ductwork as double lined with bottom elevations noted. The Coordination Drawings shall indicate:
   a. Systems above ceilings in finished areas,
   b. Systems supported from the structure in finished areas without ceilings,
   c. Systems in the mechanical rooms, and
   d. All wall, roof, floor penetrations.
4. The sheet metal fabrication shop drawings shall be completed in a timely manner so as not to conflict with construction schedule and phasing plan. At the Prime Contractor's discretion, these drawings shall be completed in phases to correspond with the project construction work sequencing. The Mechanical Contractor shall furnish an electronic copy of these ductwork shop drawings to all other Trades, specifically the Fire Protection and Electrical and other Contractors as requested by the Prime Contractor for the purpose of including other trades work on the Coordination Drawings.
5. Pre-Coordination Meetings with all necessary trades shall occur. During these meetings, the Contractors shall discuss locations/elevations where piping, conduits, cable path, etc. will be installed with respect to the sheet metal fabrication drawings and other trades. The sheet metal ductwork and gravity piping systems shall be given the first priority. Within 30 days of the meeting, each Trade shall provide the Mechanical Contractor electronic drawings of all of their systems (with

elevation noted), coordinated with the ductwork and other trades for them to incorporate into the Coordination Drawings. Coordination Meetings shall then occur so that all conflicts can be resolved between Trades. All conflicts shall be resolved between all Trades at these Coordination Meetings and the Mechanical Contractor shall then amend the Drawings to include the Final Coordinated Work.

6. It is realized that not all systems can be completely detailed. The coordination drawings shall include the following at a minimum:
   a. All supply/return/exhaust ductwork.
   b. All above slab sanitary and roof drainage piping.
   c. HVAC, fire protection and domestic water piping which are 2" in size and greater, excluding insulation.
   d. Gas mains.
   e. Electrical conduits which are 1.5" in size and greater.
   f. J-hook and cable tray cabling paths
   g. Groupings of smaller piping/conduits hung on a common hanger.
   h. All wall, roof, floor penetrations.
   i. Light fixtures.
7. After completion of the Final Coordination Drawings, a Final Review with all Trades shall occur to provide any final comments and approval by all Trades. Other interim coordination meeting will be required to ensure successful coordination drawings. Any additional coordination items will be updated by the Mechanical Contractor. The Final Approved Coordination Drawings shall be distributed electronically (on CD) to each Trade by the Mechanical Contractor. The Mechanical Contractor shall also furnish a complete 30x42 paper set of drawings to the jobsite main office and shall utilize them for updates of field conditions/deviations that occur during construction. Final Approved Coordination Drawings shall also be distributed to the Construction Manager, Owner, Architect and Engineer for their Records. This process shall be completed prior to starting any work.
8. Each Contractor shall ensure that any deviations from the Coordination Drawings are recorded as they occur, in red erasable pencil on record drawings kept at the jobsite. Upon completion of a particular phase, the Mechanical Contractor shall incorporate all field deviations into the Coordination Drawings to be utilized as Record Drawings. The Engineer shall review the Record Documents from time to time to ensure compliance with this specification. Compliance shall be a contingency of final payment. Also, pay particular attention to Deviations in the Control Systems and all exterior utilities. Keep information in a set of drawings set aside at the job site especially for this purpose. The Record Drawings shall be distributed electronically (on CD) to the Construction Manager, Owner, Architect and Engineer for their Records.
9. The Mechanical Contractor is responsible to the Prime Contractor for the shop drawing layout of the following rooms and details:
   a. Concrete pads and foundations
   b. Equipment room layouts with actual equipment
   c. Roof layouts
   d. Trench locations and sizes
   e. Dimensioned floor drain locations
   f. Congested areas above ceilings adjacent to mechanical and electrical rooms
   g. Dimensioned ductwork shop drawings
10. The Electrical Contractor is responsible to the General Contractor for the shop drawing layout of the following rooms and details:
   a. Concrete pads and foundations
   b. Equipment room layouts with actual equipment
   c. Routes of feeder conduits and all other conduits 1.5" and larger
   d. J-hook and cable tray cabling paths
   e. Trench locations and sizes
   f. Congested areas above ceilings adjacent to mechanical and electrical rooms
   g. Light fixture locations
   h. Exact layouts of all work in open ceiling areas

I. Qualification Data: Prepare written information that demonstrates capabilities and experience of firm or person. Include lists of completed projects with project names and addresses, contact information of architects and owners, and other information specified.

J. Closeout Submittals

1. Upon substantial completion of the project, provide a minimum of three bound copies with complex index and tabs to locate each item described below along with digital copy in PDF format on USB storage media.
2. As-Built Record Documentation
   a. The Contractor shall insure that any deviations from the design are being recorded daily, as necessary, on record drawings being maintained by the Contractor. Dimensions from fixed, visible permanent lines or landmarks shown in vertical and horizontal ways shall be utilized. Compliance shall be a requirement for final payment. Pay particular attention to the location of underfloor or underground exterior in-contract or utility-owned or leased service lines, main switches, and other appurtenances important to the maintenance and safety of the Electrical System. Deliver these record drawings to the Engineer as a system is completed, within ten days of the mark-up and/or while the accuracy of the mark-ups can be verified visually. Monthly payment may be withheld if the requirement is not complied with.
   b. At substantial completion, such changes to be included in the record as-built drawings shall be neatly recorded with red ink by the contractor on an unused set of contract drawing prints supplied by the Designer. Red line changes shall be reviewed by the Designer who shall modify all contract documents to reflect and incorporate all field changes.
   c. All underground utilities/piping installed as part of this project shall be surveyed by a land surveyor licensed in the State where the Work is being performed. This shall include underground electrical primary, communications, and structures. The survey shall include actual duct bank depths to top of conduit every 100 feet in length. The survey shall also include benchmarks dimensions relative to above grade, fixed structures. The survey shall be furnished on electronic storage media in AutoCad ".dwg" format and ".pdf" format. The survey information shall be included in the closeout documentation.
   d. Refer to additional record drawing requirements within the general conditions and other sections of these specifications.
3. Start-Up and System Testing Certificates
   a. Provide reports from all required testing to indicate procedures followed and complete results of all tests. Provide reports on manufacturer's standard forms for all equipment and system tests. Testing reports shall indicate applicable NEC, NFPA, UL, NETA, and/or ANSI standards.
4. Operation and Maintenance Manuals
   a. Provide operation and maintenance instructions and parts lists for all equipment provided in this contract. Formatting and content shall follow the guidelines outlined in CSI Master Format 2004.
   b. The contractors shall deliver one complete set of bookmarked manuals in electronic PDF format of all operation and maintenance manuals to the Owner through the Designer, two (2) weeks before the pre-final inspection is held. The manuals shall be bookmarked to a minimum of one level – ie: each major piece of equipment (chiller, boiler switchboard, water closet, water heater, etc.) or document category (warranties, parts list, contact information, etc.) The manuals shall be delivered by one of the following: USB Drive, CD/DVD, or downloadable file from FTP site.
   c. The operation and maintenance document directory should provide easy access and be well organized and clearly identified.
   d. The operation and maintenance manuals shall contain the following information:
      1) Emergency information should be immediately available during emergencies and should include emergency and staff and/or agency notification procedures.
      2) Provide contacts (company name, address, phone number, email) where parts may be purchased for each principal item of equipment.

3) Provide detailed maintenance instructions, including recommended preventative maintenance schedules for all equipment requiring maintenance. For lighting and lighting controls, provide recommended driver replacement schedule, provide a schedule for inspecting and recalibrating lighting controls, and provide a recommended settings list for all components with adjustable settings.
4) General Information. Provide the following:
   a) Index and page numbers
   b) Certificate of Substantial Completion
   c) Building function
   d) Building description
   e) Operating standards and logs
5) Technical Information. Provide the following:
   a) System description
   b) Operating routines and procedures – including sequence of events, emergency procedures, and other critical items
   c) Seasonal start-up and shutdown
   d) Special procedures and inspection reports
   e) Basic troubleshooting
   f) Certified Test and Balance Report
6) Equipment data sheets. Provide the following:
   a) Vendor and local representative's contact information including names, addresses, and phone numbers
   b) Operating and nameplate data
   c) Warranty
   d) Detailed operating instructions.
   e) Tools required
   f) Types of cleaners to use
7) Maintenance program information. Provide the following:
   a) Manufacturer's installation, operation, and maintenance instructions
   b) Spare parts information
   c) Preventive maintenance actions, including lubrication schedules and types of lubricant
   d) Schedule of actions
   e) Action description
   f) History
8) Test reports document observed performance during start-up and commissioning.
9) Reference Division 01 specifications for additional requirements.

e. Shop drawings will not be accepted as satisfying the requirement for Operation and Maintenance Manuals.
f. Submittals: Provide complete copies of all reviewed submittals. Where submittals were returned "Furnish as Corrected", the contractor shall make the corrections noted by the engineer and submit final corrected shop drawings with close-out documentation.
g. Parts List: Provide an inventory of all spare parts, special tools, attic stock, etc. that have been provided to the owner.

5. Warranty Documentation: Provide all documentation and certificates related to Contractor's warranty and all other specific manufacturer's warranties indicated in the construction documents, including a summary sheet of warranty expiration dates noted.
6. Training Verification: Provide certification that all specified training has been completed. List training session dates, times, and types. Include any session materials and recordings.
7. Inspection Certificates: Provide certificates of inspection from electrical inspector, fire marshal, and any other required special inspections.
8. Reports and System Certifications: Provide final reports and any system certifications required in other specification sections.
9. Power Riser Diagram: Provide a framed and mounted full-size copy of the overall power riser diagram (under glass) to the Owner. Also, provide three vinyl-coated copies of same. Where an existing power riser diagram is present, the Contractor shall obtain the document from the Owner,

and update in digital format with the scope of this project. Edits shall be in digital format and this work shall be closely coordinated with the Owner.

10. Software and Firmware Operational Documentation: Provide documentation, including the following:
    a. Software operating and upgrade manuals.
    b. Names, versions, and website addresses for locations of installed software.
    c. Device address list.
    d. Printouts of software application and graphic screens.
11. Software Back-ups: Provide software back-ups on USB media that is clearly and permanently labeled and provided with lanyard to prevent misplacement.

1.7 MAINTENANCE MATERIAL

A. Spare Parts and Extra Stock Material

1. Parts and Materials shall be properly marked and packaged for long term storage.

B. Special Tools and Keys:

1. Provide, along with the equipment provided, any special wrenches or tools necessary to dismantle or service equipment or appliances.
2. Wrenches shall include necessary keys, handles and operators for valves, switches, breakers, etc. and keys to electrical panels, emergency generators, alarm pull boxes and panels, etc.
3. Provide at least two of any such special wrench, keys, etc. to the Owner prior to completion of the project. Obtain a receipt that this has been accomplished and forward a copy to the Architect and Engineer.

1.8 QUALITY ASSURANCE

A. Manufacturer Qualifications: Manufacturer shall be a firm engaged in the manufacture of specified products of types and sizes required, and whose products have been in satisfactory use in similar service for a minimum of five years unless otherwise approved.

1. The manufacturer shall have a valid ISO 9001 certification and an applicable quality assurance system that is regularly reviewed and audited by a third-party registrar. Manufacturing, inspection, and testing procedures shall be developed and controlled under the guidelines of the quality assurance system.
2. Equipment shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

B. Installer Qualifications

1. All Electrical Contractors bidding this project must have been a licensed company for a minimum of three years to qualify to bid this project. Individual employee experience does not supersede this requirement.
2. All subcontractors bidding the electrical work must have completed one project of 70 percent this subcontract cost size and two projects of 50 percent this subcontract cost size.
3. All electrical work shall be accomplished by qualified workers competent in the area of work for which they are responsible. Untrained and incompetent workers as evidenced by their workmanship shall be relieved of their responsibilities in those areas. The Engineer shall reserve the right to determine the quality of workmanship of any worker and unqualified or incompetent workers shall refrain from work in areas not satisfactory to them. Requests for relief of a worker shall be made through the normal channels of responsibility established by the Architect or the contract document provisions.

4. All electrical work shall be accomplished by Journeymen electricians under the direct supervision of a licensed Electrician.
5. Special electrical systems, such as Fire Alarm Systems, Telecommunications or Data Systems, Video Systems, Special Electronic Systems, Control Systems, etc., shall be installed by workers normally engaged or employed in these respective trades. Refer to Divisions 27 and 28 for additional requirements.

C. Licensed Professional Engineer Qualifications: Professional Engineer possessing active qualifications in accordance with Division 01 and licensed by the State in which the Work is being performed.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Do not deliver or install indoor equipment until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above equipment is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.10 FIELD CONDITIONS

A. Ambient Conditions:

1. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
   a. Ambient Temperature: Not exceeding 104 deg F.
   b. Altitude: Not exceeding 6600 feet.

1.11 WARRANTIES

A. Contractor Warranty: Contractor shall unconditionally guarantee all equipment, apparatus, materials, and workmanship entering into this Contract to be the best of its respective kind and shall replace all parts at their own expense, which fail or are proven defective within one year from Substantial Completion of the work by the Engineer. All work shall be fully warranted for one year from the date of substantial completion by the contractor, who shall replace any defective materials and repair any defective workmanship. The effective date of completion of the work shall be the date each or any portion of the work is accepted by the Architect, Engineer, and Owner’s Statement of Substantial Completion.

B. Manufacturer Warranty: Items of equipment which have longer guarantees, as called for in these specifications or as otherwise offered by the manufacturer shall have warranties and guarantees completed in order and shall be in effect at the time of final acceptance of the work by the Engineer. The Contractor shall present the Engineer with such warranties and guarantees at the time of final acceptance of the work. The Owner reserves the right to use equipment installed by the Contractor prior to date of final acceptance. Such use of equipment shall in no way invalidate the guarantee except that the Owner shall be liable for any damage to equipment during this period due to negligence of his operator or other employee.

C. The Warranties specified herein, and other Sections shall not deprive the Owner of other rights the Owner may have under provisions of the Contract Documents and shall be in addition to and run concurrently with other warranties made by the Contractor under requirements of the Contract Documents.

1.12 INDEMNIFICATION

A. The Contractor shall hold harmless and indemnify the Engineer, employees, officers, agents and consultants from all claims, loss, damage, actions, causes of actions, expense and/or liability resulting from, brought for, or on account of any personal injury or property damage received or sustained by any person, persons,

(including third parties), or any property growing out of, occurring, or attributable to any work performed under or related to this contract, resulting in whole or in part from the negligence of the Contractor, any subcontractor, any employee, agent or representative.

1.13 HAZARDOUS MATERIALS

A. The Contractor is hereby advised that it is possible that asbestos and/or other hazardous materials are or were present in this building(s). Any worker, occupant, visitor, inspector, etc., who encounters any material of whose content they are not certain shall promptly report the existence and location of that material to the Contractor and/or Owner. The Contractor shall, as a part of their work, ensure their workers are aware of this potential and what they are to do in the event of suspicion. The Contractor shall also keep uninformed persons from the premises during construction. Furthermore, the Contractor shall insure that no one comes near to or in contact with any such material or fumes therefrom until its content can be ascertained to be non-hazardous.

B. CMTA, Inc., Consulting Engineers, have no expertise in the determination of the presence of hazardous materials. Therefore, no attempt has been made by them to identify the existence or location of any such material. Furthermore, CMTA nor any affiliate thereof will neither offer nor make any recommendations relative to the removal, handling, or disposal of such material.

C. If the work interfaces, connects or relates in any way with or to existing components which contain or bear any hazardous material, asbestos being one, then, it shall be the Contractor's sole responsibility to contact the Owner immediately.

D. The Contractor by execution of the contract for any work and/or by the accomplishment of any work thereby agrees to bring no claim relative to hazardous materials for negligence, breach of contract, indemnity, or any other such item against CMTA, its principals, employees, agents, or consultants. Also, the Contractor further agrees to defend, indemnify, and hold CMTA, its principals, employees, agents, and consultants, harmless from any such related claims which may be brought by any subcontractors, suppliers or any other third parties.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency suitable to the AHJ, and marked for intended location and application.

B. Materials used shall present no environmental or toxicological hazards as defined by current industry standards and shall comply with OSHA and EPA standards, other applicable federal, state, and local laws.

C. Standard Products

1. Except where specifically noted otherwise, all equipment supplied by the Contractor shall be the standard products of a single manufacturer of known reputation and experience in the industry.
2. Only equipment, components, and accessories in current production for at least five years beyond the completion date of this system shall be used and installed. Any equipment found to be obsolete or not in future production will be removed and replaced at Contractor’s expense. This includes all equipment, materials, and labor.
3. Products manufactured more than 2 years prior to date of delivery to site shall not be used, unless specified otherwise.

D. Product numbers are subject to change by the manufacturer without notification. In the event a product number is invalid or conflicts with the written description, notify the Engineer in writing prior to ordering the material and performing installation work.

2.2 PRODUCT SUBSTITUTIONS

A. Conform to the substitutions requirements and procedures outlined in Division 01.

B. One substitution for each product specified will be considered and substitutions must be submitted to Engineer a minimum of 10 days prior to bid using the standard CSI substitution request form.

C. If prevailing laws of cities, towns, states, or countries are more stringent than these specifications regarding such substitutions, then those laws shall prevail over these requirements.

D. Where products are noted as "or equal", a product of equivalent design, manufacture, and performance will be considered. Submit product data (product information, catalog cut sheets, test data, etc.) to substantiate that the product is in fact equivalent to that specified. The burden of proof that the substituted product is equivalent to the specified product rests with the Contractor. Whenever material, process or equipment is specified in accordance with an industry specification (ANSI, TIA, etc.), UL rating, or other association standard, present an affidavit from the manufacturer certifying that the product complies with the particular standard specification. When requested by the Engineer, submit supporting test data to substantiate compliance.

E. Manufacturers' names and model numbers used in conjunction with materials, processes or equipment included in the contract documents are used to establish standards of quality, utility and appearance and shall not be construed as limiting competition. Materials, processes, or equipment that, in the opinion of the Engineer, are equivalent in quality, utility and appearance will be approved as substitutions to that specified when “or equal” follows the manufacturers' names or model number(s).

F. When the Engineer accepts a substitution in writing, it is with the understanding that the Contractor guarantees the substituted product, component, article, or material to be equivalent to the one specified and dimensioned to fit within the construction according to contract documents. Do not provide substituted material, processes, or equipment without written authorization from the Engineer. Assumptions on the acceptability of a proposed substitution, prior to acceptance by the Engineer, are at the sole risk of the Contractor.

G. Approved substitutions shall not relieve the Contractor of responsibilities for the proper execution of the work, or from provisions of the specifications.

H. Contractor shall pay expenses, without additional charge to the Owner, in connection with substitution materials, processes and equipment, including the effect of substitution on their work or other Contractor's work.

I. In all cases where substitutions affect other trades, the Contractor offering such substitutions shall advise all such Contractors of the change and shall reimburse them for all necessary changes in their work. Any Drawings, Specifications, Diagrams, etc., required to describe and coordinate such substitutions or deviations shall be professionally prepared at the responsible Contractor's expense. Review of Shop Drawings by the Engineer does not absolve the Contractor of this responsibility.

J. Contractor shall be responsible and assume all costs for removal and replacement of any substituted product installed without prior written approval. Such costs shall include, but not be limited to labor, materials as well as any penalties, fees or costs incurred for late completion.

PART 3 - EXECUTION

3.1 INSTALLERS

A. Supervision of Work: Each Contractor and Sub-Contractors shall personally supervise the work or have a competent superintendent on the project site at all times during progress of the work, with full authority to act in matters related to the project.

B. Conduct of Workmen: The Contractor shall be responsible for the conduct of all workmen under their supervision. Misconduct on the part of any workmen to the extent of creating a safety hazard, or endangering the lives and property of others, shall result in the prompt relief of that workman. The consumption or influence of alcoholic beverages, narcotics or illegally used controlled substances on the jobsite is strictly forbidden. Possession of a fire-arm is prohibited and may result in prosecution. Foul or bad language, graffiti is strictly prohibited. Display of nude tattoos is prohibited.

C. No tobacco use, including smokeless tobacco, is allowed on property.

3.2 EXAMINATION

A. Each Contractor shall inform themself of all of the conditions under which the work is to be performed, the site of the work, the structure of the ground, the obstacles that may be encountered, the availability and location of necessary facilities and all relevant matters concerning the work. All Contractors shall carefully examine all Drawings and Specifications and inform themselves of the kind and type of materials to be used throughout the project and which may, in any way, affect the execution of their work.

B. Each Contractor shall fully acquaint themself with all existing conditions as to ingress and egress, distance of haul from supply points, routes for transportation of materials, facilities and services, availability of temporary or permanent utilities, etc. The Contractor shall include in their work all expenses or disbursements in connection with such matters and conditions. Each Contractor shall verify all work shown on the drawings and conditions at the site and shall report in writing to the Engineer ten days prior to bid, any apparent omissions, or discrepancies in order that clarifications may be issued by written addendum. No allowance is to be made for lack of knowledge concerning such conditions after bids are accepted.

3.3 PREPARATION

A. Surveys, Measurements, and Grades

1. The Contractor shall lay out their work and be responsible for all necessary lines, levels, elevations, and measurements. They must verify the figures shown on the drawings before laying out the work and will be held responsible for any error resulting from their failure to do so.
2. Base all measurements, both horizontal and vertical from established bench marks. All work shall agree with these established lines and levels. Verify all measurements at site and check the correctness of same as related to the work.
3. Should the Contractor discover any discrepancy between actual measurements and those indicated, which prevents following good practice or the intent of the drawings and specifications, they shall notify the Engineer through normal channels of job communication and shall not proceed with his work until they have received instructions from the Engineer.

3.4 INSTALLATION

A. At no time shall the contractor work on energized electrical equipment. Contractor shall comply with NFPA 70E requirements at all times throughout construction.

B. Permits and Fees

1. The Contractor shall give all necessary notices, obtain, and pay for all permits, government sales taxes, fees, and other costs in connection with their work. As necessary, the Contractor shall file all required plans, utility easement requests and drawings, survey information on line locations, load calculations, etc., prepare all documents and obtain all necessary approvals of all utility and governmental departments having jurisdiction; obtain all required certificates of inspection for their work and deliver same to the Engineer before request for final acceptance and final payment for the work.
2. Ignorance of Codes, Rules, regulations, utility company requirements, laws, etc., shall not diminish or absolve Contractor's responsibilities to provide and complete all work in compliance with such.

C. Codes and Regulations

1. The Contractor shall include in the work, without extra cost, any labor, materials, services, apparatus, or drawings required in order to comply with all applicable laws, ordinances, rules, and regulations, whether or not shown on drawings and/or specified.
2. All materials furnished and all work installed shall comply with the adopted edition of the National Electrical Codes, National Fire Codes of the National Fire Protection Association, the requirements of local utility companies, and with the requirements of all governmental agencies or departments having jurisdiction.
3. All electrical work is to be constructed and installed in accordance with plans and specifications which have been approved in their entirety and/or reflect any changes requested by the AHJ, as applicable or required. Electrical work shall not commence until such plans are in the hands of the Electrical Contractor.
4. The Contractor shall insure their work is accomplished in accord with OSHA Standards and any other applicable government requirements.
5. Where conflict arises between any code and the contract documents, the code shall apply except in the instance where the plans and specifications exceed the requirements of the code. Any changes required as a result of these conflicts shall be brought to the attention of the Engineer at least ten working days prior to bid date, otherwise the Contractor shall make the required changes at their own expense. The provisions of the codes constitute minimum standards for wiring methods, materials, equipment and construction and compliance therewith will be required for all electrical work, except where the drawings and specifications require better materials, equipment, and construction than these minimum standards, in which case the drawings and specifications shall be the minimum standards.

D. Materials and Workmanship

1. All electrical equipment, materials and articles incorporated in the work shall be new and of equal quality to the specified basis of design. All workmanship shall be first-class and shall be performed by electricians skilled and regularly employed in their respective trades.
2. The Contractor shall determine that the equipment he proposes to furnish can be brought into the building(s) and installed within the space available. All equipment shall be installed so that all parts are readily accessible for inspection, maintenance, replacement, etc. Extra compensation will not be allowed for relocation of equipment for accessibility or for dismantling equipment to obtain entrance into the building(s).
3. All fixtures, devices and wiring required shall be installed to make up complete systems as indicated on the drawings and specified herein.
4. All electrical materials, equipment and appliances shall conform to the latest standards of the National Electric Manufacturers Association (NEMA) and the National Board of Fire Underwriters (NBFU) and shall be approved by the Owner's insuring agency if so required.
5. Comply with National Electrical Contractors Association (NECA) performance standards that are published as National Electrical Installation Standards (NEIS).
6. All applicable equipment and devices provided shall meet all FCC requirements and restrictions.

E. Weatherproofing

1. Where any work penetrates waterproofing, including waterproof concrete, the method of installation shall be as approved by the Architect and/or Engineer before work is done. The Contractor shall furnish all necessary sleeves, caulking and flashing required to make openings absolutely watertight.
2. Wherever work penetrates roofing, it shall be done in a manner that will not diminish or void the roofing guarantee or warranty in any way. Coordinate all such work with the roofing installer.

F. Equipment Access

1. The Contractor shall be responsible for the sufficiency of the size of shafts and chases, the adequate clearance in partitions and above suspended ceilings for the proper installation of their work. Cooperate with the Prime Contractor and all other Contractors whose work is in the same space and advise each Contractor of equipment requirements. Such spaces and clearances shall be kept to the minimum size required to ensure adequate clearance and access.
2. The Contractor shall locate all equipment which must be serviced, operated, or maintained in fully accessible positions. Equipment shall include but not be limited to junction boxes, pull boxes, contactors, panels, disconnects, controllers, switchgear, etc. Minor deviations from drawings may be made to allow for better accessibility, and any change shall be approved where the equipment is concealed.
3. Each Contractor shall provide (or arrange for the provision by other trades) the access panels for each concealed junction box, pull box, fixtures or electrical device requiring access or service as shown on Engineer's plans or as required. Locations of these panels shall be identified in sufficient time to be installed in the normal course of work. All access panels shall be installed in accord with the Architect's standards for such work. In the absence of such specifications, at a minimum such work shall comply with the specifications below. All locations for access panels which are not specifically indicated on the drawings shall be submitted to and approved by the architect prior to ordering.
4. Access Doors; in Ceilings or Walls:
    a. In mechanical, electrical, and service spaces: 14-gauge aluminum brushed satin finish, 1" border.
    b. In finished areas: 14-gauge primed steel with 1" border to accept the architectural finishes specified for the space. Confirm these provisions with the Architect prior to obtaining materials or installing any such work.
    c. In fire or smoke rated partitions, access doors shall be provided that equal or exceed the required rating of the construction they are mounted in.

G. Connections

1. Provide rough-in and final connections to all electrically operated equipment furnished under the Work of the contract documents. Carefully coordinate with equipment suppliers, manufacturer’s representatives, vendors, and other trades to provide complete electrical and dimensional interface to all equipment.
2. Provide all power wiring complete from power source to motor or equipment junction box, including power wiring through starters or contactors. Install all starters not factory mounted on equipment.
3. Provide all control, interlock, sensor, thermocouple, and other connections required for equipment operation. Coordinate ampacity and voltage characteristics for all motors and equipment.
4. Prior to bidding the work, coordinate power, control, sensor, interlock and all other wiring requirements for equipment or motors with all other trades, to ensure all needed wiring is provided. Failure to provide such coordination shall not be justification for claims of extra compensation of a time extension to the Contract.
5. At no times shall the contractor work on energized electrical equipment. Comply with NFPA 70E requirements at all times during construction.

H. Scaffolding, Rigging, and Hoisting: The Contractor shall furnish all scaffolding, rigging, hoisting, and services necessary for erection and delivery into the premises of any equipment and apparatus furnished. All such temporary appurtenances shall be set up in strict accord with OSHA Standards and Requirements. Remove same from premises when no longer required.

3.5 RESTORATION

A. The Contractor shall replace to their original condition all paving, curbing surfaces, drainage ditches, structures, fences, shrubs, existing or new building surfaces and appurtenances, and any other items damaged or removed by his operations. Replacement and repairs shall be in accordance with good construction practice and shall match materials employed in the original construction of the item to be replaced. All repairs shall be to the satisfaction of the Engineer, and in accord with the Architect's standards for such work, as applicable. Patchwork on new construction will not be accepted.

3.6 IDENTIFICATION AND OPERATING INSTRUCTIONS

A. Provide all equipment with a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

B. Provide operating instructions for each system and principal item of equipment as specified in the technical sections for use by operation and maintenance personnel. The operating instructions shall include the following:
1. Wiring diagrams, control diagrams, and control sequence for each principal system and item of equipment.
2. Start up, proper adjustment, operating, lubrication, and shutdown procedures.
3. Safety precautions.
4. The procedure in the event of equipment failure.
5. Other items of instruction as recommended by the manufacturer of each system or item of equipment.

C. Print or engrave operating instructions and frame under glass or in approved laminated plastic. Post instructions where directed. For operating instructions exposed to the weather, provide weather-resistant materials or weatherproof enclosures. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal or peeling.

3.7 SYSTEM TESTING, VERIFICATION, AND START-UP

A. The Contractor (and Sub-Contractors) shall be responsible for starting-up, testing, checking, examining, inspecting, and verifying their systems.

B. The Electrical Contractor shall designate an individual under their employment to lead the start-up, testing and verification process. This person should not be the project manager or job site superintendent, but a person dedicated to making this critical task successful and completed in a timely manner.

C. A pre-start-up conference shall be held with the Architect, Owner, Contractors, and the Manufacturer providing startup services. The purpose of this meeting will be to discuss the goals, procedures, etc. for start-up.

D. The Contractor shall include in the bid to provide systems startup and verification for all electrical systems specified for this project. Specific startup, testing, and verification requirements are included throughout the Electrical specifications. In general, as part of the verification process, equipment suppliers shall

perform start-up by their factory authorized technicians (unless noted otherwise) and shall complete and submit start-up reports/checklists. Submit start-up reports to the Engineer. The Contractor shall have appropriate trades on site to correct all deficiencies noted by the factory representative. For each deficiency noted, documentation of corrective action (including date and time) shall be submitted to the Engineer and Owner.

E. Where manufacturer start-up is not specified for a particular piece of equipment or system, the Contractor shall be responsible to perform start-up in strict accordance with manufacturer's instructions.

F. The Contractor shall be responsible for completion of a System Verification Checklist (SVC) / Manufacturer's Checklists. Furnish to the Testing Agent and Engineer. Sample checklists shall be submitted to the Engineer, Owner, and Testing Agent for approval.

G. The completed reports shall be organized and bound together in a tabbed binder and submitted for review and approval.

3.8 FIELD QUALITY CONTROL

A. Inspections
1. Each project shall have both a pre-final and final inspection made before it is finally accepted by the Owner. A complete and thorough training shall be conducted by the design consultant(s), contractors, and subcontractors for the WCPSS Maintenance Department after the pre-final inspection.
2. The pre-final inspection shall be held with the Owner, Designer, and all Contractors and Subcontractors after all systems are in place and in operation. All contractors shall demonstrate to the Designer and Owner that all systems in the building are properly installed, balanced, and performing as designed and specified. All Contractors and Subcontractors shall attend this inspection including the HVAC air and water balance subcontractor. The Designer will generate a final punch list from this pre-final inspection and distribute to the owner and all applicable contractors and subcontractors.
3. The final inspection shall be held with the Owner, Designer, all Contractors, and Subcontractors to demonstrate to the Owner that all systems in the building are operating as designed and to their satisfaction and that all punch list items have beencompleted.
4. The final turnover meeting shall be held with the Owner, Designer, and all Prime Contractors to officially "turn over" the building to WCPSS. At this meeting, any questions are responded to about operation or maintenance of the building. At this point, the Contractors will move off site completely.
5. Before requesting a final review of the installation from the Architect and/or Engineer and/or Owner, the Contractor shall thoroughly inspect the installation to assure that the work is complete in every detail and that all requirements of the Contract Documents have been fulfilled. Failure to accomplish this may result in charges from the Architect and/or Engineers for unnecessary and undue work on their part.
6. Owner's and Engineer's inspections: Two inspections will be held to generate and then review punchlist items. All site inspections and visits thereafter shall be billed to the Contractor at the Engineer's standard hourly rates.
7. The Contractor shall provide as a part of this contract electrical inspection by a competent Electrical Inspection Agency, licensed to provide such services. The name of this agency shall be included in the list of materials of the Form of Proposal by the Contractor. All costs incidental to the provision of electrical inspections shall be borne by the Electrical Contractor.
8. The Contractor shall advise each Inspection Agency in writing (with an information copy of the correspondence to the Architect and/or Engineer) when they anticipate commencing work. Failure of the Inspection Agency to inspect the work in the stage following and submit the related reports may result in the Contractor's having to expose concealed work not so inspected. Costs associated with any rework, cutting, and patching will be at the expense of the responsible Contractor.

9. Inspections shall be scheduled for rough-in as well as finished work. The rough inspections shall be divided into as many inspections as may be necessary to correct deficiencies. Report of each such inspection visit shall be submitted to the Architect, Engineer, and the Contractor within three days of the inspection.
10. Approval by an Inspector does not relieve the Contractor from the responsibilities of furnishing equipment having a quality of performance equivalent to the requirements set forth in these plans and specifications. All work under this contract is subject to the review of the Architect and/or Engineer, whose decision is binding.
11. Before final acceptance, the Contractor shall furnish three copies of the certificates of final approval by the Electrical Inspector (as well as all other inspection certificates) to the Engineer with one copy of each to the appropriate government agencies, as applicable. Final payment for the work shall be contingent upon completion of this requirement.
12. A post construction inspection shall be held by the Designer with the Contractors and Owners prior to expiration of the 1-year warranty period. It shall address general construction as well as plumbing, HVAC, and electrical work. All problems discovered during this inspection that relate to defective materials or defective workmanship shall be corrected by the Contractor at no additional cost to the Owner.

B. Punch Lists

1. The Contractor shall review each area and prepare a punch list for each of the subcontractors, as applicable, for at least three stages of the project.
    a. For review of in-wall work that will be concealed by drywall or other materials well before substantial completion.
    b. For review of the above-ceiling work that will be concealed by tile or other materials well before substantial completion.
    c. For review of all other work as the project nears substantial completion.
2. When all work from the Contractor’s punch list is complete at each of these stages and prior to completing ceiling installations (or at the final punch list stage), the Contractor shall request that the Engineer develop a punch list. This request is to be made in writing two weeks prior to the proposed date.
3. After all corrections have been made from the Engineer's punch list, the Contractor shall review and initial off on each item. This signed-off punch list shall be submitted to the Engineer. The Engineer shall return to the site once to review each punch list and all work prior to the ceilings being installed and at the final punch list review.
4. At the engineer’s option, the contractor shall supply digital photographs via email or file-share of any installed work.
5. If additional visits are required by the Engineer to review work not completed by this review, the Engineer shall be reimbursed directly by the Contractor by check or money order (due 10 days from date of each additional visit) at a rate of $125.00 per hour for extra trips required to complete either of the above-ceiling or final punch lists.
6. All panelboard fronts shall be removed prior to final punch list inspection and re-installed after completion. Directories for each panelboard shall be completed and available for review by the Engineer at that time.

3.9 CLEANING

A. The Contractor shall, at all times, keep the area of work presentable to the public and clean of rubbish caused by their operations; and at the completion of the work, shall remove all rubbish, all tools, equipment, temporary work, and surplus materials, from and about the premises, and shall leave the work clean and ready for use. If the Contractor does not attend to such cleaning immediately upon request, the Engineer may cause cleaning to be done by others and charge the cost of same to the responsible Contractor. Each Contractor shall be responsible for all damage from fire which originates in, or is propagated by, accumulations of rubbish or debris.

B. After completion of all work and before final acceptance of the work, each Contractor shall thoroughly clean all equipment and materials and shall remove all foreign matter such as grease, dirt, plaster, labels, stickers, etc., from the exterior of materials, equipment, and all associated fabrication. Pay particular attention to finished area surfaces such as lighting fixture lenses, lamps, reflectors, panels, etc.

3.10 TRAINING

A. Upon completion of all work and all tests, each Contractor shall furnish the necessary skilled labor and helpers for operating all systems and equipment for a period of three days of eight hours each, or as otherwise specified. During this period, instruct the Owner or their representative fully in the operations, adjustment, and maintenance of all equipment furnished. Give at least one week's written notice to the Owner, Architect and Engineer in advance of this period. The Engineer may attend any such training sessions or operational demonstrations. The Contractor shall certify in writing to the Engineer that such demonstrations have taken place, noting the date, time and names of the Owner's representative that were present.

B. Training shall be accompanied by complete as-built documentation and the technical systems operation manual. The training shall be accomplished by a factory trained representative. Include a minimum of Four hours for each system described here-in unless noted otherwise. Each equipment representative shall be represented wherever their equipment is used.

C. Demonstration and Training DVDs: These training sessions shall be videotaped by the Installer. Submit two copies within seven days of end of each training module. On each copy, provide an applied label with the following information:

1. Name of Project.
2. Name and address of photographer.
3. Name of Architect and Construction Manager.
4. Name of Contractor.
5. Date video was recorded.

D. Brochures: Furnish Owner a complete set of operating instructions and diagrams.

E. Instruction Program: Submit outline of instructional program for demonstration and training, including a schedule of proposed dates, times, length of instruction time, and instructors' names for each training module. Include learning objective and outline for each training module.

F. At completion of training, submit two complete training manual(s) for Owner's use.

G. Qualification Data: For facilitator, instructor, and photographer.

H. Attendance Record: For each training module, submit list of participants and length of instruction time.

3.11 PROTECTION

A. The Contractor shall be entirely responsible for all material and equipment furnished for their work and special care shall be taken to properly protect all parts thereof from damage during the construction period. Such protection shall be by a means acceptable to the Engineer. Equipment damaged while stored on site either before or after installation shall be repaired or replaced (as determined by the Engineer) by the responsible Contractor. Electrical equipment exposed to the weather shall be replaced by the Contractor at their own expense.

END OF SECTION 260010

SECTION 260500 - COMMON WORK RESULTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Slotted Support Systems.
2. Conduit and Cable Supports.
3. Mounting, Anchoring, and Attachment Components.
4. Fabricated Metal Supports.
5. Concrete Bases.
6. Vibration Isolation pads.
7. Sleeves for penetration of non-fire-rated construction walls and floors.
8. Sleeve-seal systems.
9. Firestopping.
10. Cutting and Patching
11. Painting

1.3 REFERENCES

A. Abbreviations and Acronyms

1. EMT: Electrical Metallic Tubing.
2. FMC: Flexible Metal Conduit.
3. GRC/GRS: Galvanized Rigid Steel Conduit.
4. LFMC: Liquid-tight flexible metal conduit.
5. RMC: Rigid Metal Conduit

B. Definitions

1. Channel: A continuous slotted channel (strut) with inturned lips suitable for assembly into multiple configurations

C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.

1. Metal Framing Manufacturers Association (MFMA)
   a. MFMA-4: Metal Framing Standards Publication
   b. MFMA-103: Guidelines for the use of Metal Framing

1.4 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations with Division 07 Section "Roof Accessories."

1.5 SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of components, profiles, and finishes.
2. Include rated capacities.

B. Shop Drawings: For fabrication and installation details and include calculations for the following:

1. Slotted channel systems.
2. Equipment supports.
3. Concrete Bases for Equipment.
4. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal: Signed and sealed by a qualified professional engineer. For field assembled or fabricated hangers and supports for electrical systems.

1. Include design calculations and details of trapeze hangers.

D. Qualification Data: For professional engineer.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency acceptable to the authority having jurisdiction and marked for intended location and application.

B. Delegated Design: Design support systems, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

2.2 SLOTTED SUPPORT SYSTEMS

A. Description: Preformed, continuous slot, bolted channels with associated fittings and hardware.

1. Available Manufacturers: Subject to compliance with requirements, provide products from one of the following or an approved equal:
    a. Eaton B-Line.
    b. Kindorf.
    c. nVent Caddy.
    d. Power-Strut.
    e. SuperStrut.
    f. Unistrut.
2. Comply with MFMA-4 for factory fabricated components suitable for field assembly.
3. Material and Finish for channel, fittings, and accessories:
    a. Steel: Minimum 16 gauge, Hot-dip galvanized after fabrication and applied according to ASTM A123 or A153 suitable for indoor or outdoor wet locations.
    b. Stainless Steel (type 316) per ASTM A276 suitable for corrosive environments.
4. Channel Dimensions: Minimum 1-5/8 inches wide with varying heights and welded combinations selected to meet applicable load criteria.

2.3 CONDUIT AND CABLE SUPPORTS

A. Available Manufacturers: Subject to compliance with requirements, provide products from one of the following or an approved equal:
    1. Eaton B-Line
    2. nVent Caddy
    3. Thomas & Betts

B. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Provide plugs with number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported.

D. Device Box Mounting Brackets: Factory-fabricated sheet steel brackets for support of device boxes adjacent to or between studs.

E. Through-Stud Cable and Raceway Support Clips: Factory-fabricated spring steel clip for cables or raceways where run horizontally through metal studs.

F. Roof-mounted Raceway Support Blocking: Non-penetrating, factory-fabricated support blocking for use under roof-mounted raceways. Wedge-shaped blocking constructed of 100% recycled UV-resistant Rubber with integral galvanized steel strut to accept raceway support clips.

G. Tee Bar Grid Box Hanger: Factory-fabricated metal electrical box hanger for supporting boxes at locations between ceiling system t-grid components. Height adjustable for various electrical box depths. Attached to ceiling tee bar with screws or integral clamp for stability. Includes tab for independent support wire attachment.

2.4 MOUNTING, ANCHORING, AND ATTACHMENT COMPONENTS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Eaton B-Line
2. Empire Industries.
3. Hilti.
4. ITW.
5. MKT Fastening.

B. Description: Items for fastening electrical items or their supports to building surfaces include the following:
1. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated or stainless steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
2. Concrete Inserts: Steel, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
3. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
5. Toggle Bolts: All-steel springhead type.
6. Hanger Rods: Solid, threaded steel.

2.5 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

2.6 VIBRATION ISOLATION PADS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Korfund Maxi-Flex Pads or a comparable product by one of the following:

1. Ace Mountings Co.
2. California Dynamics Corporation.
3. Eaton B-Line.
4. Kinetics Noise Control.
5. Mason Industries.
6. Vibration Eliminator Co.
7. VMC Group

B. Description: Molded, oil resistant, non-skid elastomeric pads arranged in 2-inch square segments.

C. Size: Factory or field cut to match requirements of supported equipment.

D. Load Rating from 120 lbs. up to 360 lbs. per 2-inch segment.

2.7 SLEEVES

A. Wall and Floor Sleeves:

1. Galvanized Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.

2.8 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable. Link Seal system or approved equal.

1. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Glass reinforced nylon polymer.
3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.9 FIRESTOPPING FOR ELECTRICAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products from one of the following or approved equal:

1. Hilti
2. Specified Technologies Inc (STI)
3. Wiremold

B. Source Limitations: Obtain firestopping systems through one source from a single manufacturer.

C. General Requirements:

1. Firestopping systems shall bear UL classification marking corresponding to its Fire Resistance Directory.
2. Comply with testing requirements set forth in ASTM E814 or UL 1479.
3. Provide through-penetration firestop systems that are compatible with one another, with the substrates forming openings, and with the items, if any, penetrating through-penetration firestop systems, under conditions of service and application, as demonstrated by through-penetration firestop system manufacturer based on testing and field experience.
4. Provide components for each through-penetration firestop system that are needed to install fill materials. Use only components specified by the firestopping manufacturer and approved by the qualified testing agency for the designated fire-resistance-rated systems.

D. Fire rated cable pathways: Re-penetrable, maintenance-free cable management devices for use with cable bundles penetrating through fire rated walls or floors.

1. Shall contain a built-in fire sealing system sufficient to maintain the hourly rating of the fire rated wall or floor being penetrated.
2. The system shall adjust to the installed cable loading and shall permit cables to be installed, removed, or retrofitted without the need to remove or reinstall firestop materials.
3. Shall be engineered to allow two or more devices to be ganged together with wall plates for larger cable capacities.

E. Fire-rated cable grommets: Molded, two-piece grommet with sealing membrane for use with single cables or small bundles at through or membrane wall penetrations.

1. System shall be installed around cables and shall lock tightly into the wall assembly.

F. Outlet Box Putty Pads: Non-hardening, moldable, intumescent material shaped into preformed pads for use with metallic outlet boxes.

G. Refer to Division 07 for requirements related to other firestopping systems and materials.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation devices for compliance with manufacturer's installation requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Examine substrates and conditions for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CUTTING AND PATCHING

A. Unless otherwise indicated, provide cutting and patching necessary to install the work specified. Patching shall match adjacent surfaces to the satisfaction of the Engineer and shall be in accordance with the Architect's standards for such work.

B. Do not cut structural elements without reinforcing the structure to maintain the designed weight bearing and stiffness. Coordinate approved reinforcement method with Architect and Structural Engineer.

C. When installing electrical work in insulated concrete form (ICF) walls, provide spray foam insulation to patch the insulated form and maintain the integrity of the insulation value after the work is complete. Work shall not be installed in the concrete center of the wall. All work shall be installed on the interior side of the concrete.

3.3 SUPPORT SYSTEM APPLICATION

A. Comply with NFPA 70, NECA 1, NECA 101, and MFMA-103 for application of hangers and supports for electrical equipment and systems except where requirements of this Section are more stringent.

B. Maximum Horizontal and Vertical Support Spacing for Raceway(s): Space supports for raceways as required by NFPA 70.

C. Minimum Hanger Rod Size for Raceway Supports: 3/8-inch diameter unless noted otherwise.

D. Single Raceways:

1. For Raceways 1-1/4-inch and smaller: Install adjustable steel band hanger suspended on threaded rod.
2. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/4-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

E. Multiple Raceways and single raceways larger than 1-1/4-inch:

1. Install trapeze-type supports fabricated with slotted support system suspended on threaded rods for horizontal applications and fastened to building structure for vertical applications.
2. Size so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

3. Secure raceways and cables to these supports with two-bolt steel conduit clamps or single-bolt steel conduit clamps using spring friction action for retention in support channel.

3.4 SUPPORT SYSTEM INSTALLATION

A. Comply with NFPA 70, NECA 1, NECA 101, and MFMA-103 for installation requirements except where requirements of this Article are more stringent.

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components multiplied by a safety factor of four with a minimum of 200 lbs.

C. Mounting and Anchorage of Surface-Mounted or Recessed-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
    a. Where support anchors are required, establish their type, and locate in concrete construction before concrete is poured. Fit each hanger rod with a nut at its upper end and set nut in a universal concrete insert in the form. Where supported weight exceeds holding strength of a single insert, pass rods through top slot of inserts and interlock with reinforcing steel. Also, where particularly heavy loads are to be supported, suspend hanger rod or rods from a structural angle spanning two or more inserts and securely bolted thereto to distribute the weight.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Self-drilling concrete anchors or expansion anchor fasteners.
5. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69 or Spring-tension clamps.
6. To Light Steel: Sheet metal screws.
7. For Surface-Mounted Items on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to structure. Attachment to gypsum wall board is not acceptable as sole support means; slotted-channel rack solidly attached to structure or light-gauge metal framing at both ends is required.
8. For Recessed-Mounted Items in Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices to intermediate light-gauge metal framing members on each side of device or provide slotted-channel racks within hollow wall attached to structure by means that meet anchorage requirements. Attachment to gypsum wall board is not acceptable as sole support means.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars or existing raceways embedded in slab. Verify reinforcing locations with Structural Engineer and X-Ray existing concrete structures as required.

E. Do not support any items (equipment, piping, conduit, etc.) exceeding 2 inches in diameter from the bottom of slabs. Where intermediate supports are required between structural members, use slotted steel channels support systems attached to beams or joists in order to avoid attachment to slabs.

F. Slotted Support Systems

1. Install slotted channel systems level and plumb.
2. Remove burrs from all exposed cut edges prior to installation.

G. Wall Stud and Ceiling Supports

1. Fasten junction, pull and devices boxes securely to the building construction, independent of raceway system.
2. Install Device Box Mounting Brackets supported between two studs. Attach all device boxes to two studs, device box stabilizers are prohibited.
3. Install Tee Bar Grid Box Hanger supported between two ceiling grid tee bars where devices boxes are located flush in recessed suspended ceilings. Install at least one independent support rod from box hanger to structure.
4. Install Through-Stud Cable and Raceway Support Clips where cables or raceways run horizontally through metal studs.

H. Install Roof-mounted Raceway Support Blocking where raceways run on across roofing.

1. Coordinate installation of roof supports with items specified in Division 07 Section "Roof Accessories." Provide products compatible with rooftop materials included in the Work to maintain warranty of roof system.

I. Threaded Rod Hardware

1. Provide minimum of two lock nuts per threaded support rod except where lock nut tightens against a threaded socket, one locknut may be used.
2. Trim rod excess to within 1-inch of locknut, de-burr, and provide protective endcap.

J. Support raceways at a distance above suspended ceilings to permit removal of ceiling panels and luminaires.

K. Locate raceways and supports so as not to hinder function or code required clearance to any system or equipment.

L. Provide independent supports and hang all electrical raceways and devices from the building structure with UL listed and approved materials. Utilizing the support systems of other trade’s work is prohibited, except with written approval from the Engineer.

M. Provide riser support clamps for vertical conduit runs and install at each floor level penetration and at additional locations required to support weight of system.

N. Tighten all bolted connections to proper torque values in accordance with manufacturer’s written instructions.

O. Provide supports to maintain 1/4-inch air space between raceway and mounting surface where raceways are mounted exposed in wet or corrosive locations and where directly attached to concrete or masonry.

P. The use of tie wire or perforated metal tape for support or fastening of any raceway system is prohibited.

Q. Where galvanized wire is used for cable supports above suspended ceilings, provide minimum #12 support wire independent of ceiling system secured at both ends. Paint or provide tag to distinguish supports from ceiling system.

R. Welding directly on raceways, fittings, or outlet boxes is prohibited.

3.5 INSTALLATION OF VIBRATION ISOLATION PADS

A. Select vibration device load ratings to match equipment loading and deflection criteria.

B. Arrange pads in single or multiple layers of sufficient stiffness for uniform loading.

C. Install pre-cut segments in accordance with manufacturer recommendations to match shape of equipment base.

3.6 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.7 CONCRETE EQUIPMENT BASES

A. Housekeeping Pads: Construct concrete housekeeping pads a minimum of 4-inches thick and 6-inches larger in both directions than supported unit.

B. Exterior Equipment Pads: Construct exterior equipment pads a minimum of 8-inches thick and 6-inches larger in both directions than supported unit unless noted otherwise.

C. Use at least 3000-psi, 28-day compressive-strength concrete unless otherwise noted. Comply with Division 03 Section "Cast-in-Place Concrete" and ACI standards for subbase requirements, concrete materials, reinforcement, placement, and cover requirements.

1. Reinforce pads with a minimum #4 rebar on 12-inch centers each way or equivalent welded wire fabric. Support reinforcement and tie together to prevent displacement during construction.
2. For interior pads, provide #4 dowels at 24-inch centers each way (minimum of 4) to anchor to structural slab below. Embed dowels into slab a minimum of 3-inches.
3. Provide rubbed finish for all surfaces.
4. Provide ¾-inch chamfer at all exposed edges.
5. Provide Engineer approved repairs if pad surface is rough or shows signs of honeycomb.
6. Provide crown for exterior pads with a slope of 1/8-inch per foot.
7. Do not set heavy equipment on pad for at least 7 days after pour unless approved by Engineer.

D. Anchor equipment to concrete base.

1. Locate anchors to be a minimum of 10 bolt diameters from edge of the base.
2. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
3. Install anchor bolts to elevations required for proper attachment to supported equipment.
4. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.8 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Coordinate all required openings and provide sleeves and inserts prior to construction of wall and floor systems. Where openings are missed or incorrectly located, provide core-drilling and patching at no additional expense to owner.

C. Install sleeves without compromising structural integrity of wall or floor.

D. Sleeves for Conduits or Cable Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

   a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint.
   b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall, so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Unless sleeve seal systems are used, size pipe sleeves to provide a minimum 1/4-inch annular clear space between sleeve and raceway. Where conduit motion due to expansion and contraction will occur, provide sleeves a minimum of two conduit sizes larger than the nominal conduit diameter.
3. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls.
   a. For conduit penetrations, cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
   b. For cable penetrations, extend sleeve a minimum of 2-inches beyond surface of wall and provide plastic insulated bushing.
4. Install sleeves for floor penetrations. Extend sleeves installed in floors a minimum of 6-inches above finished floor level unless noted otherwise. Install sleeves during erection of floors.
5. Fasten sleeves securely in floors, walls, so that they will not become displaced when concrete is poured or when other construction occurs around them. Take precautions to prevent concrete, plaster or other materials being forced into the space between pipe and sleeve during construction.

E. Sleeves for Cables Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound or acoustical sealant for gypsum board assemblies.

F. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units and counter flashing applied in coordination with roofing work. Coordinate all work with roofing system to maintain roof warranty.

G. Exterior-Wall and Floor Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seal system. Size sleeves to allow for manufacturer recommended annular clear space between raceway or cable and sleeve for installing sleeve-seal system. Where sleeves are installed in core drilled openings, grout sleeve into the opening.

H. Where sleeves are installed exposed in finished spaces, provide metal escutcheon plates of size to match the sleeve.

I. Sleeve-Seal-System:

1. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.
2. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.9 ELECTRICAL SYSTEM FIRESTOPPING INSTALLATION

A. Install firestopping at all penetrations of fire-rated assemblies. Comply with requirements in Division 07 and as outlined below.

B. Coordinate location and proper selection of firestop devices with fire rated assembly. Ensure cast-in place devices are installed before placement of concrete.

C. Install firestop materials in accordance with UL Fire Resistance Directory and manufacturer's instructions.

D. Affix permanent label to each side of penetration immediately adjacent to firestopping to communicate to futures installers and code authorities the following:
   1. Fire-stop product/system used
   2. Installation Company
   3. Penetration Hour Rating
   4. Installation Date

E. Examine sealed penetration areas to ensure proper installation before concealing or enclosing areas. Keep areas of work accessible until inspection by applicable code authorities.

3.10 PAINTING

A. Touchup: Comply with requirements in Division 09 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 260500

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SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

- GENERAL

- RELATED DOCUMENTS

  - Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

- SUMMARY

  - This Section includes the following:

    - Building wire and cable rated 600 V and less.
    - Connectors, splices, and terminations rated 600 V and less.
    - Control Voltage Conductors and Cables

  - Related Requirements:

    - Refer to Division 27 for requirements related to balanced unshielded twisted pair (UTP) cabling.

- REFERENCES

  - Abbreviations

    - RoHS: Restriction of Hazardous Substances.

  - Definitions

    - Low Voltage: Circuits and equipment operating at more than 50VAC but less than 1000VAC for building electrical distribution systems.
    - Control Voltage: Circuits and equipment operating at less than 50VAC for remote-control and signaling power-limited circuits.
    - Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.
    - Homerun: The run of raceway(s) and cable(s) between the panelboard or switchboard and the junction box in the area served where branch circuit cables originate.

  - Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.

    - National Electrical Contractors Association (NECA)

      - NECA 104, “Installing Aluminum Building Wire and Cable”
      - NECA/NACMA 120, “Standard for Installing Armored Cable (Type AC) and Type Metal-Clad (MC) Cable”

- SUBMITTALS
  - Product Data: For each type of product indicated.
  - Product Schedule: indicate type, use, and location.

- PRODUCTS

- GENERAL REQUIREMENTS
  - Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
  - Comply with NFPA 70.

- BUILDING WIRE AND CABLE
  - Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    - Alpha Wire Company.
    - Cerro Wire LLC.
    - Encore Wire Corporation.
    - General Cable Technologies Corporation.
    - Okonite Compony.
    - Southwire Company.
  - Building Wire Description: Flexible, insulated, and uninsulated, drawn current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.
  - Cable Description: A factory assembly of one or more current-carrying insulated conductors in an overall protective sheath.
  - General Requirements:
    - Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
    - RoHS compliant.
    - Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."
  - Copper Conductors: 98% conductive annealed copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.
  - Aluminum Conductors: AA8000 Aluminum Alloy, complying with ASTM B 800 and ASTM B 801.
  - Conductor Insulation:
    - 600V, 90°C
    - Comply with ANSI/NEMA WC 70/ICEA S-95-658.
    - THHN/THWN-2: Comply with UL 83.
    - XHHW-2: Comply with UL 44.
    - RHW-2: Comply with UL 44 and UL 2196.

- Metal Clad Cable, Type MC
  - Comply with UL1569.
  - Circuits: Single circuit with color coded current carrying conductors and insulated ground conductor.
  - Conductor Insulation: THHN/THWN-2.
  - Armor Jacket: Aluminum Interlocking.
  - Listed for use in through penetration firestop systems.
  - Where applicable, integral 16AWG solid TFN (purple/grey) control conductors suitable for 0-10V dimming.
  - Type HCF: rated for healthcare use with grounded green exterior sheath.

- SPLICING DEVICES & CONNECTORS
  - Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    - 3M; Electrical Products Division.
    - AFC Cable Systems, Inc.
    - Burndy
    - Gardner Bender.
    - Hubbell Power Systems, Inc.
    - Ideal Industries, Inc.
    - ILSCO.
    - NSi Industries LLC.
    - O-Z/Gedney.
    - Thomas & Betts.
    - Tyco Electronics Corp.
  - Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
  - Material: Tin plated copper
  - Twist-On Wire Connectors: spring pressure type, 600V, 105°C insulation, capable of connecting two or more wires up to #8 AWG in a pigtail application.
  - Crimp Sleeve Splices: butt or parallel crimp type, copper sleeve with nylon cover and skirted insulators, capable of permanent connection of two or more wires up to #10 AWG.
  - Compression Splices: standard or long barrel type, 90°C, with cold shrink tubing, for use with hydraulic crimping tool, capable of permanent connection of wires #6 AWG and larger.
  - Ring or Flanged Fork Tongue Terminals: crimp type, 600V, 105°C insulation, insulated serrated barrel, capable of terminating wires up to #10 AWG.
  - No aluminum splicing devices or connectors are permitted.

- CONTROL VOLTAGE CONDUCTORS AND CABLE
  - Control Cable: NFPA 70, Type CMG or CMP
    - Single or Multi-pair, twisted, minimum No. 18 AWG, stranded tinned copper conductors.

- PVC insulation.
- Shielded or Unshielded.
- Flame Resistance:
  - CMG: Comply with UL1685
  - CMP: Comply with NFPA 262

- Class 1, 2, and 3 Control Circuits: Stranded Copper, Type THHN/THWN-2

- EXECUTION

- CONDUCTOR AND INSULATION APPLICATION

- Feeders and Branch Circuits: Copper. THHN/THWN-2. Solid for #10 AWG and smaller; stranded for # 8 AWG and larger.
  - Provide XHHW-2 insulation for the following:
    - Circuits routed exposed on rooftops.
    - Conductors on the load side of a Variable Frequency Drive.
  - Provide RHW-2 fire resistive cable in raceway for emergency system feeders located above ceilings and not protected by an automatic fire suppression system.

- Conductors for motors or vibrating or oscillating equipment: Extra flexible stranded.

- Cord Drops and Portable Appliance Connections: Type SOOW, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

- Conductor sizes indicated on drawings are based upon 75 degree C rating.

- Minimum branch circuit or feeder size:
  - Not less than #12 AWG copper wire unless noted otherwise.

- Minimum control circuit conductor sizes:
  - Class 1 remote-control and signal circuits; No 14 AWG.
  - Class 2 low-energy, remote-control, and signal circuits; No. 16 AWG.
  - Class 3 low-energy, remote-control, alarm, and signal circuits; No 12 AWG

- Provide all wire for the project in new and undamaged condition. Deliver in standard coils or reels. Wires and cables manufactured more than 24 months prior to date of delivery to the site are not acceptable.

- EXAMINATION

- Prior to installing conductors and cables:
  - Verify that raceway installation is complete according to Section 260533 “Raceways and Boxes for Electrical Systems” and ready for installation of conductors and cables.
  - Verify that raceways are properly sized in accordance with NEC.
  - Visually inspect exposed raceways to ensure that raceways are not damaged, and bends are not deformed.
  - Verify that raceways do not exceed the maximum number of bends between pull-points.
  - Verify raceways have been cleaned of all dirt and debris.

- INSTALLATION OF CONDUCTORS AND CABLES

  - Pulling Conductors in Raceways

    - Pull cables in accordance with cable manufacturer and pulling equipment manufacturer recommendations as well as applicable sections of the National Electric Code.
    - Use installation equipment, tools, and materials as necessary, such as sheaves, pulling eyes, basket grips, winches, cable reels and/or cable reel jacks, duct entrance funnels, and pulling tension gauges, and approved pulling lubricants where required to facilitate cable pulling without damage to cables or raceway.
    - Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not use lubricants that harden or become adhesive with age. Apply lubricant where cables enter ducts and conduits and at all intermediate access points on long or difficult pulls.
    - Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values. Utilize special remote readout equipment to ensure compliance.
    - Avoid abrasion and other damage to cables during installation. Provide physical protection of cables, such as using appropriately sized flexible cable guides or feed-in tubes, at the entrance of boxes and raceways.
    - If basket-grip type cable-pulling devices are used to pull cable in place, cut off the section of cable under the grip before splicing and terminating.

  - Bend Radius

    - Handle conductors and cables carefully. Make bends in cables and conductors such that cables, conductors, sheaths, armor, etc., are not damaged.
    - Do not bend conductors and cables to less than the NEC and manufacturer recommended minimum bending radius.
    - Ensure that tools and accessories used to install conductors and cables, such as rollers, sheaves, trolley assemblies, tube guides, and/or raceways, are properly sized and utilized to be greater than the minimum bending radii of conductors and cables.
    - Minimize bending where conductors and cables enter or exit raceways, cabinets, and boxes. Do not install cables that have been bent or kinked to a radius less than the recommended dimension.
    - Install conductors only after insulating bushings are in place.

  - If multiple circuits are pulled in a single homerun, provide a dedicated neutral for each phase conductor. In these cases, a maximum of seven conductors (six current carrying and one ground) are permitted in a single conduit except for switch legs and travelers in multi-point switching arrangements. De-rate conductors per NEC.

  - Multi-wire branch circuits with a shared neutral are not permitted unless specifically noted on the drawings. Where indicated, group the phases and neutral together with cable ties in the panelboard and in all pull boxes.

  - Install conductors for isolated power systems in as short a run of conduit as practicable. The use of pulling compound or lubricant is not permitted on conductors in isolated power systems.

  - Voltage Drop:

    - Adjust conductors and conduit sizes accordingly based on actual field installed conditions.
    - Size and Install all feeders and branch circuits for a maximum 2% voltage drop in feeders and 3% in branch circuits with a maximum total voltage drop of 5%.
    - Calculate using a load equal to 80% of the supply breaker rating unless the circuit breaker is rated to carry 100% of the load.
    - Where the conductor length from the panel to the first outlet on a circuit exceeds the values below, adjust branch circuit conductors from the panel to the first outlet. Increase the conductor size of remaining branch circuit as needed to meet above voltage drop limitations.

- For 277VAC homeruns exceeding 125-feet, #10 AWG minimum
- For 120VAC homeruns exceeding 50-feet, #10 AWG minimum
- For 120VAC homeruns exceeding 100-feet, #8 AWG minimum

- Aluminum Conductors
  - Aluminum Conductors are permitted for the following applications:
    - Service conductors
    - Aboveground normal power feeders to electrical equipment for applications 100 amps and above.
    - Provide terminations according to NECA 104 and manufacturer's instructions using connectors listed for aluminum conductors and listed oxide inhibiting joint compound.

- Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

- Install cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours.

- Bundle cables where run in groups using listed supports. Provide independent supports directly from structure, do not route through structure or on work of other trades.

- Metal Clad Cable, Type MC
  - The use of metal clad cable is not permitted, except for connections to ceiling mounted recessed and semi-recessed luminaires concealed in accessible ceiling where the maximum length is limited to 72-inches.
  - MC cable is permitted for the following applications:
    - Normal power branch circuits between wiring devices and nearest junction box, #10 and smaller, where concealed in walls and ceilings.
      - Provide no more than three MC cable circuit connections per junction box.
      - MC cable is allowed inside walls, between wiring devices only, but not above 8ft A.F.F. where exposed.
      - For lighting circuits, limit length of MC cable to 6ft from the junction box to the first luminaire and extend MC cable to other fixtures in the same room.
  - MC cable is not permitted for the following:
    - Emergency or standby power circuits
    - Feeders
    - Homeruns to panelboards.
    - Branch circuits with conductors larger than #10 AWG.
    - Branch circuits serving HVAC, elevator/escalator, medical and kitchen equipment loads.
    - Within mechanical, electrical or telecommunication equipment rooms.
    - Exposed locations.
    - Inaccessible ceiling locations.
    - Within masonry walls.
    - Exterior or outdoor locations.
    - Wet or damp locations.
    - Direct buried locations.
  - Where MC cable is permitted, comply with the following:
    - Install MC cables and connectors in accordance with NECA/NACMA 120.
    - Use only for single-circuit applications. For devices in the same wall connected to different circuits, install separate single circuit cable for each circuit.
    - Support MC cables with clamps, clips, or similar product specifically designed for supporting cables in accordance with NEC and route all runs parallel or perpendicular to building lines with right angle turns complying with manufacturer's bend radius requirements.

- Cables shall be bundled where run in groups using listed supports to maintain proper spacing. Where spacing can't be maintained, apply adjustment factors for derating conductors.
- Do not route through structure or on work of other trades. Provide independent supports directly from structure.

- Control Circuit Conductors and Cables
  - Use insulated spade lugs for wire and cable connection to screw terminals.
  - Conductors installed within environmental air plenums shall be per NEC. Article 800 and other applicable codes, with FEP-type insulation or an approved equivalent. Provide plenum-rated cable supports where plastic straps or other supports, etc., are installed in plenum areas.
  - Where indicated, systems and control conductors that are installed exposed shall not be routed across ceilings or ductwork. Provide independent supports anchored to building structure or other permanent support members.
  - Install in such a manner as to not interfere with the access to or operation of equipment or removal of ceiling tiles.
  - Nylon tie-wraps shall be installed in such a manner so as to bundle conductors neatly, allowing runouts of single conductors or groups to drop down to equipment served.
  - Install grommets where dropping out of trays or into panels or service columns.
  - Install sleeves with bushings where penetrating partitions.
  - Provide firestopping for penetrations of fire rated assemblies with approved materials.

- SPLICES, TAPS, CONNECTIONS, AND TERMINATIONS

  - Prepare cable in accordance with the conductor, cable, splice and termination component manufacturers' recommendations and instructions.

  - Cut conductors and cables using tools and methods which ensure a square cut. Do not nick or damage conductors.

  - Ensure conductor inserts fully into the connector or termination with the insulation fitting closely to the connector or termination.

  - Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B. Where a tightening torque is indicated as a numeric value on equipment or in installation instructions provided by the manufacturer, a calibrated torque tools shall be used to achieve that indicated torque value, unless the equipment manufacturer has provided installation instructions for an alternative method of achieving the required torque.

  - Splices and Taps
    - Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than un-spliced conductors.
    - Make splices and taps in junction boxes or other enclosure approved for the wiring method.
    - For conductors #10 AWG and smaller conductors, use pressure crimp type connections.
    - For conductors #8 AWG and larger, use a hydraulic compression type connection, with cold shrink tubing and tape to restore full insulation value of the wire being spliced.

  - Connections and Terminations
    - Ensure that conductor temperature and ampacity ratings are compatible with connectors, terminals, and equipment to which they are to be connected.

- Provide crimp-applied ring or flanged fork type terminals for motor and equipment terminals where such terminals are provided on motor and equipment leads or on all stranded wire terminations using #10 AWG or smaller conductors.
- Motor Connections shall use connection lugs with motor stub splice insulators.

- Wiring at Outlets: Install conductors at each outlet with at least 12 inches of slack.

- All cables and wiring, regardless of voltage, installed in manholes or cable vaults shall be routed in such a manner to provide a minimum of 10 feet of slack cable for future splicing. Install cables along walls by utilizing the longer route from entry to exit. If both routes are symmetrical, provide a loop of cable secured to wall. All cables shall be tied to insulated cable supports on wall-mounted racks, spaced a maximum of three feet apart.

- PROTECTION

- Intentional or unintentional painting of exposed low-voltage and/or control-voltage cabling insulation is prohibited. Ensure that exposed cabling is adequately protected from direct painting or overspray whether painting is required within the electrical specifications or required by other disciplines/trades.

- Review the project's painting requirements for all disciplines and provide protection as required.

- Where exposed cabling is being installed in exposed ceiling or wall spaces that are required to be painted, provide cabling in enclosed raceways, or provide alternate options for cable colors to engineer for approval.

- IDENTIFICATION

- Comply with Section 260553 "Identification for Electrical Systems."
  - Identify all conductors by means of labels placed on conductors in all junction boxes and at each terminal point with labels indicating source, circuit number or terminal number.
  - Identify each spare conductor at each end with identity number and location of other end of conductor and identify as spare conductor.
  - Identify each control voltage conductor or cable on each end and at each terminal with a number-coded identification tag. Each wire must have a unique tag.

- Provide conductors, in all sizes of cable, with continuous solid insulation color(s) from the manufacturer. Taped ends shall not be acceptable.
  - Conductors shall be color coded as follows:
    - 120/208 Volt Conductors
      - Phase A: Black
      - Phase B: Red
      - Phase C: Blue
      - Neutral: White
      - Ground: Green
      - Isolated Ground: Green/Yellow
    - 277/480 Volt Conductors
      - Phase A: Brown
      - Phase B: Orange
      - Phase C: Yellow
      - Neutral: Gray or White with Brown tracer
      - Ground: Green
      - Isolated Ground: Green/Yellow

- Isolated Power Conductors (Type XLP or XHHN-2)
  - Phase A - Brown
  - Phase B - Orange
  - Phase C - Yellow
  - Neutral - White with brown tracer stripe
  - Note: Provide each phase with tracer color other than white, green, or gray.
- Note: Further identify isolated power conductors with ½" wide purple tape at all terminations and junctions.

- Control voltage wiring color coding shall be consistent throughout the project and shall match existing equipment and standards where applicable. Color coding for each system shall be unique.
- Conductors within enclosures that may be energized when enclosure disconnect is off - yellow or taped with 1/2" yellow tape every 6" of length, inside enclosure. Provide lamacoid plate warning sign on front of enclosure where this condition occurs.
- DC Wiring:
  - Positive: Light Blue
  - Negative: Dark Blue

- FIELD QUALITY CONTROL

- Perform tests and inspections and prepare test reports.

- Visual Inspections:

  - Compare cable data with drawings and specifications.
  - Inspect exposed sections of cable for physical damage and correct connections in accordance with drawings.
  - Inspect bolted electrical connections for high resistance. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.
  - Inspect compression-applied connectors for correct cable match and indentation.
  - Inspect for correct identification and arrangements.
  - Inspect cable jacket insulation and condition.

- Electrical Tests:

  - Perform insulation resistance testing for all electrical distribution system feeders unless notes otherwise. Testing may be witnessed by the Engineer and/or Commissioning agent. Schedule all tests with Architect with sufficient notice.
  - Insulation resistance tests shall be performed at a DC voltage of 1,000 volts for 600 volt rated equipment, and at a DC voltage of 500 volts for 120-300 volt rated equipment. Test duration shall be one minute. Minimum acceptable (temperature corrected) resistance is 25 megaohms for 120-300 volt rated equipment and 100 megaohms for 600 volt rated equipment and wiring.
  - Test instruments shall be calibrated to national standards within the last 12 months.

- Test and Inspection Reports: Prepare a written report to record the following:

  - Test procedures used.
  - Results that comply with requirements.
  - Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

- Cables will be considered defective if they do not pass tests and inspections. Remove and replace malfunctioning units and retest as specified above.

- Submit test results to Architect and Engineer for approval.

END OF SECTION 260519

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

1.2 SUMMARY

A. Description: Grounding and Bonding for electrical systems covers several different but interrelated systems including Electrical System Grounding, Equipment Grounding System, Grounding Electrode System, and interfaces with telecommunications bonding infrastructure as well as lighting protection systems.

B. Section includes requirements for electrical system and equipment grounding, plus the following special applications:

1. Underground distribution grounding.
2. Grounding electrodes.
3. Ground bonding common with lightning protection system.

C. Related Requirements:
1. Refer to Section 270526 “Grounding and Bonding for Communications Systems” for requirements associated with the telecommunications bonding infrastructure.

1.3 REFERENCES

A. Abbreviations

1. MGB: Main Grounding Busbar

B. Definitions

1. Grounding: Establishing a direct or indirect connection to Earth or some conducting body that serves in place of Earth.
2. Bonding: Method by which all non-energized conductive materials are effectively interconnected to create a low impedance path.

C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.

1. National Electrical Contractors Association (NECA)
   a. NECA 331 – Standard for Building and Service Entrance Grounding and Bonding

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Field quality-control reports. Provide test reports for each test specified in the field quality control section. Include copies of current equipment calibration certification.

C. Closeout Submittal:
1. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.
2. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
   a. Instructions for periodic testing and inspection of grounding systems and features based on NETA MTS and NFPA 70B.
      1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
      2) Include recommended testing intervals.
3. As-Built Data: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:
   a. Test wells.
   b. Grounding electrodes and connections.
   c. Grounding arrangements and connections for separately derived systems.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency acceptable to authorities having jurisdiction and marked for intended location and application.

B. Comply with NFPA 70 and UL 467 for grounding and bonding materials and equipment.

2.2 MANUFACTURERS:

A. Subject to compliance with requirements, provide products by one of the following:
1. ABB Blackburn
2. Eaton B-Line
3. Harger
4. Hubbell Burndy
5. Ilsco
6. nVent Erico
7. Panduit
8. VFC Lyncole

2.3 CONDUCTORS

A. Insulated Copper Conductors: Comply with Section 260519 “Low-Voltage Electrical Power Conductors and Cables”.

B. Bare Copper Conductors:
1. Solid Conductors: ASTM B 3.

2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.

C. Straps/Jumpers: Copper tape, braided conductors pre-terminated with copper ferrules, cross-sectional area no less than a No. 6 AWG conductor.

2.4 ELECTRICAL SYSTEM BUSBARS

A. Grounding Busbar: Predrilled rectangular bars of annealed copper, minimum 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Size busbar length to accommodate initial conductor installation plus a 50% growth factor. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 1000 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.5 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Welded Connectors: Exothermic-welding kits consisting of graphite molds, copper oxide and aluminum weld metal, and electronic ignition system. Provide types recommended by kit manufacturer for materials being joined and installation conditions.

C. Irreversible Compression Connectors: Tin-plated copper, for installation using a hydraulic compression tool and die matched to connector type. Provide with die code or other visual indicator to ensure proper connector selection and uniform compression for a permanent connection.

1. Taps: C-type, H-type, or Figure 6/8 type.
2. Splices: Long Barrel straight or tee.
3. Terminals: Two-hole lug long barrel type.

D. Mechanical Connectors: Tin-plated high strength copper alloy or high strength cast bronze
1. Water Service Pipe Clamps: Heavy-Duty, two-piece saddle type with stainless steel bolts.
2. Pipe Clamps: Heavy-Duty, U-bolt type with silicon bronze hardware.
3. Lay-in Lug Connector: Heavy-Duty, open face lug with hex head set screw.

2.6 GROUNDING ELECTRODES

A. Ground Rods: 10 mil pure electrolytic copper coating with molecular bond to high strength steel core; 3/4 inch by 10 feet with chamfered end. Ensure ground rods are die-stamped near the top with the name and trademark of the manufacturer and the length in feet.

B. Enhanced Composite Backfill: Electrically conductive, environmentally safe, maintenance free backfill material with neutral PH properties that creates a stable, non-corrosive, low resistance connection between a grounding electrode and earth. Basis of Design: Erico Ground Enhancement Material (GEM).

C. Test Well: Lightweight polymer concrete, Tier 15 rated, non-slipcover, suitable for non-deliberate incidental traffic. 12-inch by 12-inch minimum, 12-inches deep unless noted otherwise, with “GROUND” legend unless noted otherwise.

PART 3 - EXECUTION

3.1 GENERAL

A. Bond grounding bus and all non-current carrying metallic parts of raceways systems and equipment to common ground in accordance with the National Electrical Code, NECA 331, as shown on the Contract Drawings, and in accordance with the requirements of the local authority having jurisdiction.

B. The size of the grounding and bonding conductors shall be not less than that given in Article No. 250 of the National Electrical Code, and/or as shown on the Contract Drawings.

C. Interconnect all grounding systems in or on the structure to provide a common ground potential.

D. Bond all outlet, junction, pull boxes, and enclosures to the equipment grounding conductor with a grounding pigtail.

3.2 APPLICATIONS

A. Conductors: Install solid conductor for #10 AWG and smaller, and stranded conductors for #8 AWG and larger unless otherwise indicated.

1. Install bare conductors where not specifically identified as bare or insulated except where installed in conduit with associated phase conductors. Install insulated conductors in conduit with insulation of the same material as the associated phase conductors with which it is installed.
2. Provide insulated conductors not exceeding No. 8 AWG in size with green colored insulation. Identify conductors larger than No. 6 AWG with 4-inch green tape at each termination and at all junctions and pull boxes.

B. Underground Grounding Electrode Conductors: Install bare copper conductor, sized per NEC, or as indicated on drawings, whichever is larger.

1. Bury at least 24 inches below grade or below the frost line depth, whichever is greater.
2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.

C. Electrical System Grounding Busbar: Install in electrical rooms housing service equipment, and elsewhere as indicated to provide a common connection point for individual grounding electrode conductors and bonding jumpers.

1. Install bus horizontally, on insulated spacers 4 inches minimum from wall, 18 inches above finished floor unless otherwise indicated.
2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.
3. Provide green laminated plastic nameplate with 1/2" high white letters indicating function of ground bus (i.e., “Service Main Ground Busbar”).

D. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Connections: Mechanical connectors.
2. Underground and Exposed Exterior Connections: Exothermic welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Mechanical connectors.
4. Connections to Structural Steel: Exothermic welded connectors.
5. Connections to Busbars: Irreversible compression connectors.

3.3 GROUNDING AT THE SERVICE

A. Equipment grounding conductors and grounding electrode conductors shall be connected to the neutral bus except where service equipment neutral and ground bussing complies with exceptions listed in the NEC. Install a main bonding jumper between the neutral bus and ground bus. Provide external grounding busbar and install grounding electrode conductor to interconnect main grounding busbar and neutral bus.

B. Where ground fault protection is installed, ensure interconnection of neutral bus and ground bus does not interfere with correct operation of fault protection.

3.4 GROUNDING SEPARATELY DERIVED SYSTEMS

A. Transformers: Provide grounding in accordance with the NEC and the following:

1. System Bonding Jumper (SBJ): Install at the source enclosure between the grounded terminal (neutral) and the equipment grounding terminal.
2. Supply Side Bonding Jumper (SSBJ): Install wire type SSBJ to bond the source enclosure to the enclosure at the first disconnect or overcurrent protective device.
3. Grounding Electrode Conductor (GEC): Install at the source enclosure from the SBJ connection point to the building grounding electrode system.
4. Bonding Jumpers: Where the metal water piping and/or the metal structural steel building frame in the area served by the separately derived system are not used as a grounding electrode, provide bonding jumper to the GEC connection point at the source enclosure.
5. Equipment Grounding Conductor (EGC): Bond the EGC of the primary feeder to the equipment grounding terminal.

3.5 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements for utility equipment.

B. Exterior Pad-Mounted Equipment: Install a minimum of two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with equipment by connecting them to underground grounding conductors and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

3.6 EQUIPMENT GROUNDING AND BONDING

A. Equipment Grounding Conductors: Install insulated equipment grounding conductors with all feeders and branch circuits. Provide conductors of the same wire/cable type as the ungrounded current carrying conductors.

B. Increase equipment grounding conductor sizes in accordance with NEC article 250 where ungrounded current carrying conductor sizes are increased to minimize voltage drop.

C. Provide all circuits with a dedicated equipment grounding conductor unless noted otherwise.

D. Provide an equipment grounding conductor to each outlet on circuits protected by a GFCI circuit breaker.

E. At all metallic outlet, junction and pull boxes, bond the equipment grounding conductor to the enclosure.

F. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

G. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

H. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

I. Metal Poles Supporting Outdoor Lighting Fixtures: Install a ground rod and a separate insulated equipment grounding conductor at each pole in addition to grounding conductor installed with branch-circuit conductors.

3.7 INSTALLATION

A. Grounding Electrode Conductors and Bonding Jumpers: Securely fasten and route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

1. Route conductors to maintain a downward or horizontal direction to ground with a minimum bend radius of 8-inches.
2. Protection: Install above grade conductors No 6 AWG or larger exposed to physical damage and all conductors smaller than No. 6 AWG in schedule 80 PVC conduit. Where metallic conduit is required, bond each conduit end to the electrode or ground conductor as close to the openings as possible with a full-size conductor and bonding bushing to create an electrically parallel path.
3. Clearance: Maintain a minimum separation of 12-inches from open telecommunications cable groups.

B. Bonding for Lightning Protection Systems: Where lightning protection systems are installed comply with NFPA70, NFPA 780, and UL 96 for bonding the lightning protection system grounding electrodes with the building grounding electrode system.

1. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor.
2. Do not use conductors and electrodes for grounding the lightning protection system in place of the grounding electrodes required by this specification and section 250.50 of NFPA 70.

C. Ground Rods: Auger 6 inch diameter hole to depth 6 inches shorter than the ground rod length. Drive rods a minimum of 12 inches into the bottom of the hole until tops are 12 inches below final grade. After installing connections, backfill around ground rod with enhanced composite backfill.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
2. Except at test wells, use exothermic welds for all below-grade connections to ground rods.
3. For grounding electrode system at the service, install at least three rods spaced at least two-rod lengths from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

D. Test Wells: Ground rod driven through drilled hole in bottom of handhole.

1. Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts. Install straps and jumpers such that it does not restrict movement of the structure to which it is connected.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

F. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes using a mechanical connector. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Other Metal Piping: Bond each aboveground portion of metal piping systems, including gas piping, downstream from its equipment shutoff valve in an accessible location.
4. Except for water piping, do not utilize piping systems as a ground path where dielectric fittings are utilized. Do not use bonding jumpers to bridge over such fittings.
5. Do not use underground portions of natural gas, flammable gas, or liquid fuel piping as grounding electrodes.

G. Grounding for Steel Building Structure:

1. Where the building’s steel frame is made discontinuous by masonry breaks or expansion joints, provide an accessible No. 500 kcmil bare copper jumper with exothermic weld connections to bond steel sections together, making the steel frame electrically continuous. The installation of the bonding jumpers shall be reviewed by the Engineer before covering.
2. Provide a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.

H. Concrete-Encased Grounding Electrode (Ufer Ground): Provide and fabricate in accordance with NFPA 70; use a minimum of 20 feet bare copper conductor no smaller than #4 AWG located in building footing that has direct contact with earth.

1. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.
2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts using exothermic weld connections. Extend grounding conductor below grade and connect to building's ground ring or to grounding electrode external to concrete.

I. Exothermic Welded Connections: Provide in kit form and selected for the specific types, sizes, and combinations of conductors and other items to be connected.

1. An electronic ignition system shall be used, and weld metal shall be a self-contained, sealed system with a bi-metallic fuse to start the reaction.
2. Comply with AWS Standards and manufacturer’s instructions for procedures, appearance, and quality of welds; and methods used in correcting welding work.
3. Ensure process joins all strands and does not cause the parts to be damaged or weakened.

4. Completed connection or joint must be equal or larger in size than the conductors joined and have the same current-carrying capacity as the largest conductor.

J. Mechanical Connections: Install mechanical connections in accessible locations.

1. Tighten connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values.
2. Where manufacturer's torqueing requirements are not indicated, tighten connections to comply with tightening torque values specified in UL 486A to assure permanent and effective grounding.

K. Connections between Dissimilar Metals: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.

1. Clean surfaces and apply anti-oxidant compound prior to installation of connections.
2. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
3. Make connections with clean, bare metal at points of contact.
4. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
5. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
6. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

3.8 FIELD QUALITY CONTROL

A. Buried or concealed grounding electrode systems shall be accepted by Engineer and Owner Representative before backfilling or covering.

B. Tests and Inspections:

1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
2. Bond Resistance Test: Test the bonding connections of the system using a certified micro-ohmmeter, taking two-point resistance measurements across each bond in the grounding electrode system. The maximum acceptable value of each bond is 0.5 milliohms.
3. After completing installation of the grounding electrode system and finished grade, but before permanent electrical circuits have been energized, test for compliance with requirements.
4. Grounding Electrode Resistance Test: Test completed grounding electrode system at service disconnect enclosure grounding terminal and at ground test wells using a manufacturer calibrated and certified 3-point ground resistance tester.

    a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    b. Perform tests by three-point fall-of-potential method according to IEEE 81.
    c. Disconnect and isolate the grounding electrode conductor from the electrical system at the main ground bus before testing.
    d. Install outer test probe outside the sphere of influence of the grounding electrode system. This value is typically 10 times the size of the grounding electrode system, between 300 and 500 feet from the main ground bus.
    e. Install inner test probe at 10 equally spaced intervals, in a straight line between the grounding electrode system connection and the outer test probe and note the resistance reading at each location.
    f. The resistance measurements taken from the flat part of the curve shall be averaged to determine the grounding electrode system resistance to earth.

g. If large variations are noted in the resistance measurements, the outer test probe should be relocated further from grounding electrode system (outside its sphere of influence) to achieve some degree of flatness on the resistance curve.

h. Excessive Ground Resistance: If resistance to ground exceeds 5-ohms, notify Engineer promptly and include recommendations to reduce ground resistance. If deemed necessary by the Engineer, additional electrodes shall be placed, and the measurement process repeated until the desired ground potential achieved.

5. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include test probe locations, observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

C. Grounding system will be considered defective if it does not pass tests and inspections.

D. Prepare detailed test and inspection reports and submit to Engineer for review.

END OF SECTION 260526

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SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 – General Requirements for Electrical Systems apply to this Section.

1.2 SUMMARY

A. This section is intended to specify the raceways, fittings, boxes, cabinets, specialties, and related items necessary to complete the work as shown on the drawings and specified herein.

B. Section Includes:

1. Metal conduits and fittings
2. Nonmetallic conduits and fittings
3. Surface metal raceway
4. Metal wireways and auxiliary gutters.
5. Boxes, enclosures, and cabinets
6. Wall ducts and trench ducts.

C. Related Requirements:

1. Refer to Division 07 firestopping section and Section 260010 “General Requirements for Electrical Systems” for penetration firestopping requirements related to electrical pathways and boxes.
2. Refer to Section 270528 “Pathways for Communications Systems” for supplemental pathway requirements related to communications systems.

1.3 REFERENCES

A. Abbreviations

1. EMT: Electrical Metallic Tubing
2. FMC: Flexible Metal Conduit
3. GRC: Galvanized Rigid Steel Conduit
4. IMC: Intermediate Metal Conduit
5. LFMC: Liquid-tight Flexible Metal Conduit.
6. RMC: Rigid Metal Conduit

B. Definitions

1. Outlet: A point on the wiring system at which current is taken to supply utilization equipment.
2. Raceway: an enclosed channel designed for enclosing and protecting electrical, communications, and signaling wires and cables.

C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.

1. National Electrical Contractors Association (NECA)
   a. NECA 101 - Standard for Installing Steel Conduits (RMC, IMC, EMT)
   b. NECA 111 - Standard for Installing Nonmetallic Raceways (RNC, ENT, LFNC)
2. National Electrical Manufacturers Association (NEMA)
   a. NEMA FB 2.10 - Selection and Installation Guidelines for Fittings for Use with Non-Flexible Metallic Conduit or Tubing (Rigid Metal Conduit, Intermediate Metal Conduit, and Electrical Metallic Tubing)
   b. NEMA FB 2.20 - Selection and Installation Guidelines for Fittings for Use with Flexible Electrical Conduit and Cable
   c. NEMA RV 3 - Application and Installation Guidelines for Flexible and Liquid-tight Flexible Metal Conduits

1.4 SUBMITTALS

A. Product Data: For each type of product.

B. Shop drawings: For custom enclosures, cabinets, or boxes.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

2.2 METAL CONDUIT AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. AFC Cable Systems, Inc.
2. Allied Tube & Conduit.
3. Anamet Electrical, Inc.
4. Calconduit
5. Electri-Flex Company.
6. Nucor Tubular Products.
7. O-Z/Gedney.
8. Picoma Industries.
9. Robroy Industries.
10. Southwire Company.
11. Thomas & Betts Corporation.
12. Western Tube and Conduit Corporation.
13. Wheatland Tube Company.

B. Electrical Metallic Tubing (EMT) and Elbows:

1. Comply with ANSI C80.3 and UL 797.

C. Galvanized Rigid Steel Conduit (GRC, RMC) and Elbows:

1. Comply with ANSI C80.1 and UL 6.
2. Zinc coating both inside and outside by means of hot-dip galvanizing.
3. Use only threaded fittings for GRC.

D. PVC Coated Galvanized Rigid Steel Conduit (GRC) and Elbows:

1. Comply with NEMA RN 1
2. Minimum 40 mil thick PVC exterior coating with overlapping sleeves protecting threaded joints.
3. Minimum 2 mil thick urethane interior coating.
4. Clear urethane coating over hot-dip galvanized threads.

E. Intermediate Metal Conduit (IMC) and Elbows:

1. Comply with ANSI C80.6 and UL 1242

F. Flexible Metal Conduit (FMC):

1. Comply with UL 1.
2. Continuous interlocked hot-dip zinc galvanized steel with smooth interior and exterior.
3. Suitable for dry locations.

G. Liquid-tight Flexible Metal Conduit (LFMC):

1. Comply with UL 360.
2. Continuous interlocked hot-dip zinc galvanized steel core with smooth interior and exterior.
3. Suitable for wet and dry locations, direct burial applications, and concrete encasement.
4. Sunlight resistant, flame retardant thermoplastic PVC jacket resistant to heat, oil, and chemical breakdown.

H. Metal Fittings

1. Comply with NEMA FB1 and UL 514B.
2. Listed and labelled for type of conduit, location, and use.
3. Fittings for EMT:
    a. Compression type, zinc-plated galvanized steel.
    b. Concrete-tight- or rain-tight, hardened steel locknuts, and nylon insulating throats.
4. Fittings for GRC and IMC:
    a. Threaded zinc plated steel.
    b. Concrete-tight- or rain-tight, nylon insulating throats.
5. Conduit Bodies:
    a. Material: gray iron or heavy copper-free cast aluminum
    b. Available in varying configurations with integral bushing and gasketed coverplate.
6. Expansion/Deflection Fittings: UL 651 listed, manufactured coupling accommodating 3/4-inch linear movement from normal and 30-degree angular movement in all directions
    a. Basis of Design: OZ/Gedney DX
    b. PVC or steel sleeve to match conduit type with neoprene jacket, rated for environmental conditions where installed.
    c. Integral braided copper bonding jumper.
7. Fittings for FMC and LFMC:
    a. LFMC: Tubular Steel, zinc-plated with gland nut, sealing ring, high tensile grounding ferrule, insulated throat, and body for liquid tight connection.
8. Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
9. “Kwik-Couple” type fittings are not permitted.
10. Indentation, set-screw, crimp type, or die-cast fittings are not permitted.

I. Joint Compound for threaded conduit: UL 2419 listed for use in conduit assemblies and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.3 NON-METALLIC CONDUITS AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Allied Tube & Conduit
2. Cantex
3. Carlon
4. Heritage Plastics
5. National Pipe & Plastics
6. Prime Conduit

B. Rigid Polyvinylchloride (PVC) Conduit:

1. Comply with NEMA TC-2 and UL 651.
2. Sunlight resistant and suitable for use with 90 degree C conductors.
3. Type EPC-40 suitable for normal duty applications.
4. Type EPC-80 suitable for heavy duty applications.

C. Non-Metallic Fittings

1. Comply with NEMA TC 3 and UL514B.
2. Listed and labelled for type of conduit, location, and use.
3. Compatible with conduit type and material.
4. Solvents and Adhesives: as recommended by conduit manufacturer.

2.4 SURFACE MOUNTED METAL RACEWAY

A. Manufacturers: Subject to compliance with requirements, provide products from one of the following:

1. Hubbell
2. Mono-Systems
3. Wiremold

B. Source Limitations: Obtain surface metal raceway, components, outlets, and fittings from single manufacturer.

C. Single and Multi-Channel Raceways:
1. Two-piece design with base and snap on cover complying with UL 5, suitable for use with electrical branch circuit wiring, data/voice network cabling, and low voltage wiring.
2. Material: Galvanized Steel
3. Finish: Manufacturer’s standard enamel finish in color selected by Architect, suitable for field painting to match adjacent surfaces.
4. Size: Available in varying widths, selected to accommodate number of conductors and services indicated on drawings with a maximum of 40-percent fill.

D. For multi-channel configurations, provide integral divider separating raceway into equal compartments for power and low voltage wiring.

E. Fittings: Include clips, straps, couplings, elbows, tees, connectors, and bushings suitable for interconnecting raceway segments in various configurations. Fittings to overlap raceway and hide uneven cuts. Material and finish to match raceway.

F. Device Boxes: single and multi-gang configurations, suitable for mounting standard devices and faceplates. Material and finish to match raceway.

G. Device Plates: sized to match raceway width with openings suitable for mounting various standard power and communications devices. Material and finish to match raceway.

H. Device Brackets: suitable for mounting standard single or two-gang devices horizontally or vertically within large raceways.

I. Plugmold: steel surface metal raceway with integral Simplex NEMA 5-20R outlets spaced 12-inches on center or as indicated on drawings.

2.5 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Eaton B-Line
2. Hubbell Wiegmann.
3. nVent Hoffman.
4. Square D.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise required by environmental application, and sized according to NFPA 70. Minimum of 14-gauge steel before finishes are applied.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for a complete system.

1. Provide knockouts on all runs, unless otherwise indicated or prohibited by codes.
2. Provide dividers to separate conductors of different insulation levels or where required by equipment vendor installation instructions.

D. Wireway Covers: Furnish with continuous hinged covers on all runs and removable covers on all fittings unless otherwise noted, to allow a continuous unobstructed path for conductor installation.

E. Finish: Manufacturer's standard enamel finish resistant to corrosion, moisture, and oil.

F. Size: available in nominal sizes 2-1/2-inch by 2-1/2-inch, 4-inch by 4-inch, 6-inch by 6-inch or 12-inch by 12-inch.

G. Install supports to allow unobstructed access to wireway interior. Use minimum 1/4-inch rod hangers for up to 4-inch by 4-inch wireway, 3/8-inch rod up to 8-inch by 8-inch wireway, and 1/2-inch rod for 12-inch by 12-inch wireway.

2.6 BOXES, ENCLOSURES, AND CABINETS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Eaton Crouse-Hinds.
2. Emerson/Appleton Electric.
3. FSR Inc.
4. Garvin Industries
5. Hoffman.
6. Hubbell Killark.
7. Milbank Manufacturing Co.

8. Mono-Systems, Inc.
9. O-Z/Gedney.
10. RACO / Hubbell.
11. Stahlin Non-Metallic Enclosures.
12. Thomas & Betts.
13. Wiremold / Legrand.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets shall be listed for intended use.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy or aluminum, Type FD, with gasketed cover.

E. Luminaire Outlet Boxes: Non-adjustable, designed for attachment of luminaires, listed, and marked for the maximum allowable weight with at least a 2.0 safety factor for the anticipated fixture weight.

F. Paddle Fan Outlet Boxes: Nonadjustable, designed for attachment of paddle fan weighing 70 lb.

G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1, constructed of code gauge, galvanized steel with sides formed and corner seams riveted or welded before galvanizing

H. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.

I. For box extensions and mud rings used to accommodate building finishes, provide with same material as recessed box.

J. Minimum Device Box Dimensions unless noted otherwise:

1. Single gang: 4-inches square by 2-1/8-inches deep with single gang extension ring.
2. Two gang: 4-inches square by 2-1/8-inches deep with two-gang extension ring.
3. Three gang: 8-5/8-inches by 4-1/2-inches by 2-1/2-inches deep with three gang extension ring.
4. Four gang: 10-7/16-inches by 4-1/2-inches by 2-1/2-inches deep with four gang extension ring.

K. Gangable boxes are prohibited.

L. Boxes assembled with sheet metal screws are prohibited.

M. Hinged Cover Enclosures: Comply with UL 50 and NEMA 250, suitable for installed environment with continuous-hinge cover and flush latch unless noted otherwise.

1. Metal Enclosures: Steel, finished inside and out with manufacturer’s standard enamel.
2. Nonmetallic Enclosures: Fiberglass
3. Interior Panels: Steel, all sides finished with manufacturer’s standard enamel.

N. For kitchen and serving line receptacles, provide cast-type, gasketed “bell box”. NEMA FB 1, cast ferrous alloy with threaded hubs.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Unless more stringent requirements are specified in Contract Documents or manufacturers' written instructions, comply with NFPA 70 for selection of raceways. Consult Architect for resolution of conflicting requirements.

B. Apply raceway products as specified below unless otherwise indicated:

1. Refer to Section 260543, “Underground Ducts and Raceways for Electrical Systems” for additional requirements related to raceways installed underground outside of the building footprint.
2. Exterior and Exposed: GRC
3. Concealed Underslab: PVC Type EPC-40 where approved.
4. Concealed Underslab with conductors above 600V: Concrete encased PVC Type EPC-40 where approved.
5. Interior, Concealed in Ceilings, Walls, and Partitions where 8ft or move above finished floor: EMT
6. Interior, Concealed in Ceilings, Walls, and Partitions where less than 8ft above finished floor: IMC, or GRC
7. Interior, Concealed in Concrete or Grouted Masonry Walls and Partitions: IMC or GRC
8. Interior, Damp or Wet Locations: GRC
9. Interior, Where exposed and Not Subject to Physical Damage: EMT, GRC, or IMC. Raceway locations include the following:
    a. Electrical Rooms
10. Interior, Where Exposed and Subject to Severe Physical Damage: GRC. Raceway locations include the following:
    a. Loading dock.
    b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
    c. Mechanical rooms (below 8’-0”).
    d. Gymnasiums.
11. Interior, where Exposed in washdown area and Subject to Severe Physical Damage: PVC Coated GRC. Raceway locations include the following:
    a. Exposed stub-ups in Commercial/Institutional Kitchen or Cafeteria.
12. Conductors operating above 600V: GRC
13. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
14. Connection to ceiling mounted recessed and semi-recessed luminaires and electrical devices: FMC.
15. Boxes and Enclosures: NEMA 250, Type 1 except as follows:
    a. Damp or Wet locations: NEMA 250, Type 3R
    b. Commercial/Institutional Kitchens and Cafeterias: NEMA 250, Type 3R
    c. Corrosive environments: NEMA 250, Type 4X
16. Exposed Boxes subject to physical damage: Die cast metal boxes with threaded hubs.
17. EMT is not permitted underslab, embedded in concrete slabs, or where exposed to physical damage.
18. Non-metallic conduit is not permitted for the following applications unless approved by the Engineer:
    a. Interior Locations including environmental air plenums.
    b. Applications where a redundant ground fault path is required by code.
19. Flexible non-metallic conduit is not permitted.
20. Unless otherwise indicated on the drawings, intermediate metal conduit (IMC) may be used in any location in place of rigid galvanized steel conduit (GRC), where permitted by codes, and where approved by the Engineer.

C. Minimum Raceway Size: 3/4-inch trade size unless noted otherwise on the drawings.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
3. EMT: Use compression, steel fittings. Comply with NEMA FB 2.10.
4. Flexible Conduit: Use only steel fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth or where prolonged contact with construction materials will degrade the aluminum.

F. Install raceways and fittings in a manner to avoid use of dissimilar metals that would result in galvanic action corrosion.

G. Install surface conduits or raceways only where indicated on Drawings.

H. Do not install surface conduits or raceways on exterior facades unless approved by Engineer.

I. Do not install nonmetallic conduit where ambient temperature or operating temperature of the conductors exceeds the rating of the raceway.

J. Conduit installed embedded in concrete slabs is not permitted.

3.2 RACEWAY INSTALLATION

A. Comply with requirements in Section 260500 "Common Work Results for Electrical Systems" for hangers and supports.

B. Comply with NECA 1, NECA 101, NECA 111 and manufacturer’s written instruction for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

C. Complete raceway installation before starting conductor installation.

D. Comply with utility company requirements for raceways and boxes containing utility company conductors.

E. Size raceways to conform with Annex C, of the National Electrical Code, unless otherwise shown on the Contract Drawings.

F. Level and square raceway runs and install at proper elevations and required heights. Hold tight to structure wherever possible, to maximize available space and not restrict other trades.

G. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated.

H. Install conduits with runs parallel or perpendicular to building lines, walls, structural members or intersections of vertical planes and ceilings, with right angle turns consisting of cast metal fittings or symmetrical bends unless otherwise shown. Randomly routed conduits are not acceptable.

I. Make bends in raceway using large-radius preformed elbows. Provide concentric bends for parallel runs of conduit. Conform with NFPA 70 minimum radii requirements for field bending. Use only equipment specifically designed for material and size involved.

J. Install no more than the equivalent of three 90-degree bends in any conduit run. Support within 12-inches of changes in direction.

K. Provide junction boxes or pull boxes so that conduit runs do not exceed 100 feet, or as shown on the Contract Drawings. Size junction boxes per NEC, Article 370.

L. Provide conduit supports spaced not more than 8-feet apart.

M. Support conduit within 12-inches of enclosures to which attached.

N. Do not drill into bar joists to support raceways or cables.

O. Install conduits at least 12-inches away from flues, steam, or hot water pipes.

P. Conduit installed under concrete slabs is permitted for feeders and for branch circuits serving floor outlets. Underslab conduit is prohibited for other locations unless noted on the drawings or with permission of the engineer. Where approved, comply with the following:

1. Locate raceway a minimum of 12-inches below the bottom of slab.
2. Provide minimum 2-inch spacing between conduits to ensure proper compaction of structural fill.
3. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
4. Transition underslab RNC to GRC for all bends larger than 20-degrees and for all stub-ups through a slab on grade. Arrange stub-ups so curved portions of bends are not visible above finished slab. Extend GRC stub-ups a minimum of 6” above the concrete slab. Schedule 80 PVC stub-ups are allowed where approved by engineer.
5. Seal around conduits when penetrating vapor barriers.
6. Where installed in corrosive soils, coat all underslab rigid steel conduit with two coats of bitumastic paint such as "Asphaltum".

Q. Where raceways are subject to environmental changes, locate seals immediately at the boundary so no fittings or boxes are between the seal and the change of environments that would allow migration of condensation within the raceway system. Seal the interior of all raceways at the following points:

1. Where conduits pass from cold to warm locations, such as boundaries of refrigerated spaces and at building wall and roof penetrations.
2. Where an underground service raceway enters a building or structure.
3. Conduit extending from interior to exterior of building.
4. Conduit extending into pressurized duct and equipment.
5. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
6. Where otherwise required by NFPA 70.

R. Install conduits in a manner so as to ensure against collection of trapped condensation. Arrange all runs of conduit so as to be devoid of traps. Provide trapped conduit runs with explosion proof drains at low points.

S. At hazardous locations, install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed non-shrink sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces.

T. Coordinate with other trades, including metal and concrete deck trades, as necessary to interface installation of electrical raceways and components.

U. Complete installation of electrical raceways before starting installation of cables or wires within raceways.

V. Take precautions to prevent the lodgment of dirt, plaster, or trash in all conduit or tubing, fittings, and boxes during construction. Use mandrel to clean all conduit for floor boxes or conduit below grade and ensure its swabbed free of debris or moisture before wiring is installed.

W. Unless using GRC, do not locate conduits, cables, raceways, and enclosures within 2 inches of bottom of metal-corrugated sheet roof decking, measured from the lowest surface of the roof decking to the top of the conduit, cable, raceway, or box.

X. Conduits, cables, raceways, and enclosures are not permitted in concealed locations of metal-corrugated sheet decking type roofing.

Y. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72-inches of flexible conduit for ceiling mounted recessed and semi-recessed luminaires, and 36-inches for all other equipment subject to vibration, noise transmission, or movement, and for transformers and motors.

1. Install as a single piece with clamp-on insulated throat connectors designed for the purpose.
2. Provide strain relief fittings where subject to vibration.
3. Provide an equipment grounding conductor and bonding jumper at all locations.
4. For LFMC, provide a minimum of 18-inches and loop to avoid restraining vibrating equipment.

Z. Stub-ups to Accessible Ceilings:

1. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or into an enclosure.
2. Where conduits terminate at a cable tray pathway, provide listed fitting to secure conduit to cable tray.

AA. Mechanically fasten conduit terminations at a wireway, provide metal insulated bushings, and bond to the wireway with bonding jumper.

BB. Furnish conduit bodies in proper configurations, avoiding excessive openings. Any openings that are left shall be properly plugged. Wiring splices within conduit bodies are not permitted.

CC. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

DD. Provide a completely separate raceway system, including junction boxes and pull-boxes, for each emergency power, optional stand-by, and normal power system for complete separation in accordance with NEC.

EE. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of secured slack at each end of pull wire. Secure pull string at each end and cap raceways.

FF. Coordinate with vendors and provide extra pull-strings as required to ensure sufficient number of pull strings.

GG. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length. Ream inside of conduit to remove burrs.

HH. Raceway Fittings: Install fittings in accordance with NEMA FB 2.10 guidelines

1. Install raceways square to enclosures and terminate with appropriate fitting:

2. For enclosures without hubs, terminate with appropriate fitting, insulated throat liner, and case-hardened locknuts on both sides of enclosure wall.
3. Terminate rigid conduits with threaded hubs or with locknuts on inside and outside of enclosure and insulated throat metal bushing.
4. Install locknuts hand tight, plus one-quarter turn more.
5. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.
6. All threaded fittings shall engage a minimum of seven full threads. Fasteners shall be properly torqued to manufacturer's recommendations.
7. Split sleeve insulators are not permitted.

II. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

JJ. Expansion-Joint Fittings:

1. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
2. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

KK. Where raceways penetrate rooms or walls with acoustical requirements, seal raceway openings on both sides of penetration with acoustically rated putty or sealant.

LL. Surface Raceways:

1. Provide surface metal raceways where indicated on drawings or approved by the Engineer.
2. Provide all trim and cover fittings, flush feed boxes, splices, and outlet fittings necessary for a complete installation.
3. Provide multi service raceway with divider for locations that require power and low-voltage wiring.
4. Install surface raceway with a minimum 2-inch radius control at bend points.
5. Secure surface raceway with two-hole straps at intervals not exceeding 24-inches and within 6-inches of boxes, transitions, and turns. Provide no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.
6. Provide box connector and junction box immediately above ceiling for transitioning raceway to conduit.

3.3 BOX AND ENCLOSURE INSTALLATION

A. Provide electrical outlets and enclosures as required for splices, taps, wire pulling, and equipment connections.

B. Provide pull boxes as required to maintain conduit run and bend limitations specified herein.

C. Size all outlets, pull boxes, junction boxes, cabinets, etc., per adopted edition of the National Electrical Code.

D. Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

E. Install interior and exterior outlet boxes recessed in building construction with face or cover flush with finished surfaces unless noted otherwise. Where outlet boxes are installed in walls of glazed tile, brick, concrete block, or in walls covered by wood wainscot or paneling, provide deep box to ensure the outlet boxes are installed straight and secure in walls.

F. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements and architectural elevations. Install boxes with height measured to center of box unless otherwise indicated.

G. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box. Do not split the mortar joint

H. Provided 3/4-inch rigid conduit pendants where lighting fixtures, appliances, or wiring devices are to be suspended from ceiling outlet boxes. Outlet boxes shall be malleable iron, provided with self-aligning covers with swivel ball joint and #14 gauge steel locking ring. Provide safety chain between building structure and housing for all fixtures, appliances, or devices greater than 10 lbs. weight. Install fixtures plumb and level. Cover pendants shall be finished to match fixtures.

I. Horizontally separate boxes mounted on opposite sides of walls, so they are not in the same vertical channel.

J. Locate boxes so that cover or plate does not span different building finishes.

K. Provide spanner bars to support all boxes from more than one side by spanning two framing members.

L. Fasten boxes up to 4-11/16 square size to their mounting surface or support with two fasteners of proper size. Fasten larger sizes with four fasteners, minimum.

M. Support boxes recessed in ceilings independent of ceiling tiles and ceiling grid.

N. Fasten junction and pull boxes to, or support from, building structure. Do not support boxes by conduits or ceiling support wires.

O. Provide all cabinets and boxes for NEMA 1 applications with knockouts, as necessary, or field cut with approved cutting tools which will provide a clean, symmetrically cut opening to maintain UL listing of enclosure.

P. Replace any unused knockouts or openings with a listed knockout closure.

Q. Coordinate with equipment vendors to provide special sized outlet boxes to support installed equipment.

R. Where boxes and enclosures are located in areas or on walls with acoustical requirements, seal openings and knockouts in back and sides of boxes with acoustically rated putty or sealant and provide gasket for wall plates and covers.

3.4 GROUNDING AND BONDING

A. Comply with requirements in Section 260526 “Grounding and Bonding for Electrical Systems”.

B. Bond all metal boxes, junction boxes and pull boxes with pigtails to the equipment grounding conductor.

C. Provide insulated throat grounding bushings with appropriately sized bonding jumpers for the following locations to maintain electrical continuity between the raceway and enclosure:

1. Metal raceways and enclosures that contain service conductors.
2. Metal raceways and enclosures that contain grounding electrode conductors.
3. Where metal raceways containing circuits over 250V terminate in a concentric or eccentric knockout at cabinets, enclosures, or sheet metal pull boxes listed in accordance with UL 50.

4. Where the integrity of a concentric or eccentric knockout has been compromised.
5. Metal raceways and enclosures that contain feeders.

3.5 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.
   1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
   2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

B. Protect threads on conduits and fittings with plastic protectors or other means to prevent damage prior to installation.

C. Provide protection for all conduit stubbed through floor during construction with plastic caps approved for this purpose.

3.6 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

B. Identify all junction, outlet and pull boxes in data/mechanical/electrical rooms and above ceilings with panel and circuit designation on outside of covers. Identify all exposed junction, outlet and pull boxes in finished areas with panel and circuit designation on inside of covers.

C. Provide black finish for exposed raceways and junction boxes in theaters.

D. Conduit Color Coding
   1. Concealed or Non-finished Spaces: Apply color coding to concealed raceway in all spaces and exposed raceway in non-finished areas.
   2. In finished areas exposed conduits shall be painted to match the finishes in the space. Conduit shall be color banded at intervals not to exceed 10 feet. Utilize natural galvanized finish conduit for conduit that is to be painted and banded. Junction boxes covers shall be painted according to color coding below.
   3. Finish: EMT shall have a factory applied finish, RGS conduit shall be field
   4. painted.
   5. Color Coding:
      a. Electrical Conduit (240 and 208 V): Natural galvanized finish
      b. Electrical Conduit (480V): Black
      c. Fire Alarm Raceway: Red.
      d. Telecom & A/V Raceway: Natural galvanized finish.
      e. Security System Raceway: Purple.
      f. Emergency Feeder/Branch Circuit Raceway: Orange.
      g. Stand-by Feeder/Branch Circuit Raceway: Green.

3.7 PAINTING

A. Raceways installed in exterior locations shall receive one coat of primer, two coats finish paint after preparation of galvanizing, color selected by Architect.

B. Exposed raceways in painted interior areas shall be painted to match adjacent finishes.

END OF SECTION 260533

SECTION 260543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Direct-buried and concrete-encased conduits, ducts, and duct accessories.
2. Handholes and boxes.
3. Utility Structure accessories.

B. Related Requirements:

1. Refer to Section 260533 “Raceways and Boxes for Electrical Systems” for pathway requirements installed under building slabs.

1.3 REFERENCES

A. Abbreviations

1. GRC: Galvanized rigid conduit.
2. IMC: Intermediate metal conduit.
3. RNC: Rigid nonmetallic conduit.

B. Definitions

1. Backfill: Earth or other controlled material placed in trenches for filling and grading back to a finished state.
   a. Initial Backfill (encasement): Backfill placed beside and over conduit arrangements in a trench, including haunches to support sides of conduits.
   b. Final Backfill: Backfill placed over initial backfill to fill a trench.
2. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying conduit.
3. Duct: A single or multiple underground conduits encased in concrete or direct buried.
4. Duct Bank: An arrangement of two or more ducts installed together.
5. Encasement: Material placed around a duct or duct bank to provide additional protection.
6. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.

1. National Electrical Manufacturers Association (NEMA):
   a. NEMA TCB-2 “Guidelines for the Selection and Installation of Underground Nonmetallic Raceways”.

1.4 SUBMITTALS

A. Product Data: For each type of product.

B. Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures along with dimensions from buildings or other benchmarks.

1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.

C. Field quality-control reports including digital photographs of all concealed work.

D. Closeout Submittals

1. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", ensure all utilities, structures, and underground conduits are surveyed and recorded on as-built drawings.

1.5 FIELD CONDITIONS

A. Ground Water: Assume ground-water level is at grade level unless a lower water table is noted on Drawings.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with IEEE C2 and NFPA 70.

2.2 CONDUITS AND FITTINGS

A. Comply with 260533 “Raceways and Boxes for Electrical Systems”.

2.3 DUCT ACCESSORIES

A. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and size of ducts with which used, and selected to provide minimum duct spacing indicated while supporting ducts during encasement or backfilling.

B. Fabric Innerduct: Continuous, nylon resin polyester, multi -pocket fabric innerduct, with internal pull tape. Maxcell or equal.

C. Pull Line: Flat, woven, polyester or polyaramid tape, low stretch, pre-lubricated for reduced friction. Strength suitable for required pulling tensions with a minimum of 200-lb. Muletape or equal.

D. Underground Detectable Warning Tape: Flexible tape constructed with solid aluminum foil backing and clear film laminate, 6-inches wide, 5-mil overall thickness.

1. Suitable for the method of installation and locating underground utility lines.

2. Chemically inert tape material and ink, resistant to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.
3. Comply with APWA Uniform Color Code.
4. Inscriptions for Red-Colored Tapes: "CAUTION BURIED ELECTRIC LINE BELOW".
5. Inscriptions for Orange-Colored Tapes: “CAUTION BURIED COMMUNICATIONS LINE BELOW”.

E. Duct Sealants: Re-enterable, two-part, closed-cell urethane foam capable of sealing conduits with multiple cable configurations.

1. Capable of withstanding temperatures from -40 deg F to 200 deg F and holding 22 feet waterhead pressure continuous.
2. Chemically resistant to gasoline, oils, dilute acids, and bases.
3. Compatible with cable jacket and shall not affect the physical or electrical properties of wire and cable.
4. Workable at temperatures as low as 35 deg F.
5. UL94 Class HBF fire retardant rating.

2.4 POLYMER CONCRETE HANDHOLES AND BOXES

A. Description: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Armorcast
2. NewBasis
3. Oldcastle
4. Hubbell Quazite

C. General Requirements:

1. Comply with SCTE 77. Minimum Tier 15.
2. Color: Gray.
3. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering, as indicated for each service.

2.5 PRECAST CONCRETE MANHOLES AND HANDHOLES

A. Description: Factory fabricated, one-piece units and units with interlocking mating sections, complete with accessories, hardware, and features. Frame and cover shall have load rating consistent with that of structure.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Christy Concrete Products
2. Oldcastle
3. Utility Concrete Products
4. Utility Vault Co

C. Comply with ASTM C 858.

D. Precast reinforced-concrete, H-20 structural load rating according to AASHTO HB 17.

E. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks, plus an additional 12 inches vertically and horizontally to accommodate alignment variations.

1. Locate windows no less than 6 inches from interior surfaces of walls, floors, or roofs of structure, but close enough to corners to facilitate racking of cables on walls.
2. Provide window opening with cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
3. Provide window opening frame with at least two additional No. 3 steel reinforcing bars in concrete around each opening.
4. Provide windows 1-1/2 to 2 inches thick.

F. Duct Entrances in Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.

1. Type and size shall match fittings to duct or conduit to be terminated.
2. Fittings shall align with elevations of approaching ducts and be located near interior corners of structures to facilitate racking of cable.

G. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

H. Provide ventilation openings where indicated on drawings.

I. Frames, Covers, and Chimney Components: Comply with structural design loading specified for structure.

1. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48/A 48M, Class 35 cast iron with milled cover-to-frame bearing surfaces; diameter, 32 inches.
   a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
   b. Special Covers: Recess in face of cover designed to accept finish material in paved areas.
2. Cover Legend: Cast in. Selected to suit system.
   a. All covers shall be provided with 2 inch lettering and with the structure number, assigned by Owner, welded onto the cover if not provided by the manufacturer.
   b. All covers shall be provided with stainless steel drop handles.
3. Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.
   a. Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. (60 L) where packaged mix complying with ASTM C 387, Type M, may be used.
   b. Seal joints watertight using preformed plastic or rubber conforming to ASTM C 990. Install sealing material according to the sealant manufacturers' printed instructions.

J. Sump Frame and Grate: ASTM A 48/A 48M, Class 30B, gray cast iron.

K. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch diameter eye, and 1-by-4 inch bolt.
1. Working Load Embedded in 6-Inch, 4000-psi Concrete: 13,000-lbf minimum tension.

L. Pulling-In and Lifting Irons in Concrete Floors: 7/8-inch diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.
1. Ultimate Yield Strength: 40,000-lbf shear and 60,000-lbf tension.

M. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch ID by 2-3/4 inches deep, flared to 1-1/4 inches minimum at base.

N. Tested Ultimate Pullout Strength: 12,000 lbf minimum.

O. Ground Rod Sleeve: 3-inch, PVC conduit sleeve in floors 2 inches from the wall adjacent to, but not underneath, the ducts routed from the facility.

P. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch bolt, 5300-lbf rated pullout strength, and minimum 6800-lbf rated shear strength.

Q. Cable Rack Assembly: Steel, hot-dip galvanized, except insulators.
1. Stanchions: T-section or channel; 2-1/4-inch nominal size; punched with 14 holes on 1-1/2-inch centers for cable-arm attachment.
2. Arms: 1-1/2 inches wide, lengths ranging from 3 inches with 450-lb minimum capacity to 18 inches with 250-lb minimum capacity. Arms shall have slots along full length for cable ties and be arranged for secure mounting in horizontal position at any vertical location on stanchions.
3. Insulators: High-glaze, wet-process porcelain arranged for mounting on cable arms.

R. Fixed Ladders & Extension: Arranged for attachment to wall of manhole. Ladder and mounting brackets and braces shall be fabricated from hot-dip galvanized steel.

2.6 SOURCE QUALITY CONTROL

A. Test and inspect precast concrete utility structures according to ASTM C 1037.

B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
1. Tests of materials shall be performed by an independent testing agency.
2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification, complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 PREPARATION

A. Coordinate layout and installation of ducts, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there are obstructions or conflicts between areas of excavation and existing structures or archaeological features to remain.

B. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of ducts and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Architect.

C. All necessary precautions shall be taken by the contractor during construction to prevent the lodging of dirt, plaster or trash in all conduit, tubing, fittings and boxes.

3.2 UNDERGROUND DUCT APPLICATION

A. Apply underground duct products as specified unless noted otherwise:

1. Refer to Section 260533, “Raceways and Boxes for Electrical Systems” for additional requirements related to underground conduit below building slabs.
2. Ducts for Utility Company primary conductors: comply with utility company standards unless noted otherwise.
3. Ducts for Electrical Service Secondary Conductors: RNC, Type EPC-40 PVC, in concrete-encased duct bank unless otherwise indicated.
4. Ducts for Electrical Cables greater than 600 V: RNC, Type EPC-40 PVC, in concrete-encased duct bank unless otherwise indicated.
5. Ducts for Electrical Feeders 600 V and Less: RNC, Type EPC-40 PVC, in concrete-encased duct bank unless otherwise indicated.
6. Ducts for Electrical Branch Circuits: RNC, Type EPC-40 PVC, in direct buried duct bank unless otherwise indicated.
7. Ducts for Communications Cables: RNC, Type EPC-40 PVC, in direct buried duct bank unless otherwise indicated.
8. Underground Ducts 600V and less Crossing Driveways and Roadways: RNC, Type EPC-40-PVC, encased in reinforced concrete. Extend reinforcement a minimum of 5-feet beyond the edge of paved surfaces.

B. Minimum Cover Requirements: Provide reinforced concrete encasement where minimum depths are not achievable.

1. Electrical Primary or Conductors more than 600V: 48-inches unless otherwise indicated by utility company requirements.
2. Electrical Secondary Service and Feeders: 36-inches
3. Electrical Branch Circuits: 24-inches
4. Communications: 30-inches

C. Transition RNC to GRC for all stub-ups and building enclosure penetrations. Use fittings manufactured for RNC-to-GRC transition.

1. Arrange stub-ups so curved portions of bends are not visible above grade. Increase burial depth where required to maintain cover for curves and bends.
2. Do not use steel raceways for equipment stub-ups where prohibited by utility company standards.

D. Minimum Underground Raceway Size: 1-inch trade size unless noted otherwise on the drawings.

3.3 EARTHWORK

A. Contractor shall accept the site as they find it and remove all trash, rubbish, and material from the site prior to starting excavation work.

B. Subsurface Data

1. Subsurface investigations have been performed and the results provided with the contract documents. The information was obtained primarily for use in preparing foundation design. Each contractor may draw their own conclusions therefrom. No responsibility is assumed by the Owner for subsoil quality or conditions other than at the locations and at the time the investigations were made.
2. Materials to be excavated shall be unclassified, and shall include earth, rock, or any other material encountered in the excavation to the depth and extent indicated on the drawings and specified herein. No adjustment in the contract sum will be made on account of the presence or absence of rock, shale, or other materials encountered in excavating.

C. Benchmarks and Monuments

1. Carefully maintain all benchmarks, monuments, and other reference points. If disturbed or destroyed, replace as directed.

D. Excavation:

1. Remove rock by using hand or power tools only. Blasting is not permitted unless authorized in writing by the Architect.
2. Any damage to existing structures, exterior services, or rock intended for bearing shall be corrected by the Contractor at their own expense.
3. Take necessary precautions to control runoff of eroded earth onto the property of others or against the structures. All such damage or any other damage incurred in the course of excavation, shall be corrected by the Contractor at their own expense.

E. Trenching:

1. Cut trenches neatly and uniformly. Work with extreme care near existing ducts, conduits, and other utilities to avoid damaging them.
2. Width: Excavate trench a minimum of 3 inches wider than duct bank on each side with a minimum trench width of 12-inches.
3. Depth: Excavate to a minimum depth that equals ductbank height plus minimum cover requirements.
4. Hand excavate trench bottom to provide uniform bearing and support of conduits on an undisturbed subgrade matching slope requirement. Remove all debris, stones, and other projections.
    a. For rock or other unyielding soils, excavate trenches 6-inches deeper than required elevation and provide level 6-inch compacted sand bedding course.
    b. For unstable soils or where bedding course is subject to washout, provide concrete trench bottom.
5. Coordinate protection of roots in tree and plant protection zones with Division 31 requirements.
6. Keep trenches free from water while construction is in progress. Installation of conduit or cable in trenches with water is not permitted. Contractor is responsible for all costs associated with dewatering of trenches.

F. Final Backfill: Comply with Division 31 and as indicated below:

1. Use satisfactory soil to backfill trenches to final subgrade elevation unless required otherwise by Civil or Structural subgrade requirements.
2. Install final backfill in 6-inch layers.
3. Compact all backfill to 95% standard proctor density.
4. Mechanical means for compaction can be used once conduits have been covered with at least 12-inches of hand tamped backfill. Do not use heavy-duty, hydraulic-operated, compaction equipment.

G. Restoration:

1. Replace area immediately after backfilling is completed or after construction in immediate area is complete.
2. Restore all surface features at areas disturbed by excavation, storing of dirt, cable laying, and other work, and re-establish original grades unless otherwise indicated.
3. Restore vegetation and include 6-inches of clean topsoil, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Division 32.

H. Cut and patch existing pavement in the path of underground ducts and utility structures according to the "Cutting and Patching" requirements in Division 01 and Section 260010, “General Requirements for Electrical”.

3.4 DUCT INSTALLATION

A. Install ducts, spacers, and accessories into ductbank configurations to accommodate duct quantities and sizes indicated on drawings.

B. Install ducts according to NEMA TCB 2.

C. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes, to drain in both directions. Install ducts in such manner to avoid traps and insure against collection of moisture.

D. Curves and Bends:

1. Use 5-degree angle couplings for small changes in direction.
2. Use manufactured long sweep bends with a minimum radius of 36 inches vertically and 60-inches horizontally, unless otherwise indicated.
3. Field manufactured bends are acceptable for a bend radius greater than 35-feet. Install field bends in accordance with NEMA TCB 2.
4. Electrical duct and duct banks: Install no more than the equivalent of three 90-degree bends in any conduit run.
5. Communications duct and duct banks: Install no more than the equivalent of two 90-degree bends in any conduit run and a maximum of 600 feet between pull points.

E. Joints: Use solvent-cemented joints in non-metallic ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same horizontal or vertical plane to ensure encasement or backfill fully surrounds each raceway.

F. Installation Adjacent to High-Temperature Steam Lines: Where duct banks are installed parallel to underground steam lines, provide minimum 6-foot separation, or perform calculations showing the duct bank will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to rise above 40 deg C, and anywhere the duct bank crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.

G. Installation Adjacent to Other Utilities:

1. Provide minimum 12-inches of earth or 3-inches of concrete between power and communications ducts.
2. Provide minimum 24-inches of earth between power or communications ducts and other parallel utilities. At utility crossings, provide minimum 6-inches of separation except provide 12-inches separation where crossing utility is gas or other line that transports flammable material.
3. Do not locate power and communications ducts below water and sewer lines.

H. Duct Entrances to Manholes and Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch ducts, and vary proportionately for other duct sizes.

1. Begin change from regular spacing to end-bell spacing 10 feet (3 m) from the end bell without reducing duct line slope and without forming a trap in the line.
2. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line direct-buried duct banks with calculated expansion of more than 3/4 inch (19 mm).
3. Grout end bells into structure walls from both sides to provide watertight entrances.

I. Building Penetrations: Make a transition from underground duct to GRC at least 10 feet outside the building wall, without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for RNC-to-GRC transition. Provide sleeves at building penetration and make water-tight with sleeve seal.

J. Duct Support

1. For concrete encased applications, support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
2. Separator Installation: Space separators at a maximum of 5-feet to prevent sagging and deforming of ducts. Place spacers within 24-inches of duct ends. Stagger separators approximately 6 inches between tiers.
3. Minimum Space between Ducts: 3 inches between ducts and between ducts and exterior envelope wall.

K. Concrete-Encased Ducts:

1. Secure separators to earth and to ducts to prevent floating during encasement. Tie entire assembly together using non-ferrous tie-wires or straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
2. Reinforcement: Where indicated, reinforce concrete-encased duct banks for their entire length. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
3. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
4. Concrete Cover: Install a minimum of 3 inches of concrete cover between edge of duct and exterior envelope wall.
5. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
    a. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations or use other specific measures to prevent expansion-contraction damage.
    b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch reinforcing-rod dowels extending a minimum of 18 inches into concrete on both sides of joint near corners of envelope.
6. Concrete Encasement:
    a. Use normal strength concrete, minimum 3000 psi at 28 days, 6 to 8 inch slump, with maximum 1/2 inch aggregate.
    b. Comply with requirements in "Concrete Placement" Article in Division 03. Place concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope.
    c. Do not allow a heavy mass of concrete to fall directly onto ducts. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces.
    d. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.
7. Complete final backfilling after concrete has cured.

L. Direct-Buried Duct Banks:

1. Set elevation of bottom of duct bank below frost line.
2. After installing first tier of ducts, install initial backfill and compact.
3. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process.
4. Perform initial backfilling/encasement in 2-inch lifts. Compact to 95% standard proctor density.
5. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inches over ducts and hand tamp.
6. Firmly tamp initial backfill around ducts to provide maximum supporting strength. Use hand tamper only.
7. After placing initial backfill over final tier, make final duct connections at end of run and complete backfilling.

8. Initial backfill/encasement material shall be crushed stone, sand, or pea gravel with a maximum aggregate size of 1/2-inch.

M. Warning Tape: Bury warning tape approximately 12 inches above all ducts. Align tape parallel to and within 3 inches of centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

N. Install pull tape in all spare ducts with 3ft of slack tied off and secured at each pull point.

O. Duct Sealing:

1. Provide temporary plugs of all ducts upon completion of each portion of work to prevent ingress of foreign material into the duct.
2. After conductors have been installed seal all ducts, including spare ducts, at building entrances and equipment terminations. Use sealing compound and foam plugs capable of withstanding at least 15-psig hydrostatic pressure.

3.5 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

A. Precast Concrete Handhole and Manhole Installation:

1. Comply with ASTM C 891 unless otherwise indicated.
2. Install units level and plumb and with orientation and depth coordinated with connecting ducts, to minimize bends and deflections required for proper entrances.
3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

B. Elevations:
1. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch above finished grade.

C. Where indicated, cast handhole cover frame integrally with handhole structure.

D. Waterproofing: Apply waterproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. After ducts have been connected and grouted, and before backfilling, waterproof joints, and connections, and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.

E. Hardware: Turn over removable hardware, including pulling eyes, cable stanchions, cable arms, to Construction Manager for use during next phase.

F. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches (97 mm) for manholes and 2 inches (50 mm) for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

3.6 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Install hand-holes and boxes level and plumb and with orientation and depth coordinated with connecting ducts, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by manufacturer.

B. Unless otherwise indicated, support units on a12-inch thick level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 1 inch above finished grade. Install handholes and boxes with bottom below frost line.

D. Field cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

E. For enclosures installed in asphalt paving, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.

1. Concrete: 3000 psi, 28-day strength, complying with Division 03, with a troweled finish.
2. Dimensions: minimum 10 inches wide and 12 inches deep or as shown on drawings.

3.7 GROUNDING

A. Comply with Section 260526 “Grounding and Bonding for Electrical Systems”.

1. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide #1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, non-shrink grout.
2. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with #4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

3.8 IDENTIFICATION

A. Comply with Section 260553 “Identification for Electrical Systems”

1. Where ducts transition through manholes or handholes, and at each termination point, provide each duct with a unique identifier to indicate origination point.

2. Cover legends shall be consistent with the owner’s standard practices, especially within existing facilities, unless otherwise require by codes.

3.9 FIELD QUALITY CONTROL

A. Prior to covering duct or underground structures, perform visual inspections to verify the following:

1. Proper installation depths and slopes have been maintained.
2. Proper vertical and horizontal spacing in multi-duct formations.
3. All conduit sections have been properly jointed.
4. Proper bend radius of curved sections have been maintained.
5. Check for damage at changes in grades or at bends.

B. Perform the following tests and inspections and prepare test reports:

1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for duct deflections or out of round conditions. Provide a minimum 6-inch- long mandrel 1/2-inch smaller in diameter than diameter of duct. If obstructions are discovered, remove obstructions and retest.

C. Correct deficiencies, replace affected duct sections, and retest as specified above to demonstrate compliance.

D. Prepare detailed test and inspection reports with accompanying digital photographs.

E. Concealed Work Photographs: Before proceeding with installing backfill that will conceal work, take photographs sufficient in number, with annotated descriptions, to record nature and location of concealed Work.

3.10 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of all ducts until duct cleaner indicates that duct is clear of dirt and debris. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

B. Clean internal surfaces of manholes and handholes, including sump. Remove dirt and foreign material.

END OF SECTION 260543

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Equipment Nameplates.
2. Cable and Conductor Labels.
3. Wiring Device Labels
4. Safety Labels.
5. Instruction Signs.
6. Miscellaneous identification products.

B. Related Requirements

1. Refer to Section 260573, “Power System Studies” for additional requirements related to fault current and arc flash labeling.
2. Refer to Section 270553, “Identification for Communications Systems” for additional requirements related to labeling of communications equipment and cabling.

1.3 REFERENCES

A. Abbreviations

B. Definitions

1. Emergency Systems: Those systems legally required and classed as emergency by NFPA 70 Article 700, municipal, state, other codes, or by any government agency having jurisdiction.

C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.

1. American National Standards Institute (ANSI)
    a. ANSI Z535.4, “Product Safety Signs and Labels”
2. National Fire Protection Association (NFPA)
    a. NFPA 70E, “Standard for Electrical Safety in the Workplace”
3. Occupational Safety and Health Administration (OSHA)
    a. 29 CFR 1910.144, “Safety color code for marking physical hazards”
    b. 29 CFR 1910.145, “Specifications for accident prevention signs and tags”

4. Underwriters Laboratories Inc (UL)
    a. UL 969, “Marking and Labeling Systems”

1.4 SUBMITTALS

A. Product Data: For each electrical identification product indicated.
1. Include project specific examples of each label type.

B. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

C. Closeout Submittal:
1. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
    a. Provide electronic Excel files of all panelboard directories to owner as part of Close-out Documentation.

1.5 COORDINATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes and standards. Use consistent designations throughout Project.

B. All identifications shall be consistent with the owner’s standard practices, especially within existing facilities, unless otherwise require by codes. Where the requirements herein are in conflict, the contractor shall notify the engineer in writing prior to ordering any material.

C. All room names and/or numbers for labeling or programming shall use the Owner’s approved room name and numbering scheme, not names and numbers indicated on floor plans. All reprogramming shall be included as required to accommodate construction phasing.

D. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

E. Coordinate installation of identifying devices with location of access panels and doors.

F. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT SIGNS AND NAMEPLATES

A. Engraved Plastic Signs and Nameplates.
1. 3-layer melamine plastic laminate
2. Weather and UV-resistant for Wet and Damp Locations.
3. Thickness:

a. For signs up to 20 sq. in., minimum 1/16 inch thick.
b. For signs larger than 20 sq. in. or 8 inches in length, 1/8 inch thick.
c. Punched or drilled for mechanical fasteners with 1/4-inch grommets in corners for mounting.
d. Framed with mitered melamine molding and arranged for attachment at applicable equipment.

4. Color: Comply with color legend.

2.2 RACEWAY AND CONDUCTOR LABELS

A. Raceway Labels: Pre-printed, self-adhesive, polyester, suitable for indoor or outdoor use, resistant to abrasion, humidity, and weather.

1. Color: Black Letters on an orange field.
2. Size: For each raceway size, comply with ANSI/ASME A13.1 for recommended letter height and field length.

B. Wire and Cable Labels: Machine printed, self-adhesive, polyester, self-laminating, suitable for indoor or outdoor use on flexible cables, resistant to abrasion, humidity, and weather.

2.3 SAFETY SIGNS AND LABELS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. All field-applied hazard markings shall warn of hazards using effective words, colors, symbols, or any combination thereof as recommended by ANSI Z535.4-2011. This applies to all instances where caution, warning, or danger signs are required per the NEC and applicable OSHA standards.

C. Self-Adhesive Safety Labels: Polyester, Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for intended use and suitable for installed environment.

D. Provide UV overlaminating film for outdoor locations.

2.4 INSTRUCTION SIGNS

A. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch.

B. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

2.5 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Floor Marking Tape: 2-inch wide, 5-mil pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

B. Paint: Comply with requirements in Division 09 painting Sections for paint materials and application requirements. Select paint system suitable for surface material and location (exterior or interior).

C. Fasteners for Labels and Signs:

1. Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.
2. Pop-Rivets.
3. Two-Part Epoxy Adhesive

D. Cable Ties: Self-extinguishing, one-piece, self-locking, UV-stabilized or plenum rated where required by installed environmental conditions. 3/16-inch minimum width.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. Verify identity of each item before installing identification products.

B. Before installation of labels, clean all surfaces using materials and methods recommended by manufacturer of identification device.

C. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

D. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

E. Install all labels in a neat manner, plumb and parallel to equipment lines.

F. Attach plastic signs and labels to equipment with mechanical fasteners appropriate to the location and substrate. Where screws cannot or should not penetrate substrate use two-part epoxy adhesive listed for use with intended substrate and environmental conditions.

G. Handwritten, non-permanent, or stenciled labels are not permitted unless noted otherwise.

H. For surfaces that require finish work, apply identification devices to surfaces after completing finish work.

I. Identification shall consist of all UPPER-CASE LETTERS.

J. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

3.2 EQUIPMENT IDENTIFICATION

A. Provide all new and modified equipment with a nameplate consisting of 1/2" letters for equipment designation and 1/4" letters for voltage, source, and feeder information. This includes but is not limited to panelboards, switchboards, switchgear, disconnect switches, transformers, power transfer equipment, generators, motor starters, variable frequency drives, lighting control panels, contactors, cabinets, push button stations, and auxiliary system control panels.

B. Distribution equipment labels shall indicate the following:
1. Equipment designation.
2. Voltage system.
3. Equipment ampacity.
4. Source equipment designation and location.

5. Feeder size.

C. Transformer labels shall indicate the following:
1. Equipment designation.
2. Primary voltage system and primary feeder ampacity.
3. Source equipment designation and location.
4. Primary feeder size.
5. Secondary voltage system and load equipment designation

D. Equipment disconnect labels shall indicate the following:
1. Equipment designation.
2. Voltage system and feeder ampacity
3. Source equipment designation and location.

E. Locate equipment nameplates at center of top of trim for panelboards, switchboards, switchgear, and centered at side for branch circuit switches.

F. Where equipment is provided with a factory installed disconnecting means or motor controller, install label on factory provided unit.

G. For equipment with multiple power sources, such as transfer switches and control panels, identify each source and its function.

H. Color Legend

1. Normal Power Systems: Black field with white letters
2. Emergency Power Systems (As defined by NEC Article 700): Red field with white letters.

I. Where electrical distribution equipment, including panelboards, switchboards, and switchgear, are connected to an emergency source, the nameplate shall incorporate the word "EMERGENCY" into the legend. Refer to drawings for further details.

J. Where the premise wiring system has feeders and/or branch circuits supplied from more than one nominal voltage system, provide sign at each switchgear, switchboard, and panelboard displaying color coded identification method for each ungrounded, grounded, and equipment grounding conductor.

K. Service Equipment and Building Feeder, Branch Circuit Disconnects.

1. Provide label for service disconnecting means to permanently identify it as the “SERVICE DISCONNECT”.
2. Where a building or structure has any combination of feeders, branch circuits, or services passing through it or supplying it, provide a permanent sign at each disconnect location identifying all other feeders, branch circuits, or services and the area served by each.

3.3 IDENTIFICATION OF CONDUCTORS

A. Service, Feeder, and Branch-Circuit Conductors: Refer to Section 260519, “Low Voltage Electrical Power Conductors and Cables” for conductor and cable color coding requirements.

B. Indicate source and circuit number of conductors to be extended in the future.

C. Auxiliary Systems Alarm, Signal, and Control Wire Identification: At termination points, identify each conductor by its system, designation, and function.

3.4 IDENTIFICATION OF RACEWAYS AND BOXES

A. Identify all junction, outlet, device, and pull boxes with wiring system, voltage, and circuit designations of conductors.

1. In concealed locations above accessible ceilings and in exposed unfinished areas such as data, mechanical, or electrical rooms, provide designations on outside of box covers.
2. For exposed boxes in finished areas, provide designations on inside of box covers.
3. System Legend shall be as follows:
    a. Power
    b. Emergency
    c. UPS

B. The inside of all junction and backboxes shall be marked with panel and circuit number in permanent marker.

C. All empty conduit runs and conduit with conductors for future use shall be identified for use and shall indicate where they terminate.

3.5 IDENTIFICATION OF WIRING DEVICES

A. All new and existing receptacle cover plates in area of work shall be marked with their panel and circuit number(s) with clear, machine printed adhesive labels with black lettering.

3.6 CIRCUIT DIRECTORIES

A. For Distribution Panelboards, Motor Control Centers, Switchboards, and Switchgear provide nameplates at each switch or circuit breaker to indicate load designation.

B. Provide clearly legible typewritten directories in each electrical panel indicating the area, item of equipment, etc. controlled by each switch, breaker, fuse, etc. Insert directories into plastic cardholders on the back of the door in each panel. Provide descriptions the identify each circuit as to its clear, evident, and specific purpose or use. The identification shall include an approved degree of detail that allows each circuit to be distinguished from all others. Spaces and Spare positions shall be described accordingly.

1. At a minimum, provide the following panel information for each panel directory:
    a. Panel name
    b. Panel bus rating
    c. Voltage System
    d. Mains Configuration and Rating
    e. Short Circuit Current Rating
2. Circuit Designation Examples:
    a. LIGHTS, ROOM 100
    b. FLOOR RECEPTACLES, ROOM 200
    c. ERV-1 RECEPTACLE, ROOF

C. Panel Schedules and circuit numbers on Record Drawings shall match.

3.7 SAFETY SIGNS

A. Install Warning, Caution, and Danger signs in accordance with NFPA 70 and OSHA requirements to ensure safe operation of electrical equipment and the items to which they connect.

B. Comply with 29 CFR 1910.145 and ANSI Z535.4.

C. Apply to exterior of door, cover, or other access point.

D. Labels and signs shall include, but are not limited to, the following legends:

1. Identify system voltage with black letters on an orange background.
2. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
3. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES"
4. Where series combination ratings are allowed: "CAUTION - SERIES COMBINATION SYSTEM RATED ____ AMPERES. IDENTIFIED REPLACEMENT COMPONENTS REQUIRED."

3.8 INSTRUCTION SIGNS

A. Operating Instruction Signs: Install instruction signs with minimum 3/8-inch letters to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation, power transfer, and load shedding.

3.9 WORKSPACE INDICATION

A. Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

END OF SECTION 260553

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SECTION 260573 - POWER SYSTEM STUDIES

GENERAL

RELATED DOCUMENTS

- Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

SUMMARY

- Section includes the following computer-based studies:
  - Fault-current study to determine the minimum interrupting capacity of circuit protective devices.
  - Overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.
  - Arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.
- Related Requirements
  - Refer to Section 260553, “Identification for Electrical Systems” for label material and performance requirements.

REFERENCES

- Abbreviations
  - SCCR: Short-circuit current rating.
- Definitions
  - Emergency Electrical Systems: Those systems legally required and classed as emergency by NFPA 70 Article 700, municipal, state, other codes, or by any government agency having jurisdiction.
  - Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed and salvaged or removed and reinstalled. Existing to remain items shall remain functional throughout the construction period.
  - One-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
  - Power System Analysis Software Developer: An entity that commercially develops, maintains, and distributes computer software used for power system studies.
  - Power Systems Analysis Specialist: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located.
  - Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion of the circuit from the system.
  - Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.
  - Single-Line Diagram: See "One-Line Diagram."

- Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.
    - Institute of Electrical and Electronics Engineers (IEEE)
        - IEEE 141 - Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems
        - IEEE 241 - Recommended Practice for Electric Power Systems in Commercial Buildings
        - IEEE 242 - Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
        - IEEE 399 - Recommended Practice for Industrial and Commercial Power System Analysis
        - IEEE 551 - Recommended Practice for Calculating AC Short-Circuit Currents in Industrial and Commercial Power Systems
        - IEEE 1015 - Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems
        - IEEE 1584 - Guide for Performing Arc-Flash Hazard Calculations
        - IEEE 3002.3 - IEEE Recommended Practice for Conducting Short-Circuit Studies and Analysis of Industrial and Commercial Power Systems
    - American National Standards Institute (ANSI)
        - ANSI C57.12.00 - Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
        - ANSI C37.13 - Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures
        - ANSI C37.010 - Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
        - ANSI C 37.41 - Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories
    - The National Fire Protection Association (NFPA)
        - NFPA 70E - Standard for Electrical Safety in the Workplace

- SEQUENCING

    - The short-circuit and protective device coordination studies shall be submitted for review prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment drawings for manufacturing.

    - If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.

- SUBMITTALS

    - Product Data: For computer software program to be used for studies.

    - Initial Study Report: The study shall provide sufficient data to ensure that selection of equipment and devices will have adequate ratings and the protective device trip characteristics will be satisfactory. Include the following:
        - Study input data, including completed computer program input data sheets including assumptions on worst case project conditions.
        - Study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.

- Final Study and Report: Submit final study at the end of the construction when all circuits are installed, and all equipment is on site and installed such that complete and accurate data can be obtained.

- Closeout Submittals
  - In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
    - Provide one (1) bound copies of the complete final report. Additional copies shall be provided on CD or USB in PDF format.
    - Certification Document to confirm system settings have been implemented.
    - Provide the study project files in electronic format including all project files and libraries to allow the owner to update and print additional copies, labels, etc. This includes copies of the actual models from the power system analysis software and all associated files required to support the model(s).
    - Report to include system one-line diagram model.

- QUALITY ASSURANCE

  - Study shall be performed using commercially developed and distributed software designed specifically for power system analysis.

  - Software algorithms shall comply with requirements of standards and guides specified in this Section.

  - Manual calculations are not acceptable.

  - Power Systems Analysis Specialist Qualifications: Professional engineer licensed in the state where Project is located and skilled in performing and interpreting the power system studies. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
    - Engineer shall be a full-time employee of the electrical equipment manufacturer.
    - The engineer shall have a minimum of five (5) years' experience performing power system studies.

  - Power System Study Certification: Report shall be signed and sealed by Power Systems Analysis Specialist.

  - Field Adjusting Personnel Qualifications:
    - Technician shall be a full-time employee of the electrical equipment manufacturer.
    - Technician responsible for all field adjusting of the Work shall have a minimum NICET Electrical Power Testing Level III certification or equivalent.

- PRODUCTS

- POWER SYSTEM ANALYSIS SOFTWARE

  - Perform studies using the latest version of one of the following:
    - Power Tools for Windows by SKM Systems Analysts.
    - ETAP by Operation Technology, Inc.
    - EasyPower by Easypower, LLC

  - Comply with IEEE 242, IEEE 399, IEEE 551, IEEE 1584, IEEE 3002.3, and NFPA 70E.

- Analytical features of power systems analysis software program shall have capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

- Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

- POWER SYSTEM STUDY REPORT CONTENTS

  - Executive summary of study findings.

  - Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.

  - One-line diagram of modeled power system, showing the following:

    - Protective device designations and ampere ratings.
    - Conductor types, sizes, and lengths.
    - Transformer kilovolt ampere (kVA) and voltage ratings.
    - Motor and generator designations and kVA ratings.
    - Switchgear, switchboard, motor-control center, and panelboard designations and ratings.
    - Derating factors and environmental conditions.
    - Any revisions to electrical equipment required by the study.

  - Study Input Data

    - Available Power source data.
    - Manufacturer, model, and interrupting rating of protective devices.
    - Conductors.
    - Transformer data.

  - Comments and recommendations for system improvements or revisions in a written document, separate from one-line diagram.

  - Protective Device Evaluation:

    - Evaluate equipment and protective devices and compare to available short-circuit currents. Verify that equipment SCCR ratings exceed available short-circuit current at equipment installation locations.
    - Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
    - For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
    - For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in standards to 1/2-cycle symmetrical fault current.
    - Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that SCCR ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

  - Short-Circuit Study Output Reports:

- Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
    - Voltage.
    - Calculated fault-current magnitude and angle.
    - Fault-point X/R ratio.
    - Equivalent impedance.
- Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
    - Voltage.
    - Calculated symmetrical fault-current magnitude and angle.
    - Fault-point X/R ratio.
    - Calculated asymmetrical fault currents:
        - Based on fault-point X/R ratio.
        - Based on calculated symmetrical value multiplied by 1.6.
        - Based on calculated symmetrical value multiplied by 2.7.
- Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
    - Voltage.
    - Calculated symmetrical fault-current magnitude and angle.
    - Fault-point X/R ratio.
    - No AC Decrement (NACD) ratio.
    - Equivalent impedance.
    - Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
    - Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

- Protective Device Coordination Study:
    - Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.
        - Phase and Ground Relays:
            - Device tag.
            - Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
            - Recommendations on improved relaying systems, if applicable.
        - Circuit Breakers:
            - Adjustable pickups and time delays (long time, short time, and ground).
            - Adjustable time-current characteristic.
            - Adjustable instantaneous pickup.
            - Recommendations on improved trip systems, if applicable.
    - Fuses: Show current rating, voltage, and class.
- Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
    - Device tag and title, one-line diagram with legend identifying the portion of the system covered.

- Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
- Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
- Plot the following listed characteristic curves, as applicable:
    - Power utility's overcurrent protective device.
    - Medium-voltage equipment overcurrent relays.
    - Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
    - Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
    - Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
    - Cables and conductors damage curves.
    - Ground-fault protective devices.
    - Motor-starting characteristics and motor damage points.
    - Generator short-circuit decrement curve and generator damage point.
    - The largest feeder circuit breaker in each motor-control center and panelboard.
- Maintain selectivity for tripping currents caused by overloads.
- Maintain maximum achievable selectivity for tripping currents caused by overloads on series-rated devices.
- Provide adequate time margins between device characteristics such that selective operation is achieved.
- Comments and recommendations for system improvements.

- Arc-Flash Study Output Reports:
    - Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each equipment location included in the report:
        - Voltage.
        - Calculated symmetrical fault-current magnitude and angle.
        - Fault-point X/R ratio.
        - No AC Decrement (NACD) ratio.
        - Equivalent impedance.
        - Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
        - Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

- Incident Energy and Flash Protection Boundary Calculations:
    - Arcing fault magnitude.
    - Protective device clearing time.
    - Duration of arc.
    - Arc-flash boundary.
    - Restricted approach boundary.
    - Limited approach boundary.
    - Working distance.
    - Incident energy.
    - Hazard risk category.
    - Recommendations for arc-flash energy reduction.

- ARC-FLASH WARNING AND AVAILABLE FAULT CURRENT LABELS

  - Comply with requirements in Section 260553 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce a 3.5-by-5-inch self-adhesive equipment label for each location indicated in the analysis unless noted otherwise.

  - Arc Flash Warning Labels shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include all information required by NFPA 70E and the following information taken directly from the arc-flash hazard analysis:

    - Location designation.
    - Engineering report number, revision number, and issue date.

  - Available Fault Current Labels shall have an orange header with the wording, “WARNING”, and shall include the following information taken directly from the short circuit study.

    - Location designation.
    - Maximum available fault current.
    - Calculation date.
    - Engineering report number, revision number, and issue date.

  - Labels shall be machine printed, with no field-applied markings.

- EXECUTION

- POWER SYSTEM DATA

  - Obtain all data necessary for conduct of the study.

    - Verify completeness of data supplied on one-line diagram. Call any discrepancies to Engineer's attention.
    - For equipment included as Work of this Project, use characteristics submitted under provisions of action submittals and information submittals for this Project.
    - For relocated equipment and that which is existing to remain, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. Qualifications of technicians and engineers shall be as defined by NFPA 70E.

  - Electrical Survey Data: Gather and tabulate the required input data to support the short-circuit study. Comply with requirements in Section 017839 "Project Record Documents" for recording circuit protective device characteristics. Record data on a Record Document copy of one-line diagram. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under direct supervision and control of the engineer in charge of performing the study. Data includes, but is not limited to, the following:

    - Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
    - Electrical power utility impedance and available short circuit current at the service.
    - Power sources and ties.
    - Short-circuit current at each system bus (three phase and line to ground).
    - Full-load current of all loads.
    - Voltage level at each bus.

- For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
- For reactors, provide manufacturer and model designation, voltage rating, and impedance.
- For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
- Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
- For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
- Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
- Motor horsepower and NEMA MG 1 code letter designation.
- Conductor sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
- Derating factors.
- Data sheets to supplement electrical distribution system one-line diagram, cross-referenced with tag numbers on diagram, showing the following:
    - Special load considerations, including starting inrush currents and frequent starting and stopping.
    - Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
    - Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
    - Generator thermal-damage curve.
    - Ratings, types, and settings of utility company's overcurrent protective devices.
    - Special overcurrent protective device settings or types stipulated by utility company.
    - Time-current-characteristic curves of devices indicated to be coordinated.
    - Manufacturer, frame size, interrupting rating in amperes root mean square (rms) symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
    - Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
    - Switchgear, switchboards, motor-control centers, and panelboards ampacity, and SCCR in amperes rms symmetrical.
    - Identify series-rated interrupting devices for a condition where the available fault current is greater than the interrupting rating of downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

- POWER SYSTEMS STUDY

    - Perform study following the general study procedures contained in IEEE 399.

    - Base study on device characteristics supplied by device manufacturer.

    - Gather all necessary data from the existing facility as needed to perform the study.

    - The Contractor shall be responsible for modifying settings on existing equipment only at over-current protection devices upstream of new equipment unless noted otherwise.

    - Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

- Include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase ac systems. Also account for the fault-current dc decrement to address asymmetrical requirements of interrupting equipment.

- Identify in the report any protective device applied outside its capacity.

- Short Circuit Study
    - Calculate short-circuit currents according to IEEE 551.
    - Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and a single line-to-ground fault at each equipment indicated on one-line diagram.
        - For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
    - Evaluate equipment and protective devices and compare to short-circuit ratings.

- Coordination Study
    - Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.
    - Transformer Primary Overcurrent Protective Devices:
        - Device shall not operate in response to the following:
            - Inrush current when first energized.
            - Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
            - Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
        - Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.
    - Motor Protection:
        - Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
        - Select protection for motors served at voltages more than 600 V according to IEEE 620.
    - Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.
    - Generator Protection: Select protection according to manufacturer's written instructions and to IEEE 242.

- Arc Flash Hazard Analysis
    - Comply with NFPA 70E and its Annex D for hazard analysis study.
    - Preparatory Studies: Perform the Short-Circuit and Protective Device Coordination studies prior to starting the Arc-Flash Hazard Analysis.
    - Calculate maximum and minimum contributions of fault-current size.
        - Maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.
        - Calculate arc-flash energy at 85 percent of maximum short-circuit current according to IEEE 1584 recommendations.
    - Calculate the arc-flash protection boundary and incident energy at locations in electrical distribution system where personnel could perform work on energized parts.
    - Include medium- and low-voltage equipment locations, except equipment rated 240 V ac or less fed from transformers less than 125 kVA.
    - Calculate the limited, and restricted approach boundaries for each location.

- Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:
  - Fault contribution from induction motors shall not be considered beyond three to five cycles.
  - Fault contribution from synchronous motors and generators shall be decayed to match the actual decrement of each as closely as possible (for example, contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).
- Arc-flash energy shall generally be reported for the maximum of line or load side of a circuit breaker. However, arc-flash computation shall be performed and reported for both line and load side of a circuit breaker as follows:
  - When the circuit breaker is in a separate enclosure.
  - When the line terminals of the circuit breaker are separate from the work location.
- Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

- LABELING

  - All labels will be based on recommended overcurrent device settings and will be provided to owner after the results of the analysis have been presented and after any system changes, upgrades, or modifications have been incorporated in the system.

  - Arc Flash Labeling:
    - Provide and install an arc-flash label for each piece of electrical equipment listed below and each piece of equipment that is likely to require examination, adjustment, servicing, or maintenance while energized:
      - Motor-control centers.
      - Switchboards.
      - Switchgears.
      - Transfer Switches
      - Generator Docking Station
      - Generator Distribution Equipment
      - Meter Enclosures.
      - Medium voltage and low volage transformers
      - Panelboards.
      - Equipment Control panels.
      - Motor Controllers.
      - Disconnect Switches.
    - Apply arc-flash label on the front cover of each section of the equipment and on side or rear covers with accessible live parts and hinged doors or removable plates for each equipment included in the study. Base arc-flash label data on highest values calculated at each location.

  - Available Fault Current Labeling
    - Provide and install an available fault current label for each piece of electrical equipment listed below:
      - Service equipment.
      - Elevator Control Panel.

  - Install warning labels under the direction of the Power System Analysis Specialist.

- Provide new labels for any existing equipment to remain with updated values based on the results of the analysis.

- FIELD ADJUSTING

  - Adjust relay and protective device settings according to recommended settings provided by the coordination study. Field adjustments shall be completed by a qualified technician from the engineering service division of the equipment manufacturer.

  - Make modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.

  - Notify Architect and Engineer in writing of any required major modifications.

  - Equipment shall not be energized until all breakers or protective relays are set either to the recommended values indicated by the studies or to minimum trip settings.

  - Certification: Prior to project Substantial Completion, submit four signed copies of a document certifying that the settings and selection scope has been completed as specified.

- DEMONSTRATION

  - Acquaint personnel in fundamentals of operating the power system in normal and emergency modes.

  - Hand-out and explain the power system study objectives, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting time-current coordination curves.

  - Arc Flash Training
    - Train Owner's maintenance personnel in potential arc-flash hazards associated with working on energized equipment and the significance of arc-flash warning labels (minimum of 4 hours).
    - The training shall be certified for continuing education units (CEUs) by the International Association for Continuing Education Training (IACET) or equivalent.
    - Include in Project Close-out Documents training notes, outlines, and Power Point presentation of training session. Also include attendance record of personnel attending the training session.
    - Training session shall be videotaped. Include copy of DVD of training session in Project Close-out Documents.

END OF SECTION 260573

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SECTION 260800 - ELECTRICAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Commissioning

Commissioning is a systematic process of ensuring that all building systems perform interactively according to the owner's project requirements and operational needs. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment startup, control system calibration, performance testing and training. Commissioning during the construction phase is intended to achieve the following specific objectives:

1. Verify that applicable equipment and systems are installed according to the manufacturer's recommendations and to industry accepted minimum standards and that they receive adequate operational checkout by installing contractors.
2. Verify and document proper functional performance of equipment and systems.
3. Verify that O&M documentation is complete.
4. Verify that the Owner's operating personnel are adequately trained.

1.2 RELATED WORK

A. Section 01 1000 – Summary of Work

B. Section 01 3300 – Submittal Procedures

C. Section 01 7700 – Closeout Procedures

D. Section 01 7823 – Operation and Maintenance Data

E. Section 01 7839 – Project Record Document

F. Section 01 7900 – Demonstration and Training

G. Section 01 9113 – General Commissioning Requirements

1.3 REFERENCE STANDARDS

A. National Electric Code (NEC)

B. American Society for Testing and Materials (ASTM)

C. Electronics Industry Association/Telecommunications Industry Association (EIA/TIA)

D. Illuminating Engineering Society (IES)

E. Institute of Electrical and Electronics Engineers (IEEE)

F. International Electrical Testing Association (NETA)

G. National Electrical Manufacturers Associates (NEMA)

H. National Fire Protection Association (NFPA)

I. Underwriters Laboratory, Inc. (UL)

J. Refer to Section 019100 for additional Reference Standards.

1.4 ABBREVIATIONS AND DEFINITIONS

A. A/E: Architect, Architect/Engineer, and/or Engineer

B. ASI: Architectural Supplemental Instruction

C. BAS: Building Automation System

D. BoD: Basis of Design. A narrative of how the designer plans to achieve the OPR

E. CxA: Commissioning Authority

F. Controls Contractor

G. CM: Construction Manager

H. Cx: Commissioning

I. Cx Plan: Commissioning Plan

J. Cx RFI: Commissioning Request for Information

K. DDC: Direct Digital Control System

L. Deficiency: A condition in the installation or function of a component, piece of equipment or system that is not in compliance with the Contract Documents and cannot be corrected in five (5) minutes time.

M. EC: Electrical Contractor

N. FBO: Furnished By Others

O. FT: Functional Performance Test

P. IAW: In Accordance With

Q. MC: Mechanical Contractor

R. O&M: Operation and Maintenance

S. OPM: Owner Project Manager

T. OPR: Owner Project Requirement. A dynamic document expressing how the owner expects the building systems to perform upon project completion.

U. PC: Prefunctional Checklist

V. RFI: Request for Information

W. Sub(s): Subcontractors or Prime Contractor

X. TC: Testing Contractor

Y. TBD: To Be Determined

1.5 ELECTRICAL EQUIPMENT AND SYSTEMS TO BE COMMISSIONED

The following electrical equipment and systems shall be commissioned in this project.

A. Controls and occupancy sensors for lighting

B. Grounding and bonding for electrical systems >600v, from the building entrance through the main switchboard, switchgear, to the distribution panels.

C. Metering equipment.

D. Motor Control Centers, Variable Speed Drives, Motor Starters, protective devices.

E. Emergency power system including generator set, transfer switch, associated equipment and testing.

1.6 SUBMITTALS

A. Refer also to Specification Section 01 9113, Subsection 1.6.

B. Provide the CxA a copy of the following items, for the systems to be commissioned:

1. Equipment and System Submittals to include, at minimum, the following:
   a. Cut Sheets
   b. Performance data
2. Manufacturer's pre-startup checklists
   a. Manufacturer's start-up checklists
   b. Installation Instructions
3. Shop drawings (including any resubmittals required by the A/E)
4. Short-circuit analysis and coordination study
5. Protective device settings
6. Testing plan
7. Completed field test report, including all completed forms and checklist; and list of all outstanding deficiencies and uncompleted items
8. Operational and maintenance documentation
9. Training plan and training materials
10. As-built documentation

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Refer to Specification Section 01 9113, Subsection 2.1.

B. Instrumentation required to verify readings and test system and equipment performance shall be provided by Contractor and made available to Commissioning Authority. Infrared scanning equipment shall be a FLIR (or approved equal) thermal imaging camera set capable of viewing an entire bus or equipment assembly at one time. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified.

2.2 Cx WEB-BASED COMMISSIONING TOOL

A. Refer to Specification Section 01 9113, Subsection 2.1.

PART 3 - EXECUTION

3.1 MEETINGS

A. Refer to Specification Section 01 9113, Subsection 3.3.

3.2 START-UP, PREFUNCTIONAL CHECKLISTS AND INITIAL CHECKOUT

A. The following procedures apply to all equipment to be commissioned, according to Section 1.5 above.

B. General

Prefunctional checklists are important to ensure that the equipment and systems are hooked up and operational. It ensures that functional performance testing (in-depth system checkout) may proceed without unnecessary delays. Each piece of equipment receives full prefunctional checkout. No sampling strategies are used. The prefunctional testing for a given system must be successfully completed prior to formal functional performance testing of equipment or subsystems of the given system.

Independent Testing Agencies: For systems where independent testing agencies (TA) are specified, the cost of this testing is borne by the contractor. Much of the testing performed by these independent agencies will cover aspects required in the commissioning startups and functional performance tests requirements. Contractor and testing agencies shall coordinate with the CxA so that they can witness the testing and approve the applicable aspects of the FPTs. CxA may in some cases independently spot check work of the testing agencies if the tests were not witnessed. However, it is not the intent for the TA to re-accomplish testing that is specified in the construction specifications. For instance, much of the testing requirements for the Electrical Testing will be performed by the independent electrical testing agency provided under the contract. The CxA will witness the indicated sample of the TA testing and record the results in the record of functional performance testing.

C. Start-up and Initial Checkout Documentation

1. The CxA will provide prefunctional checklists (PCs). PCs indicate the required procedures to be executed as part of startup and initial checkout of equipment and systems.
2. The subcontractor responsible for providing and installing the equipment develops the full start-up plan by combining (or adding to) the CxA's prefunctional checklists with the manufacturer's detailed start-up and checkout procedures from the O&M manual and the normally used field checkout sheets. The plan will include checklists and procedures with specific boxes or lines for recording and documenting the checkout and inspection of each piece of equipment and a summary statement with a signature block at the end of the checklist.
3. The full start-up document shall consist of:

    a. The CxA's prefunctional checklists.
    b. The manufacturer's standard written start-up procedures copied from the installation manuals with check boxes by each procedure and a signature block at the end.
    c. The manufacturer's normally used field checkout sheets.

4. The contractor submits the full startup document to the CxA for review and approval.
5. The CxA reviews and approves the procedures and the format for documenting them, noting any procedures that need to be added.

D. Execution of Prefunctional Checklists and Startup

1. Two weeks prior to startup, the Subs and vendors shall schedule startup and checkout with the OPM, CM and CxA. The performance of the prefunctional checklists, startup and checkout are directed and executed by the Sub or vendor. When checking off prefunctional checklists, signatures may be required of other Subs for verification of completion of their work.
2. The CxA and possibly the A/E will observe the procedures and tests for selected pieces of primary equipment. It is the intent that the CxA will observe the tests during contractor testing. If the contractor does not inform the CxA of testing, the CxA may request the contractor to repeat the test.
3. The CxA will observe the physical start-up of the first major system or equipment. Additional observations of related or duplicate equipment or systems may be observed at the discretion of the CxA.
4. The Subs and vendors shall execute startup and provide the CM with a signed and dated copy of the completed start-up and prefunctional tests and checklists. The CM reviews for completion and accuracy, then submits to the CxA and A/E.
5. Only individuals that have direct knowledge and witnessed that a line item task on the prefunctional checklist was actually performed shall initial or check that item off. It is not acceptable for witnessing supervisors to fill out these forms.
6. Completed startup testing report must be provided to CxA prior to functional testing.

E. Deficiencies, Non-Conformance and Approval in Checklists and Startup

1. The Sub(s) shall clearly list any outstanding items of the initial start-up and prefunctional procedures that were not completed successfully. The procedures form and any outstanding deficiencies shall be provided to the CxA within two days of test completion.
2. The CxA will work with the Sub(s) and vendors to determine what is required to correct outstanding deficiencies and retest deficiencies of uncompleted items. The CxA will involve the PM and others as necessary. The installing Subs or vendors shall correct all areas that are deficient or incomplete in the checklists and tests in a timely manner and shall notify the CxA as soon as outstanding items have been corrected.
3. Items left incomplete, which later cause deficiencies or delays during functional testing may result in backcharges to the responsible party. Refer to Section 01 9113, 3.7 – Documentation, Non-Conformance, and Approval of Tests.

3.3 FUNCTIONAL PERFORMANCE TESTING - DEMONSTRATION

A. This sub-section applies to functional testing for equipment and system in this division.

B. The general list of equipment and systems to be commissioned is found in Paragraph 1.5.

C. Objectives and Scope

1. The objective of functional performance testing is to demonstrate that each system is operating according to the owner's project requirements, documented project program, and contract documents. Functional testing facilitates bringing the systems from a state of substantial completion to full dynamic operation. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and function of the systems.
2. In general, each system shall be operated through all modes of operation (seasonal, occupied, unoccupied, failures, interlocks, warm-up, safety, etc.) where there is a specified system response. Verifying each sequence in the sequence of operation is required.
3. Testing proceeds from components to subsystems to systems. When the proper performance of all interacting individual systems has been achieved, the interface or coordinated responses between systems is checked.
4. The contractor shall supply all personnel and equipment for the demonstration, including, but not

limited to, tools, instruments, ladders, lifts, computers, software, cables, etc. Contractor supplied personnel must be competent with and knowledgeable of all project- specific systems, and automation hardware and software. All training documentation, O&Ms, and submittals shall be at the job site before functional testing commences.

D. Development of Test Procedures

1. The CxA develops specific functional test procedures and forms to verify and document proper operation of each piece of equipment and system. The CxA provides a copy of the test procedures to the A/E, OPM and installing Sub who shall review the tests prior to testing. The A/E and Sub(s) shall point out to the CxA any specific problems as related to feasibility, safety, equipment, and warranty protection.

E. Coordination and Scheduling

1. The CM shall provide sufficient notice to the CxA regarding the Subs completion schedule for the prefunctional checklists and startup of all equipment and systems. The CxA will schedule functional tests after written notification from the CM and affected Subs. The CxA shall direct, witness and document the functional testing of all equipment and systems. The Subs shall execute the tests.
2. In general, functional testing shall not be scheduled until all hardware and software submittals are approved, Prefunctional checklists are approved, and start-up has been satisfactorily completed. Scheduling of functional testing shall be done with a minimum of two weeks notice prior to testing. Functional testing of the equipment and systems listed in section 1.5 of this specification section shall not be conducted out of the presence of the CxA and OPM, unless specifically approved to do so in writing by the CxA or OPM. Any functional testing which occurs outside the presence of the CxA or OPM without written authorization to do so will be required to be re-tested at no expense to the owner.

F. Demonstration, Verification and Validation

The electrical systems demonstration shall include, at minimum, the following (as applicable):

1. Lighting Control Systems
2. Metering
3. Panelboards
4. Circuit Breakers
5. Disconnect Switches
6. Switchboards/Motor Control Centers
7. Emergency power systems

G. Problem Solving

The CxA will recommend solutions to problems found; however, the burden of responsibility to solve, correct, and retest problems is with the CM, Subs and A/E.

3.4 DOCUMENTATION, NON-CONFORMANCE, AND APPROVAL OF TESTS

A. Refer to Specification Section 01 9113, Subsection 3.7.

3.5 OPERATION AND MAINTENANCE MANUALS

A. In addition to installation manuals, the contractor shall provide one copy of the Operation and Maintenance Manuals to the CxA for the systems to be commissioned. The O&M Manuals shall be provided to the CxA at least 8 weeks prior to the start of Functional Testing. O&M Manuals shall be in electronic form, the file format shall be Adobe Acrobat readable document. The document shall be formatted to include level 1

bookmarks that link to each main section of equipment. Refer to specification section 01 9113, subsection 3.8 for further detail.

3.6 TRAINING OF OWNER PERSONNEL

A. See Specification Section 01 9113, Subsection 3.9.

B. Provide designated Owner personnel with comprehensive training in the understanding of the systems and the operation and maintenance of each major piece of electronic detection and alarm equipment or system.

C. Training shall start with classroom sessions, if necessary, followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including start- up, shutdown, normal power, emergency power, etc.

D. Training sessions shall not exceed 4 hours per period (unless prior approval provided by Owner). Provide minimum Level I, II and III instructional training hours per following table. Two separate scheduled sessions of Level I and Level II training shall be provided. One scheduled session of Level III training shall be provided where applicable.

3.7 DEFERRED TESTING

A. See Specification Section 01 9113, Subsection 3.10.

END OF SECTION 260800

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SECTION 260913 - ELECTRICAL POWER MONITORING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Multi-function power meters
2. Energy meters
3. Multi-circuit energy meters
4. Accessories

B. Related Requirements:

1. Refer to Division 25 for interface with building automation and data acquisition network.

1.3 REFERENCES

A. Abbreviations and Acronyms

1. CT: Current Transformer
2. EM: Energy Meter
3. MCM: Multi-Circuit Meter
4. PM: Power Meter

B. Definitions

1. Active Power: The average power consumed by a unit. Also known as "real power."
2. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.
3. Apparent (Phasor) Power: "S = VI" where "S" is the apparent power, "V" is the RMS value of the voltage, and "I" is the RMS value of the current.
4. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.
5. Power Factor: The ratio of active power to apparent power, sometimes expressed in percentage.

C. Reference Standards

1. American National Standards Institute (ANSI)
   a. ANSI C12.20, "Electricity Meters - 0.2 and 0.5 Accuracy Classes.”
2. Underwriters Laboratories, Inc. (UL):
   a. UL 61010, “Electrical Equipment for Measurement, Control, and Laboratory Use.”
   b. UL 61010-1, “Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements.”

1.4 COORDINATION

A. Coordinate features of distribution equipment and power monitoring and control components to form an integrated interconnection of compatible components.

1. Match components and interconnections for optimum performance of specified functions.

B. Coordinate Work of this Section with those in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.

1.5 PREINSTALLATION MEETING

A. Schedule preconstruction conference with Architect, Engineer, Owner, and all affected trades. Agenda topics should include, but are not limited to, the following:

1. Communication network wiring requirements.
2. Wire labelling.
3. Current Transformer (CT) and metered load locations.
4. Static IP addresses and Gateway requirements for proper communication with building automation and data acquisition system.

1.6 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Provide the following

1. Include details of equipment assemblies. Indicate dimensions, method of field assembly, components, and location and size of each field connection.
2. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
3. Include diagrams for power, signal, network, and control wiring. Coordinate nomenclature and presentation with a block diagram.

C. Field quality-control reports.

D. Closeout Submittals

1. Operation and Maintenance Data: For metering and components to include in operation and maintenance manuals.
2. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
    a. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

1.7 MAINTENANCE MATERIAL

A. Extra Stock Materials: Provide one set of each type of power and control fuses installed within equipment.

1.8 WARRANTIES

A. Manufacturer Warranty: Manufacturer agrees to repair or replace meters, controls, wiring, and all of its components that fail in materials or workmanship within 5 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide products indicated on Drawings or comparable product by one of the following:

1. ABB
2. Eaton
3. Siemens
4. Square D

B. Source Limitations: Obtain metering devices, and all other electrical distribution equipment through one source from a single manufacturer.

2.2 GENERAL REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Addressable Devices: Transmitters and receivers must communicate unique device identification and status reports to monitoring and control clients.

C. Interface with building automation and data acquisition system: Provide factory-installed hardware and software to enable the building automation and data acquisition system to monitor, display, and record data for use in processing reports.

1. BACnet IP communication interface with the building automation and data acquisition system must enable the system operator to remotely monitor meter information from a system workstation. Control features and monitoring points displayed locally at metering panel must be available through the building automation and data acquisition system.

2.3 POWER METERS

A. Description: Modular, permanently installed, solid-state, digital I/O instrument for power monitoring and control; complying with UL 61010-1.

1. Capable of metering four-wire wye, three-wire wye, three-wire delta, and single-phase power systems.

B. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.

C. Accuracy: Comply with ANSI C12.20, Minimum Class 0.2.

D. Communications:

1. Integral ethernet to serial gateway
2. One RS-485 serial port with Modbus RTU

3. Two Ethernet ports capable of both Modbus TCP/IP and BACnet IP.

E. Meter Physical Characteristics:

1. Display: Backlit LCD with antiglare and scratch-resistant lens.
2. Display of Metered Values: One screen to show at least four lines of user-selected values on one screen at the same time. Provide graphical representation of user-selected values. The screen selections available at the display must include the following:

a. Meters, including those listed under the following:

1) Measurements.
2) THD.
3) Energy.
4) Demand.
5) Minimum and maximum values.
6) Power demand.

F. Sampling Rate: Continuously sample and record voltage and current at a rate not less than 128 samples per cycle, simultaneously on voltage and current channels of the meter.

G. Meters:

1. Measurements: Instantaneous, in real time, RMS to the 63rd harmonic.

a. Voltage: L-L each phase, L-N each phase, and three-phase average.
b. Current: Each phase, three-phase average, and neutral.
c. Unbalanced current, L-L V(ac) and L-N V(ac).
d. Active Power (+/- kW): Each phase and three-phase total.
e. Reactive Power (+/- kVAR): Each phase and three-phase total.
f. Apparent Power (+/- kVA): Each phase and three-phase total.
g. Displacement Power Factor: Each phase and three-phase total.
h. Distortion Power Factor: Each phase and three-phase total.
i. Frequency.

2. THD from measurements simultaneously from the same cycle, through 63rd harmonic.

a. Voltage THD: L-L each phase, L-N each phase, and three-phase average.
b. Current THD: Each phase and three-phase average.
c. Total demand distortion.

3. Energy: Accumulated, indicate whether in-flow or out-flow, net, and absolute values. Store the values in instrument's nonvolatile memory.

a. Active kWh.
b. Reactive kVARh.
c. Apparent kVAh.

4. Demand: Present, last, predicted, peak.

a. Three-phase average current.
b. Three-phase total active power (kW).
c. Reactive power (kVAR).
d. Apparent power (kVA).

5. Minimum and Maximum Values:

a. L-L and L-N voltages.
b. Current in each phase.
c. Power factor.
d. Active power total.
e. Reactive power total.

f. Apparent power total.
g. THD L-L and L-N voltages.
h. THD current in each phase.
i. Frequency.

H. Power Demand, User Selectable:

1. Thermal Demand: Sliding window updated every second for the present demand and at end of the interval for the last interval. Adjustable window that can be set in 1-minute intervals, from 1 to 60 minutes.
2. Block Interval with Optional Subintervals: Adjustable for 1-minute intervals, from 1 to 60 minutes. User-defined parameters for the following block intervals:

   a. Sliding block that calculates demand every second, with intervals less than 15 minutes, and every 15 seconds with an interval between 15 and 60 minutes.
   b. Fixed block that calculates demand at end of the interval.
   c. Rolling block subinterval that calculates demand at end of each subinterval and displays it at end of the interval.

3. Demand Calculation Initiated by a Synchronization Signal:

   a. Signal is a communication signal. Calculation must be configurable as either a block or rolling block calculation.
   b. Provide for synchronizing the demand with the internal of this instrument.

I. Data Recording: Store the listed values in instrument's nonvolatile memory, indicate which of the three phases relates to the value. Attach a date and time stamp to the peak values and the alarms.

1. Minimum and maximum of real-time RMS measurement.
2. Energy.
3. Demand values.
4. Alarms, store a minimum of 14 parameters every 15 minutes for 90 days.

J. Output Signals: Provide two mechanical relays, rated not less than 250 V(ac), 2 A resistive, and rated for 200,000 cycles or more. The relays must be user configurable in one of the following listed modes:

1. Normal contact closure where the contacts change state for as long as the signal exists.
2. Latched mode when the contacts change state when a pickup signal is received and are held until a dropout signal is received.
3. Timed mode when the contacts change state when a pickup signal is received and are held for a preprogrammed duration.

K. Meter Face:

1. Display: Backlit LCD display, six lines, with antiglare and scratch-resistant lens.
2. Display of Metered Values: One screen to show at least four user-selected values on one screen at the same time.
3. Provide for the reset of metered peak values.

L. Capacities and Characteristics:

1. Power Supply: Self powered
2. Circuit Connections:
   a. Voltage: Measurements auto ranging, 90 to 300 V(ac) L-N. Connect directly to low-voltage (600 V and less) without using voltage transformers. Meter impedance must be 2 megohm L-L or greater. Overload Tolerance: 1500 V(ac), RMS, continuously.
   b. Current: Connect to instrument grade current transformer with a metering range of 5 mA to 6 A. Overcurrent tolerance of the instrument must be 10 A continuous, 50 A for 10 seconds once per hour, and 120 A for one second per hour.

c. Frequency: 45 to 65 Hz.
d. Time: Input from a GPS receiver to synchronize the internal clock of the instrument and to time-synchronize this instrument with the network to a deviation of not greater than 1 ms.

2.4 MULTI CIRCUIT ENERGY METERS

A. Multifunction Energy Meter: Separately or internally mounted, modular, permanently installed, solid-state, digital I/O instrument for energy metering and monitoring of multiple circuits; complying with UL 61010-1.

1. Capable of metering four-wire wye, three-wire wye, three-wire delta, and single-phase power systems.
2. Capable of supporting up to 28 three-phase meters.

B. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.

C. Accuracy: Comply with ANSI C12.20, Class 0.5.

D. Communications:

1. Integral ethernet to serial gateway
2. One RS-485 serial port with Modbus RTU
3. Two Ethernet ports capable of both Modbus TCP/IP and BACnet IP.

E. Sampling Rate: Continuously sample and record voltage and current at a rate not less than 128 samples per cycle, simultaneously on voltage and current channels of the meter.

F. Meters:

1. Instantaneous, real time RMS:

a. Current: Each phase, neutral and three-phase average.
b. Voltage: L-L each phase, L-L three-phase average, L-N each phase, and L-N three-phase average.
c. Active Power (kW): Each phase and three-phase total.
d. Apparent Power (kVA): Each phase and three-phase total.
e. Power Factor: Each phase and three-phase total.

2. Energy: Accumulated

a. Active Energy (kWh): Per phase and Three-phase average.

G. Capacities and Characteristics:

1. Power Supply: Self Powered
2. Circuit Connections:

a. Voltage: Measurement auto ranging, 90 to 300 V(ac) L-N. Connect directly to low-voltage (600 V and less) without using voltage transformers. Overload Tolerance: 1500 V(ac), RMS, continuously.
b. Current: Connect to instrument grade low voltage current transformers (LVCT) with a metering range of 50A to 5,000A and a maximum lead length of 100-feet.
c. Frequency: 45 to 65 Hz.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install products in accordance with manufacturer’s instructions.

B. Wiring Method: Install cables in raceways except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

D. Wiring and Cabling Installation: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power wiring.

E. Raceways Installation: Comply with Section 260533 "Raceway and Boxes for Electrical Systems" for electrical power wiring and NFPA 70 Class 1 remote-control and signaling circuits.

3.3 IDENTIFICATION

A. Comply with requirements in Section 260553, “Identification for Electrical Systems” and as noted below:

1. Provide nameplate for each meter.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.

B. Field tests and inspections must be witnessed by Owner’s Representative.

C. Tests and Inspections

1. Visual and Mechanical Inspections

a. Examine equipment nameplate data and confirm proper identification.
b. Inspect the physical, electrical, and mechanical condition of the equipment and all components in accordance with the manufacturers’ instructions.
c. Verify tightness of electrical connections.
d. Visually inspect cable placement, cable termination, grounding, and bonding, and labeling of components.
e. Confirm and record settings for system configuration, CT and PT ratios, multipliers, communications, and other specified parameters are in accordance with record drawings or customer supplied specifications.

2. Electrical Tests

   a. Verify meter accuracy is within manufacturer's published tolerances.
   b. Calibrate meters in accordance with manufacturer's instructions.
   c. Verify all instrument multipliers.
   d. Verify integrity of current transformer circuits.
   e. Confirm correct operation and setting of any auxiliary input/output features.
   f. Verify proper system operation.

D. Nonconforming Work: Wiring and cabling will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 260913

SECTION 260923 - LIGHTING CONTROL DEVICES

• GENERAL

• RELATED DOCUMENTS

- Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

• SUMMARY

- Description:
  - Section includes requirements for the provision of Lighting Controls including manufacturing, fabrication, configuration, and installation as required for the complete performance of the Work, as shown on the Drawings, as specified herein.
  - This work consists of providing all labor, materials, accessories, mounting hardware and equipment necessary for an operationally and aesthetically complete installation of all lighting controls.
  - Specifications and drawings are intended to convey all salient features, functions, and characteristics of the lighting control devices only, and do not undertake to illustrate or set forth every item or detail necessary for the work. Minor details, not usually indicated on the drawings nor specified, but that are necessary for proper execution and completion of the lighting controls shall be included, the same as if they were herein specified or indicated on the drawings.
- Section Includes:
  - General lighting control devices
  - Digital lighting control devices
  - Lighting Control Relay panels
  - Lighting Control Panelboards
  - Lighting Contactor Cabinets
  - Electronic Digital Time Switches
  - Outdoor Photoelectric Switches
  - Emergency lighting control devices
- Related Requirements:
  - Refer to Section 260500, “Common Work Results for Electrical Systems” for requirements related to equipment supports.
  - Refer to Section 262726, “Wiring Devices” for requirements related to lighting snap switches and wall plates.

• REFERENCES

- Abbreviations and Acronyms
  - BAS: Building Automation System.
  - DDC: Direct Digital Controller/Direct Digital Control.
  - IP: Internet protocol.
  - NRTL: Nationally Recognized Testing Laboratory
  - SPD: Surge Protection Device

- Definitions
  - Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE 100 and ANSI/IES LS-1.
  - Scene: The lighting effect created by adjusting several zones of lighting to the desired intensity.
  - Zone: A light fixture or group of light fixtures controlled simultaneously as a single dimmer/relay/entity.
  - Occupancy Sensor: Motion sensing device programmed as automatic on and automatic off.
  - Vacancy Sensor: Motion sensing device programmed as manual on and automatic off.

- Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.
  - National Electrical Contractors Association (NECA):
    - NECA NEIS 130, “Standard for Installing and Maintaining Wiring Devices”
  - Underwriters Laboratories, Inc. (UL):
    - UL 508, “Standard for Industrial Control Equipment.”
    - UL 773, “Plug-in, Locking Photocontrols for Use with Area Lighting.”
    - UL 773A, “Nonindustrial Photoelectric Switches for Lighting Control.”
    - UL 916, “Standard for Energy Management Equipment Systems.”
    - UL 917, “Clock Operated Switches.”
    - UL 924, “Emergency Lighting and Power Equipment.”
    - UL 1008, “Transfer Switch Equipment.”
    - UL 1449, “Transient Voltage Surge Suppressors.”
    - UL 2108, “Low-Voltage Lighting Systems.”

SUBMITTALS

- Product Data: For each type of product indicated including physical data and electrical performance. Include data on features, accessories, finishes, and the following:
  - Physical description, including dimensions.
  - All available finishes and colors for each device and wall/cover plate shall be submitted to the Architect for selection during review.
  - Control type: 0-10V, DMX, etc.
  - Sample Warranty.
- Shop Drawings: Show installation details for occupancy, vacancy, light-level sensors, and digital control devices.
  - Lighting floor plan showing location, orientation, and coverage area of each wall and ceiling mounted sensor.
  - Interconnection diagrams showing field-installed wiring.
  - Riser diagrams indicating device network and cabling types.
  - Include systems descriptions, set points, and controls settings and adjustment.
- Manufacturer's Installation Instructions: Include for manufactured components.
- Control Schedules: After confirming with owner, list operating hours for each day of the week, include observed holidays.

- Qualification Data: For Start-Up Field Technician

- Closeout Submittals
  - Operation and Maintenance Data: For each type of product to include in operation and maintenance manuals. In addition to items specified in Division 01 and Section 260010 “General Requirements for Electrical Systems”, include the following:
    - Description of operation and servicing procedures.
    - Technical support contact
    - List of components.
    - Recommended spare parts.
    - Programming instructions and system operation procedures.
    - Include interconnection wiring diagrams complete field installed system with identified and numbered, system components and devices.
    - Include operation and maintenance manuals for equipment and devices, including sensors, power supplies, and other equipment furnished.
    - Provide detailed set-up information for furnished equipment, indicating required initial configuration switch settings, jumper positions, to facilitate equipment replacement.
    - Include device calibration settings after system programming and start-up with manufacturer's representative.

- MAINTENANCE MATERIAL
  - Extra Stock Material: Provide one (1) of each type of sensor, switch, dimmer, power pack, and emergency lighting control device installed. Package with protective covering for storage and identified with labels describing contents.
  - Keys and Special Tools: Provide one extra set for access to locked or tamperproof enclosures.

- QUALITY ASSURANCE
  - Manufacturer Qualifications:
    - Manufacturer must maintain an authorized service organization within 100 miles of the project location that stocks a full complement of parts for all equipment specified in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.
    - Provide toll free technical telephone support.
  - Installer Qualifications:
    - An employer of workers qualified and trained in electrical safety as required by NFPA 70E.
  - Start-Up Field Technician Qualifications:
    - Minimum experience of 2 years training in the electrical/electronic field.
    - Certified by the manufacturer on the system installed.

- DELIVERY, STORAGE, AND HANDLING
  - Comply with manufacturer instructions for storage of equipment and devices to prevent damage from dirt, moisture, or other environmental concerns.

- COORDINATION
  - Preinstallation Conference: Arrange a pre-installation conference between all applicable subcontractors and architect/engineer prior to the installation of rough-ins for the lighting controls.
  - Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, speakers, fire alarm, HVAC equipment, fire-suppression system, and partition assemblies.
  - Coordinate protocol and interface points of lighting control devices with temperature controls (BAS/DDC) specified in Division 23.
  - Product procurement and coordination:
    - Order products according to application.
    - Confirm the proper and complete catalog number with distributor and agent.
    - Provide additional parts and pieces required to complete the installation in the location and manner intended by the design.
    - Confirm voltages.
  - Contractor shall coordinate with Vendors and other trades, in advance of installation work, to define all infrastructure and installation requirements. Contractor shall coordinate all infrastructure requirements with all approved lighting control devices prior to infrastructure installation. This includes, but not limited to, appropriately sized, positioned, and located junction boxes, structural supports, feeds, power conduits, control conduits, and remote code-compliant power-supply enclosures.

- WARRANTY
  - Manufacturer's Warranty: Manufacturer agrees to repair or replace lighting controls, finishes, wiring, cabling, and all of its components that fail in materials or workmanship within 5 years from date of Substantial Completion.

- PRODUCTS

- GENERAL REQUIREMENTS
  - Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  - Comply with NFPA 70, as well as applicable ANSI, IEC standards, and FCC regulations.
  - Comply with CFR Title 47, Part 15, Subparts A and B, for Class A digital devices.
  - Devices shall be in accordance with NFPA 70, NEMA, and UL listed and labeled.
  - RoHS compliant.
  - Devices located in above ceilings shall be plenum rated.
  - Power failure: Incorporate non-volatile memory. Should power be interrupted and subsequently restored, settings and parameters saved in protected memory shall not be lost and should restore system to its last operating state without requiring user input.
  - Failsafe operation: If automatic switching device loses power, device will latch to closed "ON" position.
  - Components shall be designed and tested to withstand discharges without impairment of performance when subjected to discharges of 15,000 volts per IEC 801-2.

- Products tested in identical manner, complaint to NEMA WD 7 -2011 Occupancy Motion Sensors Standards.

- Voltage: 120/277VAC unless noted otherwise
- Line-Voltage Surge Protection: Include in all 120- and 277-V solid-state equipment. Comply with UL 1449 and with ANSI C62.41 for Category A locations.
- Refer to Section 262726 “Wiring Devices” for device and faceplate colors.

- Standard Operating Range: 32 to 120 deg F, up to 90 percent relative humidity, non-condensing, unless noted otherwise.

- Minimum load rating: 800W at 120VAC and 1200W at 277VAC.

- Provide all control devices with LED status indicator.

- Minimum Occupancy and Vacancy Sensor Coverage Radius:
  - Wall Switch: 35 ft for large motion, 20 ft for small motion.
  - Ceiling, 360 deg, Standard Range: 12 ft radius for small motion.
  - Ceiling, 360 deg, Extended Range: 28 ft radius for large motion.
  - Corner, 120 deg: 40 ft for large motion.
  - Hallway: 100 ft for large motion.
  - High Bay, 360 deg: 20 ft radius at 15 ft mounting height for large motion

- GENERAL LIGHTING CONTROL DEVICES

  - Basis of Design: Subject to compliance with requirements, provide products indicated on Drawings or equivalent by one of the following:
    - Acuity Sensorswitch
    - Hubbell
    - Leviton
    - Lutron
    - Wattstopper

  - General Requirements:

  - Wall Switch Occupancy and Vacancy Sensors: Decora style sensor with on/off switch(es) for mounting in a single gang switchbox.
    - Programmable Automatic On and Manual On Operating Modes.
    - Time Delay for Automatic Off: Adjustable up to 20 minutes.
    - Programmable sensitivity settings.
    - Sensing Technology: Dual technology, PIR and Ultrasonic or Microphonics unless noted otherwise.
    - Noise filtering to eliminate false triggers.
    - Vandal resistant lens
    - Multi-Way: Multi-way: Capable of operation in 3-way application where indicated.
    - Dimming: Provide 0-10V dimming output where indicated.
    - Dual Relay: Where independent control of two loads is required, provide unit with two isolated relays and override switches, capable of independent operating modes and time delays.

  - Line Voltage Occupancy Sensors: Self-contained occupancy sensor with integral power supply and relay suitable for mounting to a standard outlet box in ceiling and wall mounted applications.

- Automatic On operation.
- Time delay for Automatic Off: Adjustable up to 20 minutes.
- Sensing Technology: Dual technology, PIR and Ultrasonic or Microphonics unless noted otherwise.
- Dual Relay: Where independent control of two loads is required, provide unit with two isolated relays and override switches, capable of independent operating modes and time delays.

- Interval Timer Light Switch: Combination countdown timer and conventional switch lighting control unit, switchbox mounted, decorator style.
  - On/Off Switch with Status LED.
  - Adjustable preset intervals.
  - Warning: Audible and/or flash timeout warning.

- Wallbox Dimmer Switches
  - Single gang decorator style, suitable for full range continuous variable control of luminaire light intensity.
  - Comply with UL 1472.
  - Preset slide style dimming control with a mechanical air-gap switch to totally disconnect power from the load when in the off position.
  - Compatible with luminaire ballast or driver.

- DIGITAL LIGHTING CONTROL DEVICES

  - Manufacturers: Subject to compliance with requirements, provide products indicated on drawings or equivalent by one of the following:
    - Acuity nLight
    - Crestron Zum
    - Hubbell NX
    - Wattstopper DLM

  - Description: Intelligent control devices capable of operating in standalone control zones or in a networked configuration for remote, time-based, and global operation with inputs from digital signal sources and remote configuration and monitoring through a software interface.

  - System Architecture:
    - Free topology plug-in wiring with green Cat 5e network cabling for power and data between control devices, switches, and sensors.
    - Self-configuring, digitally addressable control devices.
    - Any combination of inputs shall be programmable to any number of control devices.
    - Automatic configuration and connection of room loads to the connected control devices in the space without commissioning or the use of any tools.
    - Units shall not have any dip switches or potentiometers for field settings.

  - Sensors, power packs, and wall stations shall be interconnected through RJ-45 ports and comply with General Requirements section specified herein.

  - System Accessories: Provide the following accessories as required for implementation of the control intent illustrated on the drawings.
    - Relay Panels: Mechanically latching relays with individual manual override in steel enclosure. Digital integration with other system devices. Relay quantity, poles, and voltages per drawings.
    - BACnet Appliance: Provides BACnet MS/TP digital networked communication between rooms, panels, Gateway, or BAS and automatically creates BACnet objects representative of connected devices.

- Programming and Configuration Software: PC-native application capable of accessing DLM control parameters within a room, for the local network, via a USB adapter, or globally, for many segment networks simultaneously, via BACnet/IP communication.

- Emergency Modes:
  - Lighting relay room controllers and/or ELCD's shall comply with UL 924 requirements. Upon loss of power to a lighting relay room controller or ELCD, lighting relays shall operate in the closed ('on') position and associated LED drivers shall operate in a full light output state. Once normal or backup power is restored, lighting relays shall remain in the closed ('on') position and LED drivers shall remain in a full light output state until a new command is initiated.

- LIGHTING CONTROL RELAY PANELS

  - Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    - Douglas Lighting Controls
    - Leviton Greenmax
    - Lighting Controls & Design (LC&D)
    - Lyntec
    - Wattstopper Lighting Integrator

  - Description: Lighting control panel using mechanically latched relays to control lighting and appliances based on inputs from sensors, switches, or other sources along with zone based timed overrides and blink warnings. Capable of operation in a standalone application or interconnected with digital communications to operate multiple panels as a single system.

    - Pre-assembled steel enclosure with incoming lighting branch circuits, control circuits, switching relays, and on-board timing and control unit. Comply with UL 508.
    - A vertical barrier separating branch circuits from control wiring.
    - Suitable for surface or flush mounting with a hinged locking door assembly.
    - Relay capacity and configuration as required to accommodate switched zones shown on drawings plus 20 percent spare capacity.
    - Surge Protective Device: Factory installed as an integral part of control components or field-mounted surge suppressors complying with UL 1449, SPD Type 2.

  - Control Unit: Contain the power supply and electronic control for operating and monitoring individual relays.

    - Native Ethernet Communications: Comply with TCP/IP protocol. Provide for programming of all control functions of lighting control panels including timing, sequencing, and overriding.
    - Integral keypad, USB port, and LCD digital-display for local programming
    - Nonvolatile memory must retain all setup configurations. After a power failure, the controller must automatically reboot and return to normal system operation, including accurate time of day and date.
    - Protocol: Capable of interfacing with BAS/DDC system to enable remote control and monitoring of the lighting control system. Control features and monitoring points displayed locally at lighting panel must be available through the HVAC DDC system.
    - Web Server: Display control, setup, and diagnostic information over a standard Web-enabled server for displaying information over a standard browser.
    - Timing Unit

      - 365-day calendar, astronomical clock, and automatic adjustments for daylight savings and leap year.
      - Clock configurable for 12-hour (A.M./P.M.) or 24-hour format.
      - Four independent schedules, each having 24 time periods.
      - Schedule periods settable to the minute.

- Day-of-week, day-of-month, day-of-year with one-time or repeating capability.
- 10 special date periods.

- Sequence Control and Override:
  - Automatic sequenced on and off switching of individual or groups of relays at times set at the timing unit, allowing timed overrides from external switches.
  - Sequencing control must operate relays one at a time, completing the operation of all connected relays in not more than 10 seconds.
  - Override control must allow any relay connected to it to be switched on or off by a manual switch or by an automatic switch, such as a sensor. Provide 2-hour override unless otherwise noted.
  - Override control "blink warning" must warn occupants approximately five minutes before actuating the off sequence. Does not apply to exterior lighting.
  - Activity log, storing previous relay operation, including the time and cause of the change of status.

- Relays
  - Electrically operated, mechanically held, minimum 20 A rating at 120/277 VAC for single pole switches and 208/240/480VAC for double pole switches.
  - Integral manual ON/OFF switch with visual display of switch state.
  - Suitable for control of incandescent, fluorescent, LED, and HID loads.
  - Short-circuit current rating must not be less than available fault current as indicated in power system study.
  - UL924 listed for use on emergency circuits, relays must close upon loss of system power.

- Integral Power Supply: NFPA 70, Class 2, sized for connected equipment, plus 20 percent spare capacity. Powered from a dedicated branch circuit of the panelboard that supplies power to the line side of the relays, sized to provide control power for the local panel-mounted relays, bus system, control-voltage inputs, and any field-installed sensors.

- Push-Button and Key Operated Wall Station Switches: Modular, momentary contact or digital, for operating one or more relays and to override automatic controls.

- Sensors and photocells: Powered from the lighting control relay panel and signal compatible with the relay panel control unit. Comply with General Requirements section specified herein.

- LIGHTING CONTACTOR CABINETS

  - Basis of Design: Subject to compliance with requirements, provide product indicated or equivalent product by one of the following:
    - Asco
    - Eaton
    - Square D

  - Description: Factory-wired and tested, lighting control cabinet with contactors, controls, and accessories in single enclosure.

  - Contactors: Electrically operated, dual acting single solenoid mechanism, mechanically held in both open and closed positions, combination-type remote control lighting contactors, complying with NEMA ICS 2 and UL 508.

    - Current Rating for Switching: 30A up to 600VAC.

- Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
- Visual position indicator.
- Control Coil Voltage: Match control power source.
- Provide contactor capacity and configuration as required to accommodate switched zones shown on drawings plus 4 spares.

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- Control Modules: Solid State interface module, start/stop, two-wire, or three-wire control, mounted directly to contactors.
  - Integral auxiliary SPDT contacts to indicate position of the contactor.
  - Provide solid state control modules as necessary to interface with BAS/DDC systems, timers, photoelectric switches, and similar control devices as required by lighting control zones and sequences.
- Enclosure: Comply with NEMA 250, Steel, NEMA 1 enclosure with hinged lockable cover cabinet enclosure sized as required for components, unless otherwise indicated. Mount switches and indicating lights required on front of enclosure. Install terminal strips for connection of all external control wiring connections. Surface or flush mounted as shown on drawings.
- Provide the following integral control and indicating devices:
  - Hand-off-auto (HOA) selector switch, of the heavy-duty “oil-tight”, maintained-contact type, mounted on the front cover with legend plate.
  - Auxiliary SPDT contacts to indicate position of HOA switch.
  - Auxiliary relay to convert maintained-contact type control circuit to momentary-contact type control circuit necessary for contactor control.
  - Control transformer with primary voltage as indicated and 120-volt, single phase, 60 hertz secondary including fuse and fuse holder.
  - Green and Red pilot lights to indicate “Power ON” and “Power OFF” condition. Mount on front cover with legend plate.
  - Time Clock: Integral 365-day/7-day digital time clock with LCD display.
  - Photocell: Compatible with control voltage and complies with Outdoor Photoelectric Switches section specified herein.
  - Interface with BAS/DDC System for HVAC: Provide hardware interface to enable the DDC system for HVAC to monitor and control lighting contactors.
    - Monitoring: Contactor On-off status, HOA switch On, HOA switch Auto.
    - Control: Contactor On-off operation.

- EMERGENCY LIGHTING CONTROL DEVICES
  - Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - Bodine
    - Dual-Lite
    - LVS
    - Wattstopper
  - Automatic Load Control Relays (ALCR)

- Operation: Automatically switch emergency lighting on and off as normal lighting is switched. When normal power is not available, the unit shall force and hold emergency lighting on regardless of the state of any external control device until normal power is restored.
- UL 924 listed device with relay switching circuitry, test switch, normal power indicator light, and an alternate power indicator light in a single enclosure.
- Universal Input Voltage: 120-277V, 60Hz
- Load Rating: 20A
- Suitable for indoor or damp locations.

- Branch Circuit Emergency Lighting Transfer Switches (BCELTS)
  - Operation: Automatically switch a lighting load from a normal source to a designated emergency source when normal power is lost.
  - UL 1008 listed device with relay switching circuitry, test switch, normal power indicator light, and an alternate power indicator light in a single enclosure.
  - Universal Input Voltage: 120-277V, 60Hz
  - Load Rating: 20A
  - Suitable for indoor or damp locations.

- CONDUCTORS AND CABLES
  - Wiring to supply side of remote-control power sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519, Low-Voltage Electrical Power Conductors and Cables
  - Low-voltage control cable for 0-10VDC dimming: Manufacturer's standard multi-conductor cable with stranded-copper conductors not smaller than No. 18 AWG, plenum rated unless otherwise recommended by the manufacturer.
  - Class 1 and 2 Control Cables: Multi-conductor cable with copper conductors not smaller than No. 14 AWG, plenum rated unless otherwise recommended by the manufacturer.
  - UTP cabling: Unshielded, plenum rated, Cat5e twisted-pair cable. Comply with lighting control system manufacturer's recommendations.

- SOURCE QUALITY CONTROL
  - Factory Tests and Inspections: Perform full-function testing on 100 percent of all system components and panel assemblies at the factory prior to delivery.
  - System control components shall be certified by the manufacturer to have been designed, manufactured, and tested for interoperability.

- EXECUTION

- EXAMINATION
  - Examine lighting control devices and equipment before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.
  - Examine walls, ceilings, and other mounting surfaces for suitable conditions where lighting control devices and equipment will be installed.
  - Proceed with installation only after unsatisfactory conditions have been corrected.

- INSTALLATION
  - Install lighting controls and equipment in accordance with manufacturer's written instructions, applicable requirements of NEC, and NECA 500 and 501.
  - Electrical installations shall conform to and meet IEEE C2, NFPA 70, and to the requirements specified herein.
  - Devices and Equipment shall be installed and programmed to meet the control intent.
  - Device Installation:
    - Comply with Section 262726 "Wiring Devices" for wall mounted device and faceplate installation requirements.
    - Install in a single box and provide a single cover plate where two or more devices are shown adjacent on plans. Provide voltage barrier where required.
    - Verify door swings with door frame installed prior to rough-in for switches and sensors. Locate switches on latch side of door.
    - Device Orientation: Install switches and dimmers with the "OFF" position down.
  - Panels and Cabinets:
    - Install panels and cabinets in accordance with NECA 407.
    - Mount top of trim no greater than 90-inches above finished floor unless otherwise indicated.
    - Mount panel cabinet plumb and rigid without distortion of box.
    - Install filler plates in unused spaces.
  - Conductors/Wiring:
    - Wiring Methods: Comply with Section 260519, Low-Voltage Electrical Power Conductors and Cables.
    - Size conductors in accordance with lighting control device manufacturer's instructions unless otherwise indicated.
    - Voltage Drop: Adjust conductors and conduit sizes accordingly based on actual field installed conditions.
    - Where the total conductor length for 0-10VDC dimming applications exceeds the values below, adjust conductor size as noted.
      - Conductor lengths up to 300 feet: #18 AWG minimum.
      - Conductor lengths between 300 feet and 430 feet: #16 AWG minimum.
      - Conductor lengths between 430 feet and 690 feet: #14 AWG minimum.
      - Conductor lengths between 690 feet and 1100 feet: #12 AWG minimum.
      - Conductor lengths between 1100 feet and 1750 feet: #10 AWG minimum.
    - Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
    - Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
    - Provide plenum-rated cable, where installed exposed or in open cable tray, within environmental airspaces, including plenum ceilings.
  - Lighting Controllers/Power Packs:
    - Room controllers shall be surface mounted in accessible ceiling space above entry door. Install no higher than 6" above accessible ceiling.
    - Install controllers/power packs on the unswitched line side of local switches to keep sensors powered at all times.
    - Provide controllers/power packs(s) for each room/area/control zone for a working system.
    - Note all power pack locations and branch circuiting on as-built record drawings.
  - Lighting Contactors

- Install lighting contactors as indicated on plan. Install at accessible locations.
- Mount contactors in a manner to eliminate structure-borne vibration.

- Occupancy and Vacancy Sensors
  - Provide quantity of sensors indicated as a minimum. Provide additional units to give full coverage over controlled area. Provide full coverage for hand and arm motion detection in office, classroom, and administration type areas and walking motion for storage rooms and hallways.
  - Install wallbox sensors at switch height indicated on drawings,
  - Install wall sensors without manual switches at 8 ft above finished floor unless otherwise noted on drawings.
  - Install ceiling mounted sensors at locations indicated on manufacturer's shop drawings. Sensor manufacturer shall provide quantity of sensors as required to provide complete coverage for rooms.
  - Locate sensors such that motion through open doors will not falsely activate sensors.
  - Do not locate ultrasonic sensors within six feet of supply air diffusers.
  - Locate infrared sensors to avoid obstructions.

- IDENTIFICATION
  - Comply with Section 260553 "Identification for Electrical Systems."
    - Identify all components and power and control wiring.
    - Label time switches and contactors with a unique designation.
    - Provide directories inside relay panels and contactor cabinets that identify each relay and the associated control zone.

- FIELD QUALITY CONTROL
  - Visual and Mechanical Inspections:
    - Upon completion of installation, verify that equipment is properly installed, connected, and adjusted.
    - Inspect control components for defects and physical damage, testing laboratory labeling, and nameplate compliance with the Contract Documents.
  - System Start-up:
    - Complete installation and startup checks according to manufacturer's written instructions.
    - Confirm layout and location of sensors with manufacturer's recommendations to achieve proper coverage of indicated areas. Provide additional sensors and control units as required to achieve complete minor motion coverage of the space indicated. Provide customizable sensor masks to block off unwanted viewing areas.
    - Confirm control schedules with owner including operating hours for each day of the week and holiday schedules. Submit to design team for approval.
    - Confirm correct communications wiring, initiate communications between panels, and program the lighting control system according to approved configuration schedules, time-of-day schedules, and input override assignments.
  - System Functional Tests: After installing all control devices, automatic time switches, and sensors, and after electrical circuitry has been energized, test systems for compliance with approved sequences in accordance with energy code requirements.
    - Adjust time delays, trim settings, dead bands, and scene settings.
    - Owner and architect/engineer shall be present during adjustment of scene settings. Exterior scenes shall be adjusted during non-daylit hours.

- Set and operate devices to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions.
- Include testing of devices under conditions that simulate actual operational conditions including occupied and unoccupied states.
- Verify all emergency lighting functions upon loss of power.
- Record all control settings, operations, cues, and functional observations.

- Nonconforming Work:
  - Lighting control devices and equipment will be considered defective if it does not pass tests and inspections.
  - Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace defective units and retest.
  - Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
- Prepare test and inspection reports.

- ADJUSTING
  - Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose.
  - The lighting and lighting controls systems shall be synchronized and fully operable to address the lighting operation in a complete and code-compliant manner.
  - All ladders, scaffolds, lifts, gloves, cleaning cloths, access/adjustment tools, etc. required for aiming and adjusting lighting controls shall be furnished by the Contractor.

- PROTECTION
  - Install lighting control devices after all wall preparation, including painting, is complete.
  - Replace all devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
  - Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
  - Do not remove surface protection, such as plastic film and smudge covers, until final cleaning has been completed.

- DEMONSTRATION
  - Engage a factory-authorized service representative to train Owner's facility management and maintenance personnel, and selected Owner representatives. as specified below:
    - Train Owner's maintenance personnel on troubleshooting, servicing, adjusting, and preventive maintenance. Provide a minimum of four (4) hours training.
    - Training Aid: Use the approved final version of maintenance manuals as a training aid.
    - Training shall include, but not be limited to, overview, adjustment, operation, use, maintenance, and demonstration of the lighting control system.

END OF SECTION 260923

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SECTION 262200 - LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

1.2 SUMMARY

A. Description: Section includes requirements for the provision of Low-Voltage, dry type distribution transformers including manufacturing, fabrication, configuration, and installation as required for the complete performance of the Work, as shown on the Drawings, as specified herein.

B. Section includes distribution, energy efficient, dry-type transformers with a nominal primary and secondary rating of 600 V and less.

C. Related Requirements:

1. Refer to Section 260500 “Common Work Results for Electrical Systems” for requirements related to equipment bases, supports, and vibration pads.

1.3 REFERENCES

A. Abbreviations

1. DOE: Department of Energy
2. FCAN: Full Capacity Above Normal
3. FCBN: Full Capacity Below Normal
4. XFMR: Transformer

B. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.

1. National Electrical Contractors Association (NECA)
   a. NECA 409, “Standard for Installing and Maintaining Dry-Type Transformers”.
2. National Electrical Manufacturers Association (NEMA)
   a. NEMA ST20, “Dry Type Transformers for General Applications”.
3. Underwriters Laboratories Inc (UL)
   a. UL 1561, “Dry-Type General Purpose and Power Transformers”.
4. Federal Regulations and Policies
   a. DOE 10 CFR Part 429, “Certification, Compliance, and Enforcement for Consumer Products and Commercial and Industrial Equipment”.
   b. DOE 10 CFR Part 431, “Energy Efficient Program for Certain Commercial and Industrial Equipment”.

1.4 SEQUENCING

A. Submit the preliminary power system study prior to receiving final approval of equipment and system protective devices submittals and prior to release of equipment drawings for manufacturing. Adjust equipment sizes, frame sizes, and trip units as necessary to achieve performance requirements outlined in Section 260573, “Power Systems Studies”.

1.5 SUBMITTALS

A. Product Data: For each type of product. Include the following:

1. Basic Performance characteristics including insulation class, temperature rise, core and coil materials, impedances & audible noise level, unit weight, and inrush data expressed in either Amperes RMS or Times Rated input current.
2. Efficiency Data per NEMA ST20 and 10 CFR Part 431 at 35% loading point.
3. No load and full load losses calculated per NEMA ST20 test methods.
4. Efficiency levels at 25%, 50%, 75%, and 100% load points.

B. Shop Drawings: For each product type.

1. Enclosure dimensions and clearances
2. Wiring Diagrams: Power, signal, and control wiring.
3. Wire Bending Dimensions
4. Location for Ground Lug Provisions
5. Factory provided mounting brackets
6. Field installed accessories.

C. Factory quality-control test reports.
1. Acceptance Tests
2. Sound Level Tests

D. Field quality-control test reports.

E. Closeout Submittals

1. Provide Operation and Maintenance Data for transformers to include in operation and maintenance manuals.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Remove and replace access fencing, doors, lift-out panels, and structures as required to provide pathway for moving transformers into place.

B. Comply with manufacturer instructions for storage of electrical equipment to prevent damage from condensation or other environmental concerns.

1.7 COORDINATION

A. Coordinate size and location of concrete bases with dimensions of transformer provided.

B. Coordinate installation of wall and ceiling mounting hardware and structural supports with transformer provided.

C. Distribution equipment sizes and equipment layouts shall be considered basis of design. Equipment sizes vary by manufacturer. If proposed equipment is larger than the sizes illustrated, the burden shall be on the Contractor to provide equipment which fits in the space allotted while maintaining all code-required and manufacturer-recommended clearances.

D. Drawings indicate space available for electrical equipment, including clearances between equipment and adjacent surfaces and other items. Equipment installed must comply with all clearance, access and replacement working space requirements of the NEC and Owner.

E. Conduct and submit results of power system studies before submitting Product Data and Shop Drawings for electrical equipment.

F. Coordinate inrush current values of transformer provided with overcurrent protection device settings as described in Section 260573, “Power System Studies”. Adjust overcurrent protection device size, settings, and feeder size to eliminate nuisance operation in response to the actual transformer inrush current.

1.8 WARRANTY

A. Manufacturer’s Warranty: Manufacturer agrees to repair or replace transformers, finishes, controls, wiring, and all of its components that fail in materials or workmanship within 12 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB/General Electric.
2. Eaton.
3. Siemens.
4. Square D.
5. Acme

B. Source Limitations: Obtain transformers and all other electrical distribution equipment through one source from a single manufacturer.

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70, NEMA ST 20, and list and label as complying with UL 1561.

C. Comply with (DOE) 10 CFR 431 for minimum energy efficiency levels. Transformers shall bear the UL Energy Efficiency Verification Mark to confirm that the unit meets minimum efficiency levels.

D. Provide transformers that are constructed to withstand seismic forces specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

F. Phase, kVA Ratings, and Primary and Secondary Voltages: as indicated on drawings.

G. Cores: Grain-oriented, non-aging silicon steel with high permeability and low hysteresis and eddy current losses. Magnetic flux densities are to be kept well below the saturation point to prevent core overheating.
1. One leg per phase.
2. Core volume shall allow efficient transformer operation at 10 percent above the nominal tap voltage.
3. Visibly grounded to the enclosure by means of a flexible grounding conductor sized in accordance with applicable UL and NEC standards.
4. Cores shall be clamped with structural angles and bolted to the enclosure to prevent damage during shipment or rough handling.

H. Coils: Continuous windings without splices except for taps. Coils shall have a final wrap of electrical insulating material designed to prevent injury to the coil wire.
1. Coil Material: Copper.
2. Internal Coil Connections: Brazed or pressure type.
3. Terminal Connections: Welded.

I. Insulation Class: Minimum 220 deg C, UL-component-recognized insulation system.
1. Temperature Rise: 115 deg C unless noted otherwise.
2. All insulation materials shall be flame-retardant and shall not support combustion as defined in ASTM Standard Test Method D635
3. Wire left bare will not be accepted, all conductors must have insulation material.

J. Enclosure: Ventilated

1. NEMA 250, Type 2 unless otherwise required by environmental conditions. Provide weathershield for ventilation openings where located outdoors.
2. Heavy gauge steel construction.
3. The core and coil unit shall be completely isolated from the enclosure by means of a vibration isolating system and shall be so designed as to provide for continual securement of the core and coil unit to the enclosure.
4. Core and coil shall be encapsulated within non-hygroscopic thermosetting varnish, sealing out moisture and air.
5. Wiring Compartment: Sized for conduit entry and wiring installation.
6. Minimum clearances from ventilated openings to obstructions shall be indicated on the nameplate and not exceed 6-inches.
7. The maximum top of case temperature shall not exceed 35 deg C above 40 deg C ambient.
8. Finish: Gray weather resistant baked enamel, complying with NEMA 250.

K. Taps:

1. Three-phase transformers rated 15 kVA and larger shall be provided with six 2-1/2% full capacity taps, two above and four below rated primary voltage.
2. Three-phase transformers rated below 15kVA shall be provided with two 5% full capacity taps below rated primary voltage.

L. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for non-sinusoidal load current-handling capability to the degree defined by designated K-factor.
1. Neutral rated 200 percent of full load current.
2. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
3. Indicate value of K-factor on transformer nameplate.

M. Electrostatic Shielding:
1. Where shielding is indicated on Drawings, each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.
a. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
b. Include special terminal for grounding the shield.
2. Common mode noise attenuation: Minus 80 dBA minimum at 0.1 kHz to 1.5 kHz; minus 55 dBA minimum at 1.51 kHz to 100 kHz. Normal mode (Transverse mode) noise atténuation : Minus 35dBA minimum at 1.5 kHz to 10 kHz.

N. Grounding: Provide ground bar installed on the inside of the transformer enclosure.

O. Wall and Ceiling Brackets: Manufacturer's standard brackets.

P. Low-Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

Q. Terminations: Mechanical Lugs listed to accept specified wiring method, conductor size, and temperature rating.

2.3 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.91 and IEEE C57.12.91.
1. Ratio tests at the rated voltage connection and at all tap connections.
2. Polarity and phase relation tests on the rated voltage connection
3. Applied potential tests
4. Induced potential test
5. No-load and excitation current at rated voltage on the rated voltage connection

B. Factory Sound-Level Tests: Conduct prototype sound-level tests on equipment for this Project.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances and equipment operation required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install transformers level and plumb with vibration dampening supports.

1. Provide wall and ceiling mounted transformers with brackets fabricated by transformer manufacturer.
2. Coordinate installation of structural steel supports with actual transformer provided.

B. Construct concrete bases and anchor floor-mounted transformers according to manufacturer's written instructions.

C. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.

D. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Provide flexible connections at all conduit and conductor terminations and supports according to Section 260533, "Raceways and Boxes for Electrical Systems" and Section 260500, "Common Work Results for Electrical Systems" to eliminate sound and vibration transmission to the building structure.

D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

E. Where a tightening torque is indicated as a numeric value on equipment or in installation instructions provided by the manufacturer, use a calibrated torque tool to achieve that indicated torque value, unless the equipment manufacturer has provided installation instructions for an alternative method of achieving the required torque.

3.4 IDENTIFICATION

A. Comply with requirements in Section 260553, "Identification for Electrical Systems".

1. Where primary disconnecting means is not provided within sight of transformer, identify transformer with equipment designation and location of remote lockable disconnecting means by permanent nameplate.
2. All distribution equipment shall be shipped from the manufacturer with factory-applied warning labels affixed to the outside front of the equipment (as it will be installed per the plans). All labeling shall be in compliance with NFPA 70 requirements.
3. Labels affixed to equipment by the equipment manufacturer shall comply with drawing and specification labeling requirements or shall be omitted by the manufacturer and field-installed by the Contractor. Labels which are factory-installed and not in compliance shall be removed and replaced and equipment enclosures refinished or replaced by the manufacturer to repair finish.

3.5 FIELD QUALITY CONTROL

A. Tests and Inspections: Perform the following tests and inspections. Certify compliance with test parameters.

1. Visual and Mechanical Inspection

    a. Document equipment nameplate data on the test report. Verify that transformer nameplate ratings are in accordance with drawings.
    b. Inspect the physical and mechanical condition of the equipment.
    c. Inspect anchorage, alignment, and grounding.
    d. Verify that resilient mounts are free and that any shipping brackets have been removed.
    e. Inspect bolted electrical connections for high resistance by verifying tightness with calibrated torque-wrench method in accordance with manufacturer's published data.

2. Electrical Tests

    a. Perform insulation-resistance tests. Measurements shall be made from winding-to-winding and each winding-to-ground. Test voltages and minimum resistance shall be in accordance with manufacturer's published data.
    b. Verify correct secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.

B. Test and Inspection Reports: Prepare a written report to certify compliance with test parameters and record the following:

1. Test procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

C. Products will be considered defective if they do not pass tests and inspections. Remove and replace malfunctioning units and retest as specified above.

D. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.6 CLEANING:

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 262200

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SECTION 262413 - SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

1.2 SUMMARY

A. Description: Provide labor, material, equipment, related services, and supervision required, including, but not limited to, manufacturing, fabrication, configuration, and installation for low voltage switchboards as required for the complete performance of the Work, as shown on the Drawings as specified herein.

B. Section Includes:

1. Service and distribution switchboards rated 600 V and less.
2. Disconnecting and overcurrent protective devices.
3. Instrumentation.
4. Accessory components and features.
5. Identification.

C. Related Requirements:

1. Refer to Section 260500, “Common Work Results for Electrical Systems” for requirements related to equipment pads.

1.3 REFERENCES

A. Abbreviations

1. SPD: Surge Protective Device
2. SWBD: Switchboard

B. Definitions:

1. Switchboard: A large single panel, frame, or assembly of panels on which are mounted switches, over-current, and other protective devices, buses, and instruments.

C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.

1. National Electrical Contractors Association (NECA):
    a. NECA 400, “Standard for Installing and Maintaining Switchboards"
2. National Electrical Manufacturers Association (NEMA):
    a. NEMA PB 2, "Deadfront Distribution Switchboards."
    b. NEMA PB 2.1, "General Instructions for Proper Handling, Installation, Operation and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less."

3. Underwriter Laboratories (UL):

   a. UL 50, "Enclosures for Electrical Equipment, Non-Environmental Considerations."
   b. UL 489, "Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures."
   c. UL 891, "Standard for Switchboards"

1.4 SEQUENCING

A. Submit the preliminary power system study prior to receiving final approval of equipment and system protective devices submittals and prior to release of equipment drawings for manufacturing. Adjust equipment sizes, frame sizes, and trip units as necessary to achieve performance requirements outlined in Section 260573, "Power Systems Studies".

1.5 SUBMITTALS

A. Product Data: For each Switchboard.

1. Include materials, switching and overcurrent protective device, ground-fault protector, arc energy reduction switches, accessories, and components.
2. Include manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each Switchboard and related equipment.

1. Include dimensioned plans, front and side elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Include conduit entrance locations and requirements; nameplate legends; one-line riser diagrams; equipment schedule; and switchboard instrument details.
3. Detail enclosure types for types other than NEMA 250, Type 1.
4. Detail bus configuration, current, and voltage ratings.
5. Detail short-circuits current rating of Switchboards and overcurrent protective devices.
6. Where specified, detail utility company's metering provisions with indication of approval by utility company.
7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
8. Include diagram and details of proposed mimic bus.
9. Include schematic and wiring diagrams for power, signal, and control wiring.

C. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Closeout Submittals

1. Operation and Maintenance Data: For Switchboards and components to include in operation and maintenance manuals.
2. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
   a. Routine maintenance requirements for switchboards and all installed components.
   b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

c. Time-current coordination curves for each type and rating of overcurrent protective device included in Switchboards.

1.6 MAINTENANCE MATERIAL

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Equal to 10 percent of quantity installed for each size and type, but no fewer than one of each size and type.

1.7 QUALITY ASSURANCE

A. Installer Qualifications:

1. Minimum of five years of successful installation experience with projects utilizing switchboards similar in type and scope to that required for this Project.
2. An employer of qualified workers as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver Switchboards in sections or lengths that can be moved past obstructions in delivery path. Remove and replace access fencing, doors, lift-out panels, and structures as required to provide pathway for moving switchboards into place.

B. Handle and prepare Switchboards for installation according to NECA 400 and NEMA PB 2.1. Lift only by lifting means provided for this express purpose. Handle carefully to avoid damage to switchboard internal components, enclosure, and finish.

C. Comply with manufacturer instructions for storage of electrical equipment to prevent damage from condensation or other environmental concerns.

1.9 COORDINATION

A. Coordinate layout and installation of Switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with dimensions of actual equipment provided.

C. Distribution equipment sizes and equipment layouts shall be considered basis of design. Equipment sizes vary by manufacturer. If proposed equipment is larger than the sizes illustrated, the burden shall be on the Contractor to provide equipment which fits in the space allotted while maintaining all code-required and manufacturer-recommended clearances.

D. Drawings indicate space available for electrical equipment, including clearances between equipment and adjacent surfaces and other items. Equipment installed must comply with all clearance, access and replacement working space requirements of the NEC and Owner.

1.10 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace switchboards, circuit breakers, finishes, controls, wiring, and all of its components that fail in materials or workmanship within 12 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB.
2. Eaton.
3. Siemens.
4. Square D.

B. Source Limitations: Obtain switchboards, overcurrent protection devices, and all other electrical distribution equipment through one source from a single manufacturer.

2.2 GENERAL REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NEMA PB 2, NFPA 70, and UL 891.

C. Provide switchboards that are constructed to withstand seismic forces specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Front-Connected, Front-Accessible Switchboards unless otherwise indicated:

1. Main Devices: Fixed, individually mounted unless otherwise indicated.
2. Branch Devices: Panel mounted.
3. Sections front and rear aligned.

E. Nominal System Voltage and Main Bus Ratings as indicated on drawings.

F. Short Circuit Current Rating: Switchboards shall be rated with a minimum short circuit current rating of 100,000 AIC, unless otherwise indicated on drawings.

G. Service Entrance: Where panelboards are used as service equipment with one or more main service disconnecting and overcurrent protective devices, provide marking by an NRTL acceptable to authority having jurisdiction indicating panelboard is suitable for use as service equipment. Coordinate with utility company for any additional requirements.

H. Utility Metering Compartment: Where indicated, provide barrier compartment and section complying with utility company's requirements; hinged sealable door; buses provisioned for mounting utility company's current transformers and potential transformers, or potential taps as required by utility company. If separate vertical section is required for utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features.

I. Indoor Enclosure: Steel, NEMA 250, Type 1 unless otherwise.

1. Finish: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
2. Provide removable steel base channels bolted to the frame to rigidly support the entire shipping section for moving on rollers and floor mounting. The framework is to be formed of code gauge steel, rigidly welded together to support all cover plate, bussing and component devices.
3. All front covers shall be screw removable with a single tool and all doors shall be hinged with removable hinge pins.

J. Barriers: Between adjacent switchboard sections.

1. Access Provisions: Permit checking of bus-bolt tightness.

K. Customer Metering Compartment: Provide a separate customer metering compartment and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks.

L. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

M. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

N. Provide Pull Box on Top of Switchboard when required by quantities and sizes of feeders:

1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
2. Set back from front to clear any circuit-breaker removal mechanisms.
3. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
4. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.

O. Buses and Connections: Three phase, four wire unless otherwise indicated.

1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from the front of the switchboard.
2. Phase-, Neutral, and Ground -Bus Material: Tin-plated, Hard-drawn copper of 98 percent conductivity.
3. Copper feeder circuit-breaker line connections.
4. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
5. Ground Bus: Size per current NEC and UL 891 Tables 28.1 and 28.2, equipped with pressure connectors for feeder and branch circuit ground conductors.
6. Main-Phase Buses, Neutral Buses, and Equipment-Ground Buses: Uniform full capacity for entire length of switchboard's main and distribution sections to comply with ampacity indicated. Tapered bus is not permitted. Provide sufficient cross-sectional area to meet UL 891 temperature rise requirements. Provide for future extensions from both ends.
7. Disconnect Links:
   a. Isolate neutral bus from incoming neutral conductors.

b. Bond neutral bus to equipment-ground bus with an appropriately sized main bonding conductor for switchboards utilized as service equipment or separately derived systems.

P. Future Devices: Equip all unused spaces and compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment to allow future installation of OCPDs.

Q. Switchboard and/or main service equipment will be be designed with 25% minimum spare capacity, both physically and electrically, for future growth capacities.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings where indicated:
   a. Instantaneous trip.
   b. Long- and short-time pickup levels.
   c. Long and short time adjustments.
   d. Ground-fault pickup level, time delay, and I squared t response.
4. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
5. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
6. MCCB Features and Accessories:
   a. Standard frame sizes, trip ratings, and number of poles.
   b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
   c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits: Type HACR for heating, air-conditioning, and refrigeration equipment.
   d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   e. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
   f. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
   g. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
   h. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

B. Provide equipment ground fault protection for all overcurrent protective devices 1000 amps or greater on 480Y/277V systems.

C. Provide arc energy reduction maintenance switch for all overcurrent protective devices rated 1200 amps or greater or where the continuous current trip setting can be adjusted to 1200A or greater.

D. Provide phase failure relays on main service entrance breaker.

2.4 INSTRUMENTATION

A. Instrument Transformers: NEMA EI 21.1, ANSI/IEEE C57.13, and the following:
   1. Potential Transformers: Secondary voltage rating of 120 volts and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
   2. Current Transformers: Ratios shall be as indicated with accuracy class and burden suitable for connected relays, meters, and instruments.
   3. Control Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kV.
   4. Current Transformers for Neutral and Ground Fault Current Sensing: Connect secondaries to ground overcurrent relays to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit breaker ground fault protection.

2.5 METERING

A. Comply with requirements in Section 260913, “Electrical Power Monitoring” for integral power meters.

B. Overcurrent Protective Device Communication Capability: Where indicated provide electronic trip circuit breakers and integral communication module with functions and features compatible with power monitoring and control system specified in Section 260913, "Electrical Power Monitoring".

2.6 SURGE PROTECTIVE DEVICES

A. Where Switchboards are indicated with integral SPD, comply with requirements in Section 264300, “Surge Protective Devices”. Surge protective devices shall be installed by, and shipped from, the electrical distribution equipment manufacturer’s factory.

2.7 CONTROL POWER

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer, if required.

B. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

C. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for #8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.8 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Lock-out, Tag-out: All circuit breakers in the Switchboard to include fixed padlock attachments.

2.9 IDENTIFICATION AND MARKINGS

A. Mimic bus: Provide anodized aluminum or laminated plastic mimic bus factory applied to front of switchboard. Arrange in single-line diagram format, using symbols and letter designations consistent with final mimic-bus diagram.

1. Coordinate mimic-bus segments with devices in switchboard sections to which they are applied. Produce a concise visual presentation of principal switchboard components and connections.

B. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components complete with lettering designations.

C. Service Equipment Label: Where Switchboard is provided with one or more service disconnecting and overcurrent protective devices, provide NRTL label indicating use as service equipment.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to NECA 400 and NEMA PB 2.1.

B. Examine Switchboard interior and exterior before installation. Reject Switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive Switchboards for compliance with installation tolerances and other conditions affecting performance of the Work.
1. Verify concrete pads are level and free of irregularities.
2. Ensure area to receive switchboard has adequate clearance for switchboard installation.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install Switchboards and accessories according to manufacturer's written guidelines, NECA 400 and NEMA PB 2.1.

B. Equipment Mounting: Install Switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Division 03 and Section 260500, “Common Work Results for Electrical Systems.”

1. Install conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches above concrete base after switchboard is anchored in place.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to Switchboards.

C. Temporary Lifting Provisions: Remove any temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from Switchboard units and components.

D. Operating Instructions: Frame and mount basic operating instructions for Switchboards, including any control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of Switchboards.

E. Install filler plates in unused spaces of panel-mounted sections.

F. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.

G. Comply with NECA 1.

3.3 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B. Where a tightening torque is indicated as a numeric value on equipment or in installation instructions provided by the manufacturer, use a calibrated torque tool to achieve that indicated torque value, unless the equipment manufacturer has provided installation instructions for an alternative method of achieving the required torque.

B. Provide ground bushings and bonding conductor connections to the equipment ground bus sized per NFPA 70 on each metallic conduit entering or leaving the switchboard and at the terminal end for each continuous metallic feeder conduit.

C. Support and secure conductors within the switchboard according to NFPA 70.

3.4 IDENTIFICATION

A. Comply with requirements in Section 260553, “Identification for Electrical Systems.”

1. Identify field-installed conductors, interconnecting wiring, and components.
2. Provide warning signs and labels to advise personnel of possible hazards in accordance with UL, NFPA 70, NFPA 70E, and other applicable standards.
3. Provide nameplate for each switchboard compartment.
4. Provide nameplate for each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors.
5. All distribution equipment shall be shipped from the manufacturer with factory-applied warning labels affixed to the outside front of the equipment (as it will be installed per the plans). All labeling shall be in compliance with NFPA 70 requirements.
6. Labels affixed to equipment by the equipment manufacturer shall comply with drawing and specification labeling requirements or shall be omitted by the manufacturer and field-installed by the Contractor. Labels which are factory-installed and not in compliance shall be removed and replaced and equipment enclosures refinished or replaced by the manufacturer to repair finish.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Tests and Inspections:

1. Visual and Mechanical Inspection: Provide manufacturer’s standard start-up inspections, including the following:

a. Examine equipment nameplate data and confirm proper identification.

b. Inspect the physical, electrical, and mechanical condition of the equipment and all components in accordance with the manufacturers' instructions.
c. Inspect anchorage, alignment, and grounding.
d. Verify controls and instrumentation, ensuring that current and potential transformer ratios are correct.
e. Inspect bolted electrical connections and terminations for high resistance by verifying tightness with calibrated torque-wrench method in accordance with manufacturer's published data.
f. Exercise all active components.
g. Inspect all mechanical indicating devices for correct operation.
h. Physically test key interlock systems to check for proper functionality prior to energizing.

2. Electrical Acceptance Testing: Provide manufacturer's standard start-up testing, including the following:

a. Perform insulation resistance test for one minute on each switchboard bus section. Open control and metering circuits within the switchboard and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test. Test voltages and minimum resistance shall be in accordance with manufacturer's published data.
b. Perform a control wiring performance test by applying control voltage.

3. Circuit Breaker Testing: For all circuit breakers with electronic trip units, determine minimum pickup current, long-time and short-time pickup and delay, and instantaneous pickup by secondary current injection. Certify compliance with test parameters and ensure settings match recommendations from final approved power system study.
4. Test ground-fault protection of equipment for service equipment per NFPA 70.
5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
6. Perform the following infrared scan tests and inspections:
a. Initial Infrared Scanning: Prior to Substantial Completion after all loads are connected, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard.
b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device in report.

C. Switchboard will be considered defective if it does not pass tests and inspections.

D. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest as specified above.

E. Prepare test and inspection reports, including a certified report that identifies Switchboards included. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges and time delay settings to recommended values identified in the final approved power system study.

3.7 DEMONSTRATION

A. Engage a factory-authorized instructor to train Owner's maintenance personnel to adjust, operate, and maintain Switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram any microprocessor-based trip, monitoring, and communication units.

B. Training shall consist of not less than one session with four hours of onsite classroom and hands-on instruction for a minimum of four attendees. Training shall cover the following topics at a minimum:

1. Theory of operation
2. Operation of Switchboard and components
3. Maintenance and configuration
4. Troubleshooting and Repair
5. Replacement of components.

END OF SECTION 262413

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SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

1.2 SUMMARY

A. Description: Section includes requirements for the provision of Panelboards including manufacturing, fabrication, configuration, and installation as required for the complete performance of the Work, as shown on the Drawings, as specified herein.

B. Section Includes:

1. Distribution panelboards
2. Lighting and appliance branch-circuit panelboards
3. Disconnecting and overcurrent protective devices.

C. Related Requirements:

1. Refer to Section 260500, “Common Work Results for Electrical Systems” for requirements related to equipment supports.

1.3 REFERENCES

A. Abbreviations

1. AFCI: Arc-fault circuit interrupter.
2. GFCI: Ground-fault circuit interrupter.
3. GFPE: Ground-fault protection of equipment.
4. MCCB: Molded Case Circuit Breaker
5. SWD: Switching Duty
6. VPR: Voltage protection rating.

B. Definitions

1. Panelboard: A single panel or group of panel units designed for assembly in the form of a single panel, including buses and automatic overcurrent devices, and equipped with or without switches for the control of light, heat, or power circuits; designed to be placed in a cabinet or cutout box placed in or against a wall, partition, or other support; and accessible only from the front.

C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.

1. National Electrical Contractors Association (NECA):

a. NECA 407, “Standard for Installing and Maintaining Panelboards"

2. National Electrical Manufacturers Association (NEMA):

   a. NEMA AB 1, "Molded Case Circuit Breakers and Molded Case Switches."
   b. NEMA PB 1, "Panelboards."
   c. NEMA PB 1.1, "General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less."

3. Underwriter Laboratories (UL):

   a. UL 50, "Enclosures for Electrical Equipment, Non-Environmental Considerations."
   b. UL 67, "Standard for Panelboards."
   c. UL 489, "Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures."

1.4 SEQUENCING

A. Submit the preliminary power system study prior to receiving final approval of equipment and system protective devices submittals and prior to release of equipment drawings for manufacturing. Adjust equipment sizes, frame sizes, and trip units as necessary to achieve performance requirements outlined in Section 260573, "Power Systems Studies".

1.5 SUBMITTALS

A. Product Data: For each type of panelboard,

1. Include materials, switching and overcurrent protective device, accessories, and component indicated.
2. Include manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types and details for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
6. Include wiring diagrams for power, signal, and control wiring.

C. Closeout Submittals

1. Operation and Maintenance Data: For Panelboards and components to include in operation and maintenance manuals.
2. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
   a. Routine maintenance requirements for panelboards and all installed components.
   b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
   c. Time-current coordination curves for each type and rating of overcurrent protective device included in Panelboards.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An employer of qualified workers as defined in NEMA PB 1.1 and trained in electrical safety as required by NFPA 70E.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Handle and prepare panelboards for installation according to NECA 407 and NEMA PB 1. Handle carefully to avoid damage to internal components, enclosure, and finish.

B. Comply with manufacturer instructions for storage of electrical equipment to prevent damage from condensation or other environmental concerns.

1.8 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Distribution equipment sizes and equipment layouts shall be considered basis of design. Equipment sizes vary by manufacturer. If proposed equipment is larger than the sizes illustrated, the burden shall be on the Contractor to provide equipment which fits in the space allotted while maintaining all code-required and manufacturer-recommended clearances.

C. Drawings indicate space available for electrical equipment, including clearances between equipment and adjacent surfaces and other items. Equipment installed must comply with all clearance, access and replacement working space requirements of the NEC and Owner.

1.9 WARRANTY

A. Manufacturer’s Warranty: Manufacturer agrees to repair or replace panelboards, circuit breakers, finishes, controls, components, and accessories that fail in materials or workmanship within 12 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB.
2. Eaton.
3. Siemens.
4. Square D.

B. Source Limitations: Obtain panelboards, overcurrent protection devices, and all other electrical distribution equipment through one source from a single manufacturer.

2.2 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70 and NEMA PB 1.

C. Provide circuit breaker type panelboards unless noted otherwise.

D. Enclosures: Flush- or surface-mounted, dead-front cabinets as indicated on drawings.

1. Rated for environmental conditions at installed location.
    a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
    b. Outdoor and Wet Locations: NEMA 250, Type 3R.
    c. Corrosive and Wash Down Environments: NEMA 250, Type 4X.
    d. Kitchens: NEMA 250, Type 1 with Stainless Steel cover.
2. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box and keep tight to wall with no gaps allowing access to live parts. Oversize trims will not be acceptable.
4. Interior trim shall be of dead-front construction to shield user from all energized parts.
5. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
6. Materials and Finishes:
    a. Panels, Back Boxes and Trim: Galvanized Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
    b. Boxes: Galvanized steel with same finish as panels and trim. Unpainted galvannealed steel is not acceptable.
7. Boxes shall have removable end walls. End walls shall not be provided with concentric knockouts. Boxes shall have welded interior mounting studs. Interior mounting brackets are not required.
8. Directory Card: Inside panelboard door, mounted in metal frame with transparent protective cover.
9. All lock assemblies shall be keyed alike.
10. All panelboards will be designed with 25% minimum spare capacity, both physically and electrically, for future growth capacities.

E. Incoming Mains:

1. Circuit breaker or Lugs only as indicated on drawings.
2. Location: Top or bottom to match feeder conduit entry.
3. Feeders routed through the side gutters to reach the top or bottom main breakers from the opposite end of the panel are not acceptable.
4. Main lugs or main breakers shall have barriers on five sides.

F. Phase, Neutral, and Ground Busses:

1. Material: Hard-drawn copper, 98 percent conductivity.
    a. Bus shall be fully rated the entire length, with one continuous bus bar per phase.
2. Phase bussing shall be pre-drilled to accommodate field installable options.
3. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.

4. Equipment Ground Bus: Extend full length of panelboard and adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
5. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box. Provide where indicated on drawings.
6. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.
7. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and labelled by an NRTL as suitable for nonlinear loads. Connectors shall be sized for double-sized or parallel conductors as indicated on Drawings. Do not mount neutral bus in gutter. Provide where indicated on drawings.
8. Split Bus: Vertical buses divided into individual vertical sections. Provide where indicated on drawings.

G. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Tin-plated aluminum.
2. Terminations shall allow use of 75 deg C rated conductors without derating.
3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
4. Main and Neutral Lugs: Mechanical type.
5. Ground Lugs and Bus-Configured Terminators: Mechanical type.
6. Feed-Through Lugs: Where indicated provide mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device. Provide where indicated on drawings.
7. Subfeed (Double) Lugs: Where indicated provide mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
8. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus where indicated.

H. Service Entrance: Where panelboards are used as service equipment with one or more main service disconnecting and overcurrent protective devices, provide marking by an NRTL acceptable to authority having jurisdiction indicating panelboard is suitable for use as service equipment. Coordinate with utility company for any additional requirements.

I. Future Devices: Provide mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices. Where panelboards. are noted to have “space” or “space only”, this shall be prepared space with all bussing, lugs, etc. as required to accept future installation of over-current devices.

J. For all recessed panelboards, provide three (3) 3/4” spare conduits stubbed-up above accessible ceilings. When panel is in an area with hard ceilings, conduits shall be stubbed to nearest accessible above ceiling location.

K. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Panelboard and overcurrent protective device short circuit ratings shall be at least 110 percent of the actual available fault current.
1. Panelboards rated 240V or less: minimum 10,000 A.
2. Panelboards rated above 240V: minimum 14,000 A.

2.3 DISTRIBUTION PANELBOARDS

A. Panelboards: NEMA PB 1, power and feeder distribution type.

B. Provide bolt-on circuit breakers for overcurrent protective devices.

C. Doors: Secured with three point vault-type latch with tumbler lock; keyed alike. For doors more than 48 inches high, provide two latches.

D. All panelboards shall be capable of accepting 225 amp 3 pole branch breakers as a minimum unless otherwise noted.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

B. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

C. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

D. All panelboards shall have space to accept forty-two 20 amp single pole circuit breakers unless otherwise noted.

2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers:
   a. Inverse time-current element for low-level overloads.
   b. Instantaneous magnetic trip element for short circuits.
   c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers:
   a. Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic trip circuit breakers:
   a. RMS sensing.
   b. Field-replaceable rating plug or field-replicable electronic trip.
   c. Digital display of settings, trip targets, and indicated metering displays.
   d. Multi-button keypad to access programmable functions and monitored data.
   e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
   f. Integral test jack for connection to portable test set or laptop computer.
   g. Field-adjustable Instantaneous, Long- and short-time pickup, and Ground-fault pickup settings.
4. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
5. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
6. AFCI Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
7. MCCB features and accessories:
   a. Standard frame sizes, trip ratings, and number of poles.
   b. Breaker handle indicates tripped status.
   c. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
   d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   e. Shunt Trip: 120 V or 24V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.

f. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
g. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
h. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.

B. Provide Ground Fault protection for circuit breakers rated 1000 A and higher on solidly grounded wye systems more than 150V to ground.

C. Provide Arc Flash energy reducing maintenance switch with local status indicator for circuit breakers rated 1200A and higher or where circuit breaker trip setting can be adjusted to 1200A or greater.

2.6 METERING

A. Where indicated comply with requirements in Section 260913, “Electrical Power Monitoring.”

B. Overcurrent Protective Device Communication Capability: Where indicated provide electronic trip circuit breakers and integral communication module with functions and features compatible with power monitoring and control system specified in Section 260913, "Electrical Power Monitoring".

2.7 SURGE PROTECTION DEVICES

A. Where panelboards are indicated with integral SPD, comply with requirements in Section 264300, “Surge Protective Devices”. Factory install SPDs prior to shipment.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.

B. Receive, inspect, handle, and store panelboards according to NECA 407 and NEMA PB 1.1.

C. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work. Ensure area to receive panelboard has adequate clearance for panelboard installation.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Install panelboards and accessories according to NECA 407 and NEMA PB 1.1.

C. Temporary Lifting Provisions: Remove any temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

D. Mount top of trim 90 inches above finished floor unless otherwise indicated or where required to maintain center of trip handle on overcurrent protection devices below 79-inches. Where mounted in groups, align top of trim or tub for all panels in an area.

E. Mount panelboard cabinet plumb and rigid without distortion of box.

F. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

G. Provide steel slotted support structures where required for freestanding equipment or where building mounting surface is unsuitable.

H. Install overcurrent protective devices and controllers not already factory installed. Set field-adjustable, circuit-breaker trip ranges.

I. Install filler plates in unused spaces.

J. Stub four (4) 1-inch and two (2) 1-1/4-inch empty conduits from recessed panelboard into accessible ceiling space or space designated to be ceiling space in the future. Provide suitable closures for spare conduits and identify with a suitable label.

K. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

L. Comply with NECA 1.

3.3 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B. Where a tightening torque is indicated as a numeric value on equipment or in installation instructions provided by the manufacturer, use a calibrated torque tool to achieve that indicated torque value, unless the equipment manufacturer has provided installation instructions for an alternative method of achieving the required torque.

3.4 IDENTIFICATION

A. Comply with requirements in Section 260553, “Identification for Electrical Systems” and as noted below:

1. Provide a directory card inside each door, covered with a plastic non-yellowing shield. Directory Card to indicate installed circuit loads after balancing panelboard loads. Obtain approval before installing. Use a computer to create directory in Microsoft Excel; handwritten directories are not acceptable. Digital versions to be provided to Owner.
2. The room numbers used to fill out the panel directories shall match the actual final name and numbering scheme selected by the Owner. They shall not be filled out per the construction drawing numbering scheme unless the Contractor is directed to do so by the Architect or Engineer.
3. Provide nameplate for each panelboard.
4. For distribution panelboards, provide nameplate for each branch circuit device.

5. All distribution equipment shall be shipped from the manufacturer with factory-applied warning labels affixed to the outside front of the equipment (as it will be installed per the plans). All labeling shall be in compliance with NFPA 70 requirements.
6. Labels affixed to equipment by the equipment manufacturer shall comply with drawing and specification labeling requirements or shall be omitted by the manufacturer and field-installed by the Contractor. Labels which are factory-installed and not in compliance shall be removed and replaced and equipment enclosures refinished or replaced by the manufacturer to repair finish.

3.5 FIELD QUALITY CONTROL

A. Perform the following Tests and Inspections:

1. Visual and Mechanical Inspection:

   a. Examine equipment nameplate data and confirm proper identification.
   b. Inspect the physical, electrical, and mechanical condition of the equipment and all components in accordance with the manufacturers' instructions.
   c. Inspect anchorage, alignment, and grounding.
   d. Inspect bolted electrical connections and terminations for high resistance by verifying tightness with calibrated torque-wrench method in accordance with manufacturer's published data.
   e. Exercise all active components.
   f. Inspect all mechanical indicating devices for correct operation.
   g. Physically test key interlock systems to check for proper functionality prior to energizing.

2. Electrical Acceptance Testing:

   a. Perform insulation resistance test for one minute on each panelboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within the panelboard and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test. Test voltages and minimum resistance shall be in accordance with manufacturer's published data.

3. Circuit Breaker Testing: For all circuit breakers with electronic trip units, determine minimum pickup current, long-time and short-time pickup and delay, and instantaneous pickup by secondary current injection. Certify compliance with test parameters and ensure settings match recommendations from final approved power system study.
4. Test ground-fault protection of equipment for service equipment per NFPA 70.
5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

B. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

C. Panelboards will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 CLEANING

A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

3.7 ADJUSTING

A. Adjust moving parts and operable component to function smoothly and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573, “Power System Studies”.

C. All circuit breakers identified as spares shall be left in the OFF position.

END OF SECTION 262416

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

1.2 SUMMARY

A. This section of the specifications covers all wiring devices and cover plates, standard, weatherproof and dust tight.

B. Section Includes:

1. Straight Blade receptacles.
2. GFCI receptacles.
3. AFCI receptacles.
4. USB receptacles.
5. SPD receptacles.
6. Twist-locking receptacles.
7. Controlled receptacles.
8. General use snap switches.
9. Manual Motor Control switches.
10. Wall Plates.
11. Cord and plug sets.
12. Floor service fittings.
13. Poke-through assemblies.
14. Prefabricated multioutlet assemblies.
15. Service poles.
16. Cord Reels.

1.3 REFERENCES

A. Abbreviations

1. AFCI: Arc-fault circuit interrupter.
2. CR: Corrosion Resistant
3. EMI: Electromagnetic interference.
4. GFCI: Ground-fault circuit interrupter.
5. IG: Isolated Ground
6. SPD: Surge Protective Device
7. TR: Tamper Resistant.
8. USB: Universal Serial Bus.
9. WR: Weather Resistant.

B. Definitions

1. Emergency Electrical Systems: Those systems legally required and classed as emergency by NFPA 70 Article 700, municipal, state, other codes, or by any government agency having jurisdiction.
2. Essential Electrical Systems: Those systems designed to ensure continuity of electrical power to designated areas and functions of a healthcare facility during disruption of normal power sources, and also to minimize disruption within the internal wiring system as defined by NFPA 70 Article 517 and NFPA 99.
3. Outlet: A point on the wiring system at which current is taken to supply utilization equipment.
4. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
5. Receptacle. A receptacle is a contact device installed at the outlet for the connection of an attachment plug. A single receptacle is a single contact device with no other contact device on the same yoke. A multiple receptacle is two or more contact devices on the same yoke.

C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.

1. National Electrical Contractors Association (NECA):

a. NECA 130, “Standard for Installing and Maintaining Wiring Devices"

2. National Electrical Manufacturers Association (NEMA)

a. NEMA WD 1, “General Color Requirements for Wiring Devices”
b. NEMA WD 6, “Wiring Devices—Dimensional Specifications”

1.4 SUBMITTALS

A. Product Data: For each type of product.

B. Schedules: List of legends and description of materials and process used for pre-marking wall plates.

C. Samples: Where requested by architect or engineer, one for each type of device and wall plate, in each color specified.

D. Closeout Submittals

1. Operation and Maintenance Data: For Wiring Devices to include in operation and maintenance manuals.
2. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:

a. Manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide product indicated or equal from one of the following:

1. Eaton/Arrow Hart

2. Hubbell
3. Leviton
4. Pass & Seymour/Legrand

B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

C. RoHS compliant.

D. Devices for Fixtures, Furnishings, and Equipment:
1. Receptacles: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

E. All terminations shall be side-wired clamping type. “Backstab” terminations or modular connectors are not permitted.

F. Device Color:

1. Wiring devices in finished spaces connected to normal power system: As selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices in unfinished spaces connected to normal power system: Grey unless otherwise indicated or required by NFPA 70 or device listing.
3. Wiring Devices Connected to Emergency or Essential Electrical System: Red.
4. SPD Devices: Blue.
5. Isolated-Ground Receptacles: Orange or as specified above with orange triangle on face.

G. Wall Plate Color:

1. For plastic covers, match device color unless noted otherwise.
2. Where normal and essential system devices are ganged under a common wall plate, the plate shall be the color of normal power plates.

2.3 SPECIFICATION GRADE STRAIGHT-BLADE RECEPTACLES

A. Specification Grade Receptacle, Comply with NEMA WD 6, UL 498, FS W-C-596.

TYPE	RATING	CONFIGURATION	BASIS OF DESIGN
Duplex	20A, 125V	NEMA 5-20R	Hubbell 5362
Single	20A, 125V	NEMA 5-20R	Hubbell 5361
Duplex-TR	20A, 125V	NEMA 5-20R	Hubbell 5362TR
Duplex-IG	20A, 125V	NEMA 5-20R	Hubbell IG5362

Duplex-WR	20A, 125V	NEMA 5-20R	Hubbell 5362WR
Duplex-CR	20A, 125V	NEMA 5-20R	Hubbell HBL53CM62
Single	30A, 250V	NEMA 6-30R	Hubbell HBL9330
Single	50A, 250V	NEMA 6-50R	Hubbell HBL9367
Single	20A, 250V	NEMA 10-20R	Hubbell HBL9326

2.4 SPECIFICATION GRADE GFCI RECEPTACLES

A. Specification Grade GFCI Receptacles, Comply with UL 498, FS W-C-596, and UL 943 Class A.

B. Non-feed through type unless otherwise required, Integral self-testing GFCI with "Test" and "Reset" buttons and LED indicator light that is lighted when the unit is tripped. If critical components are damaged and ground fault protection is lost, power to receptacle shall be discontinued.

TYPE	RATING	CONFIGURATION	BASIS OF DESIGN
Duplex GFCI	20A, 125V	NEMA 5-20R	Hubbell GFRST20
Duplex GFCI with Alarm	20A, 125V	NEMA 5-20R	Hubbell GFRST20A
Duplex GFCI - TR	20A, 125V	NEMA 5-20R	Hubbell GFTRST20
Duplex GFCI - WR	20A, 125V	NEMA 5-20R	Hubbell GFTWRST20
Duplex GFCI - CR	20A, 125V	NEMA 5-20R	Hubbell GFRST52M
GFCI Blank Face	20A, 125V		Hubbell GFBFST20

2.5 SPECIFICATION GRADE AFCI RECEPTACLES

A. Specification Grade AFCI Receptacles, Comply with UL 498, FS W-C-596, and UL 1699A.

B. Non-feed through type unless otherwise required, Integral self-testing AFCI with "Test" and "Reset" buttons and LED indicator light that is lighted when the unit is tripped. If critical components are damaged and ground fault protection is lost, power to receptacle shall be discontinued.

TYPE	RATING	CONFIGURATION	BASIS OF DESIGN
Duplex AFCI - TR	20A, 125V	NEMA 5-20R	Hubbell AFRTR20
GFCI Blank Face	20A, 125V		Hubbell AFR20BF

2.6 USB RECEPTACLES

A. USB Charging Receptacle and Outlet, Comply with UL 1310, and USB 3.0 devices.

B. Dual port, combination USB Type A and C, 5 V dc, and 5 A per receptacle (minimum).

TYPE	RATING	CONFIGURATION	BASIS OF DESIGN
Duplex USB - TR	20A, 125V	NEMA 5-20R	Hubbell USB20AC5
Duplex USB - WR	20A, 125V	NEMA 5-20R	Hubbell USB20AC5WR

2.7 SPECIFICATION GRADE SPD RECEPTACLES

A. Specification Grade SPD Receptacles, Comply with UL 498, FS W-C-596, and UL 1449, Type 3:

B. Self-grounding. Integral SPD in line to ground, line to neutral, and neutral to ground. Visual and audible SPD indication, with LED indicator light visible in face of device to indicate device is "active" or "no longer in service.".

C. SPD Components: Multiple metal-oxide varistors; with a nominal clamp-level rating of 500 V and minimum single transient pulse energy dissipation of 340 J in each mode, according to IEEE C62.41.2 and IEEE C62.45.

TYPE	RATING	CONFIGURATION	BASIS OF DESIGN
Duplex SPD	20A, 125V	NEMA 5-20R	Hubbell HBL5362SA

2.8 HOSPITAL-GRADE RECEPTACLES

A. Hospital-Grade Receptacles, Comply with requirements above and UL 498 Supplement SD:

B. Marking: Listed and labeled as complying with NFPA 70, Article 517 "Health Care Facilities".

TYPE	RATING	CONFIGURATION	BASIS OF DESIGN
Duplex	20A, 125V	NEMA 5-20R	Hubbell HBL8300H
Single	20A, 125V	NEMA 5-20R	Hubbell HBL8310
Duplex - TR	20A, 125V	NEMA 5-20R	Hubbell 8300TRA
Duplex - IG	20A, 125V	NEMA 5-20R	Hubbell IG8300
Duplex GFCI	20A, 125V	NEMA 5-20R	Hubbell GFRST83
Duplex GFCI - TR	20A, 125V	NEMA 5-20R	Hubbell GFTRST83
Duplex USB	20A, 125V	NEMA 5-20R	Hubbell USB8300AC5

Duplex SPD	20A, 125V	NEMA 5-20R	Hubbell 8362

2.9 TWIST-LOCKING RECEPTACLES

A. Twist-Lock, Single Receptacles, with matching plug as required by equipment. Comply with NEMA WD 6, UL 498, FS W-C-596.

TYPE	RATING	CONFIGURATION	BASIS OF DESIGN
Single	20A, 125V	NEMA L5-20R	Hubbell HBL2310
Single	20A, 250V	NEMA L6-20R	Hubbell HBL2320
Single	20A, 277V	NEMA L7-20R	Hubbell HBL2330

2.10 CONTROLLED RECEPTACLES

A. Specification Grade Receptacle, Permanently marked and suitable for use with automatic switching means. Comply with NEMA WD 6, UL 498B, FS W-C-596.

TYPE	RATING	CONFIGURATION	BASIS OF DESIGN
Duplex Single Face Control	20A, 125V	NEMA 5-20R	Hubbell 5362C1TR
Duplex Two Face Control	20A, 125V	NEMA 5-20R	Hubbell 5361C2TR

2.11 GENERAL USE SNAP SWITCHES

A. Switches, 120/277 V, Comply with UL 20 and FS W-S-896.

TYPE	RATING	CONFIGURATION	BASIS OF DESIGN
Single Pole	20A, 120/277V		Hubbell 1221
Double Pole	20A, 120/277V		Hubbell 1222
Three Way	20A, 120/277V		Hubbell 1223
Four Way	20A, 120/277V		Hubbell 1224

B. Pilot-Light Switches, illuminated when switch is ON:

TYPE	RATING	CONFIGURATION	BASIS OF DESIGN
Single Pole	20A, 120/277V		Hubbell 1221PL

C. Illuminated Switches, illuminated when switch is OFF:

TYPE	RATING	CONFIGURATION	BASIS OF DESIGN
Single Pole	20A, 120/277V		Hubbell 1221IL

D. Key-Operated Switches, Factory-supplied key in lieu of switch handle:

TYPE	RATING	CONFIGURATION	BASIS OF DESIGN
Single Pole	20A, 120/277V		Hubbell 1221L
Three Way	20A, 120/277V		Hubbell 1223L
Four Way	20A, 120/277V		Hubbell 1224L

E. Double-Throw, Momentary-Contact, Center-off Switches.

TYPE	RATING	CONFIGURATION	BASIS OF DESIGN
Single Pole	20A, 120/277V		Hubbell 1557
Low Voltage	5A, 24VDC		Hubbell 1557LV

2.12 MANUAL MOTOR CONTROL SWITCHES

A. Motor-Starting Switches (MSS): "Quick-make, quick-break" toggle type for manual control of single or three phase motors up to 3/4 HP where overload protection is not required or is provided separately, marked to indicate whether unit is on or off.
   1. Standard: Comply with NEMA ICS 2, general purpose, Class A.

B. Fractional Horsepower Manual Controllers (FHPMC): "Quick-make, quick-break" toggle type with integral overload protection for use with single phase motors up to 1HP; marked to show whether unit is off, on, or tripped.
   1. Configuration: Non-reversing unless noted otherwise on drawings.
   2. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor and ambient temperature; external reset push button; melting alloy type.
   3. Red pilot light where indicated on drawings.
   4. HOA selector switch with dry contact inputs where indicated on drawings.

C. Provide with NEMA 1, NEMA 3R or other enclosure suitable for the location and atmosphere.

D. All manual starters located in finished areas shall be in flush-mounted enclosures.

2.13 PENDANT CORD-CONNECTOR DEVICES

A. Description: Matching, locking-type plug and receptacle body connector, heavy-duty grade.

B. Body: Nylon, with screw-open, cable-gripping jaws and provision for attaching external cable grip.

C. External Cable Grip: Woven wire-mesh type made of high-strength, galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.14 CORD AND PLUG SETS

A. Match voltage and current ratings and number of conductors to requirements of equipment being connected.

B. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.

C. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.15 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.
   1. Plate-Securing Screws: Metal with head color to match plate finish.
   2. Material for Finished Spaces: Smooth, 0.060-inch high-impact thermoplastic or satin-finished, type 304 stainless steel.
   3. Material for Unfinished Spaces: satin-finished, type 304 stainless steel.
   4. Material for Rough Service Locations including gymnasiums, kitchens, mechanical rooms, material management, and food service areas: satin-finished, Type 304 stainless steel.
      a. For kitchen and food service areas, provide foam gasket behind plate to help prevent water infiltration.

B. Material for Interior Damp Locations: Cast aluminum with spring-loaded lift cover and listed and labeled for use in wet and damp locations.

C. Wet-location, Weatherproof, in-use cover plates: extra duty, suitable for use with and decorator style devices, die-cast aluminum lockable cover, self-closing, gasketed, standard box mounting.
   1. Vertical mounting - Hubbell WP26E or equal.
   2. Horizontal mounting - Hubbell WP26EH or equal.

D. Cover plates for lighting control devices exposed to severe physical damage: Low profile, flip-up clear polycarbonate cover. STI Stopper or equal.

2.16 FLOOR BOXES AND POKE-THROUGH ASSEMBLIES

A. Description: Single or multi-service, recess activated, multi-gang floor outlet with devices capable of supplying combinations of power, data, voice, and AV services in a single assembly.

B. Manufacturers: Subject to compliance with requirements, provide product indicated on drawings or approved equal by one of the following:

   1. FSR
   2. Hubbell
   3. Legrand (Wiremold)

C. Floor Boxes and Poke-Thru Assemblies
   1. Comply with UL514A.

2. Material: Cast metal or sheet metal with finished interior
3. Type: Fully adjustable before and after floor installation.
4. Shape: Rectangular or Round
5. Designed for use with industry standard wall plates, devices, and modular inserts.
6. Painted with corrosion resistant fusion-bonded epoxy where used in on-grade floor applications.
7. Classified for fire resistance up to 2 hours where used in rated floors.
8. Evaluated by UL to meet U.S. safety standards for scrub water exclusion.
9. Provide separate paths for management of telecommunications and power cables in compliance with NFPA 76.
10. Cover: ADA-compliant, with less than 0.15-inch rise to cover flange, hinged for 180-degree opening, Gasketed, Die-cast powder coated aluminum suitable for multiple floor surfaces.
    a. Surface style for carpet and VCT floor finishes.
    b. Flush style for wood, tile, finished concrete, and terrazzo floor finishes.

2.17 PREFABRICATED MULTIOUTLET ASSEMBLIES

A. Description: Two-piece surface metal raceway, with factory-wired multioutlet harness.

B. Components shall be products from single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.

C. Raceway Material: Metal, with manufacturer's standard finish.

D. Multioutlet Harness:
1. Receptacles: 20-A, 125-V.
2. Receptacle Spacing: 18 inches unless noted otherwise.
3. Wiring: No. 12 AWG solid, Type THHN copper.

2.18 SERVICE POLES

A. Dual-Channel Service Poles
1. Description: Factory-assembled and -wired units to route power and communications cabling from connections above ceiling to outlets below ceiling.
2. Listed and labeled in accordance with UL 5 for exposed power raceway and fittings, and UL 2024 for communications raceway and fittings.
3. Poles: Minimum 2.5-inch- square cross-section, with height adequate to extend from floor to at least 6 inches above ceiling, and with separate channels for power wiring and voice and data communication cabling.
4. Mounting: Ceiling trim flange with concealed bracing arranged for positive connection to ceiling supports; with pole foot and carpet pad attachment.
5. Material: Aluminum.
6. Finishes: Manufacturer's standard painted finish and trim combination.
7. Wiring: Sized for minimum of five No. 12 AWG power and ground conductors and a minimum of four, balanced twisted pair data communication cables.

2.19 CORD REELS

A. Description: Reel equipped with, or intended for use with, length of flexible cord, providing means for cord to be unwound by user as desired, providing spring take-up mechanism to rewind cord on reel, and providing latch to restrain action of spring take-up mechanism while cord reel is in use.

B. Comply with UL 355.

C. Spring Driven, suitable for industrial and commercial use, No. 12 AWG conductors, 20A rating, Black aluminum housing, Ball stop, pivot base, 40ft spool capacity with double 20A duplex receptacles unless noted otherwise.

PART 3 - EXECUTION

3.1 APPLICATION

A. Provide receptacles and cover plates listed for the installed environment.

B. Outdoor receptacles and receptacles located in wet locations shall be weather resistant, GFCI type, with weather proof enclosure.

C. Provide GFCI receptacles where required by the NEC in addition to the locations noted on the drawings.

D. Provide weather-resistant rating for GFCI receptacles installed in wet locations.

E. Where GFCI receptacles are located in areas that are not readily accessible, provide GFCI blank face device in readily accessible location approved by Architect.

F. Provide GFCI receptacles with audible alarm for refrigeration and vending applications.

G. Provide tamper resistant receptacles where required by the NEC in addition to the locations noted on the drawings. NOTE: ALL devices located in elementary school, where students have access, shall be tamper resistant.

3.2 INSTALLATION

A. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA 130.

B. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.

C. Devices that have been installed before painting shall be masked. No plates or covers shall be installed until all finishing and cleaning has been completed. Replace stained or improperly painted wiring devices and coverplates.

D. Install non-feed-through GFCI receptacles where protection of downstream receptacles is not required. Where GFCI receptacles share a single circuit with other devices, a ground fault on any GFCI receptacle shall not interrupt power to downstream devices.

E. Coordination for all receptacles: Confirm receptacle configuration of all special purpose receptacles with approved submittals prior to installation and provide devices to match equipment plugs. Contractor shall replace any incompatible receptacle discovered during owner move-in.

F. Coordination with Other Trades:

1. Adjust locations of outlets to suit arrangement of partitions and furnishings. Locate outlets to avoid blocking by supports, furnishings, and other architectural fixtures.
2. Adjust locations of floor boxes and poke-throughs to coordinate with locations of structural members, concealed piping, and concealed conduit.

3. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
4. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
5. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
6. Install wiring devices after all wall preparation, including painting, is complete.

G. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Where re-using existing conductors:
   a. Cut back and pigtail or replace all damaged conductors.
   b. Straighten conductors that remain and remove corrosion and foreign matter.
   c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

H. Device Installation:

1. Replace all devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until all finish work is complete.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. Use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than #12 AWG are installed on 15- or 20-A circuits, splice #12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.
10. Install devices and assemblies' level, plumb, and square with building lines. Align devices vertically and horizontally. Securely fasten devices into boxes.

I. Device Orientation:

1. Install switches with "OFF" position down.
2. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left so the neutral blade is at the top.

J. Device Plates:

1. Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.
2. All outlets not provided with wiring devices shall be closed with a blank plate matching other plates in the area.
3. Align coverplate mounting screw slots in the same direction, either vertical or horizontal. Do not overtighten coverplate mounting screws. Overtightening can cause the coverplate to warp, dimple, bend, and in the case of plastic faceplates, crack, or break.

3.3 IDENTIFICATION:

A. Comply with Section 260553 "Identification for Electrical Systems."
1. All device boxes shall have circuit number identified within the box.

3.4 FIELD QUALITY CONTROL

A. Test Instruments: Use instruments that comply with UL 1436.

B. Using a test plug, perform the following tests and inspections for receptacles:

1. Insert and remove test plug to verify that devices are securely mounted.
2. Verify correct configuration of hot, neutral, and ground pins.
3. Verify correct operation of ground fault protective devices.

C. Nonconforming Work:
1. Device will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

D. Prepare test and inspection reports.

END OF SECTION 262726

SECTION 262813 - FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

1.2 SUMMARY

A. Description: Provide labor, material, equipment, related services, and supervision required for the installation of cartridge fuses where utilized for overcurrent and/or current limitation applications.

B. Section Includes:

1. Cartridge fuses rated 600V-AC and less for use in control circuits, enclosed switches, panelboards, switchboards, and motor controllers.
2. Spare fuse cabinet.

1.3 REFERENCES

A. Definitions

1. Fuse: A protective device that opens a circuit during specified overcurrent conditions by means of a current responsive element.

B. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.

1. National Electrical Contractors Association (NECA)
   a. NECA 420, “Fuse Applications”

1.4 SEQUENCING

A. Submit the preliminary power system study prior to receiving final approval of equipment and system protective devices submittals and prior to release of equipment drawings for manufacturing. Adjust equipment sizes, frame sizes, and trip units as necessary to achieve performance requirements outlined in Section 260573, “Power Systems Studies”.

1.5 SUBMITTALS

A. Product Data: For each fuse type indicated:

1. Include let-through current curves for fuses with current-limiting characteristics.
2. Time-current curves, coordination charts and tables, and related data.

B. Ambient Temperature Adjustment Information: Where ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.

1. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
2. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.

C. Closeout Submittals

1. Operation and Maintenance Data: For Fuses include in emergency, operation, and maintenance manuals.
2. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
   a. Let-through current curves for fuses with current-limiting characteristics.
   b. Time-current curves, coordination charts and tables, and related data.
   c. Ambient temperature adjustment information.

1.6 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels indicated in power system study.

1.7 MAINTENANCE MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to one spare for every 10 installed units, but not less than 5 units for each size and type.
2. Fuse Pullers: Two for each size and type.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace fuses that fail in materials or workmanship within 12 months from date of Substantial Completion.

1.9 FIELD CONDITIONS

A. Where ambient temperature to which fuses are exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Bussmann, Inc.
2. Littlefuse, Inc.
3. Mersen USA.

B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.2 GENERAL REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with:

1. NEMA FU 1 – Low Voltage Cartridge Fuses.
2. UL 248 – Standard for Low Voltage Fuses.
3. UL 512 – Fuseholders.

2.3 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, current limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

1. Type RK-1: 250 or 600-V, zero- to 600-A rating, 200 kAIC minimum, fast acting or time delay.
2. Type RK-5: 250 or 600-V, zero- to 600-A rating, 200 kAIC minimum, fast acting or time delay.
3. Type CC: 600-V, zero- to 30-A rating, 200 kAIC minimum, fast acting or time delay.
4. Type L: 600-V, 601- to 6000-A rating, 200 kAIC minimum, time delay option.

B. Voltage: Rating suitable for circuit phase-to-phase voltage.

C. Provide dual element fuses with separate overload and short circuit elements.

2.4 SPARE-FUSE CABINET

A. Manufacturer: Bussmann #SFC-FUSE-CAB spare fuse cabinet or equal.

B. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
2. Finish: Gray, baked enamel.
3. Identification: "SPARE FUSES" in 1-1/2 inch high white letters on black lamicoid plate. Mount plate on exterior of door.
4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPICATIONS

A. Service, Feeders, and Branch Circuits (601-6000A): Class L, time delay. Bussmann HI-CAP Fuses KRP-C or equal. Fuses shall hold 500% of rated current for a minimum of 4 seconds.

B. Feeders and Branch Circuits (0-600A): Class RK1, time delay. Bussmann Low-Peak Dual Element Fuses, LPN-RK (250 volts) or LPS-RK (600 volts) or equal. The fuse shall hold 500% of rated current for a minimum of 10 seconds.

C. Motor Circuits – Class RK1 or Class L, time delay as indicated above.

1. Motor with 1.15 service factor: Size at 125% of motor FLA. For high inrush current applications size 150% to 200% of motor FLA.
2. Motor with 1.0 service factor: Size at 115% of motor FLA.

D. Control Circuits: Class CC, time delay. Bussmann Low-Peak Fuses LP-CC or equal. Fuses shall hold 200% of rated current for a minimum of 12 seconds.

E. Adjust fuse type and selection as required to ensure available fault current at equipment controllers indicated in power systems study does not exceed labeled SCCR values.

3.3 INSTALLATION

A. Fuses shall be shipped separately. Any fuses shipped installed in equipment, shall be replaced by the Electrical Contractor with new fuses as specified above prior to energizing at no additional expense to Owner. All fuses shall be stored in moisture free packaging at job site and shall be installed immediately prior to energizing of the circuit in which it is applied.

B. No fuses shall be installed in the equipment until the installation is complete, including tests and inspections required prior to being energized. All fuses shall be of the same manufacturer to ensure retention of selective coordination, as designed.

C. Provide a complete set of fuses for all fusible devices. Arrange fuses so rating information is readable without removing fuse.

D. Install spare-fuse cabinet(s). Locate in Main Electrical Room.

E. Upon completion of the building, the Contractor shall provide the Owner with spare fuses in Spare-Fuse Cabinet.

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems".

1. Indicate fuse rating and type on the outside door of each fused switch.

END OF SECTION 262813

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SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

1.2 SUMMARY

A. Description: Section includes requirements for the provision of individually enclosed switches and circuit breakers including manufacturing, fabrication, configuration, and installation as required for the complete performance of the Work, as shown on the drawings and specifications

B. Section includes:

1. Fusible and Non-Fusible Switches.
2. Enclosed Circuit Breakers.
3. Elevator Shunt trip switches.
4. Enclosures.

1.3 REFERENCES

A. Abbreviations

1. HD: Heavy Duty
2. MCCB: Molded Case Circuit Breaker
3. NC: Normally Closed
4. NO: Normally Open
5. SCCR: Short Circuit Current Rating

B. Definitions

1. Disconnect: A switch, device, group of devices, or other means used to disconnect conductors of a circuit from their source of supply.
2. Switch (switching device): A device, manually operated, unless otherwise designated, for opening and closing or for changing the connection of a circuit. Also referred to as safety switches or disconnect switches.

1.4 SEQUENCING

A. Submit the preliminary power system study prior to receiving final approval of equipment and system protective devices submittals and prior to release of equipment drawings for manufacturing. Adjust equipment sizes, frame sizes, and trip units as necessary to achieve performance requirements outlined in Section 260573, “Power Systems Studies”.

1.5 SUBMITTALS

A. Product Data: For each product type.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Short-circuit current ratings (interrupting and withstand, as appropriate).
3. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.

B. Shop Drawings: For each type of enclosed switch, circuit breaker, accessory, and component indicated.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types and details for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of overcurrent protective devices.
5. Include evidence of NRTL listing for series rating of installed devices.
6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
7. Include wiring diagrams for power, signal, and control wiring.
8. Cable terminal size and quantity.

C. Closeout Submittals

1. Operation and Maintenance Data: For enclosed switches and circuit breakers include in emergency, operation, and maintenance manuals.
2. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
   a. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.6 COORDINATION

A. Product Selection for Restricted Space: Drawings indicate space available for enclosed switches including clearances between enclosed switches and adjacent surfaces and other items. Furnish and install equipment to comply with NEC clearances.

1.7 WARRANTY

A. Manufacturer’s Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace devices that fail in materials or workmanship within 12 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB/General Electric.
2. Eaton Electrical Inc.
3. Siemens.
4. Square D

B. Source Limitations: Obtain enclosed switches, overcurrent protection devices, and all other electrical distribution equipment through one source from a single manufacturer unless approved otherwise.

2.2 GENERAL REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

C. Service-Rated Switches and Circuit Breakers: Labeled for use as service equipment.

D. Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Switch and overcurrent protective device short circuit ratings shall be at least 110% of the actual available fault current.

2.3 FUSIBLE AND NON-FUSIBLE SWITCHES

A. Type HD, Heavy Duty, Single Throw, 250-VAC, or 600-VAC, 1200 A and Smaller unless noted otherwise.

B. Quick-make, quick-break operating handle and switch mechanism integral to box.

C. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate fuses where indicated.

D. Externally operable dual interlocked handle to prevent opening front cover with switch in ON position, or closing switch when door is open. Visible load interrupter knife switch blades in the off position with door open.

E. Lockable handle with capability to accept three padlocks and interlocked with cover in closed position.

F. All current carrying parts shall be plated by an electrolytic process to resist corrosion and to promote cooling.

G. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Lugs: UL Listed, mechanical type, front removeable, and suitable for number, size, and conductor material at 75 deg C.
4. Auxiliary Contact Kit: NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating as required for application.
5. Electrical Interlock Kit: Pivot arm operated from the switch mechanism, breaking a control circuit before the main switch blades break.

H. For receptacle switches provide interlocking linkage between the receptacle and switch mechanism to prevent inserting or removing plug while switch is in the on position, inserting any plug other than specified, and turning switch on if an incorrect plug is inserted or correct plug has not been fully inserted into the receptacle.

2.4 ENCLOSED MOLDED-CASE CIRCUIT BREAKERS

A. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

B. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.

C. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.

D. MCCBs shall be equipped with a device for locking in the open position.

E. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

F. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

1. Long-time, Short-time, and Instantaneous trip unless noted otherwise on drawings.

G. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

H. Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single-, two-pole, and three-pole configurations with Class A ground-fault protection (6-mA trip).

I. Ground-Fault Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

J. Features and Accessories:
1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: UL Listed, mechanical type, suitable for number, size, trip ratings, and conductor material at 75 deg C.
3. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
4. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact. Coordinate coil voltage and provide control circuits as required for application.

2.5 ELEVATOR SHUNT TRIP SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Bussmann
2. Littlefuse
3. Mersen

B. General Requirements: Comply with ASME A17.1, UL 50, and UL 98, with Class J fuse block and 200-kA interrupting and short-circuit current rating.

C. Type HD, Heavy-Duty, Three Pole, Single-Throw Fusible Switch; UL 98 and NEMA KS 1; integral shunt trip mechanism; horsepower rated, with clips or bolt pads to accommodate fuses; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

D. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses.

E. Accessories:
1. Key switch for key-to-test function.
2. Red ON pilot light.
3. Isolated neutral lug.
4. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
5. Form C alarm contacts that change state when switch is tripped.
6. Three-pole, double-throw, fire-safety, and alarm relay; 24-V dc coil voltage.

F. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.

2.6 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor and Wet Locations: NEMA 250, Type 3R.
3. Kitchen and Wash-Down Areas: NEMA 250, Type 3R, stainless steel.

B. Enclosure Finish: The enclosure shall be finished with the standard manufacturer gray finish.

C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

C. Securely fasten each switch and circuit breaker to the supporting structure or wall, utilizing a minimum of four (4) 1/4-inch bolts. Do not mount in an inaccessible location or where the passageway to the switch may become obstructed.

D. After equipment has been installed, inspected, and is ready to be energized, install fuses in fusible devices in accordance with equipment nameplates and Section 262816, “Fuses”.

E. Comply with NFPA 70 and NECA 1.

F. Provide electrical interlock kit and low voltage wiring where utilized on the line side of VFD controller to shut down VFD prior to disconnection of power. Coordinate control wire termination with Division 25.

G. Provide electronic trip breakers where required to achieve performance requirements outlined in Section 260573, “Power Systems Studies”.

H. Provide fusible switches with current limiting fuses or current limiting circuit breaker for equipment disconnecting means where equipment short circuit current rating is insufficient for available fault current.

I. Where battery lowering devices are specified with Hydraulic Elevators, provide connection between an auxiliary contact at the elevator disconnect and the battery lowering device.

3.3 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B. Where a tightening torque is indicated as a numeric value on equipment or in installation instructions provided by the manufacturer, use a calibrated torque tool to achieve that indicated torque value, unless the equipment manufacturer has provided installation instructions for an alternative method of achieving the required torque.

3.4 IDENTIFICATION

A. Comply with requirements in Section 260553, “Identification for Electrical Systems”

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with nameplate.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Visual and Mechanical Inspection:

a. Examine equipment nameplate data and confirm proper identification.
b. Verify and record fuses sizes and types are in accordance with nameplates and power systems study.
c. Inspect the physical, electrical, and mechanical condition of the equipment and all components in accordance with the manufacturers’ instructions.
d. Inspect anchorage, alignment, and grounding.
e. Inspect bolted electrical connections and terminations for high resistance by verifying tightness with calibrated torque-wrench method in accordance with manufacturer’s published data.

f. Exercise all active components to ensure proper mechanical operation.
g. Check all interlocking systems for correct operation.

2. Circuit Breaker Testing: For all circuit breakers with electronic trip units, determine minimum pickup current, long-time and short-time pickup and delay, and instantaneous pickup by secondary current injection. Certify compliance with test parameters and ensure settings match recommendations from final approved power system study.
3. Test ground-fault protection of equipment for service equipment per NFPA 70.
4. Test all auxiliary devices/system interfaces and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

B. Switches and Circuit Breakers will be considered defective if they do not pass tests and inspections.

C. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

D. Prepare test and inspection reports, including a certified report that identifies switches and circuit breakers included and that describes results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Power System Studies".

END OF SECTION 262816

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SECTION 262900 - MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

1.2 SUMMARY:

A. Extent of motor starter work is indicated by drawings and schedules.

B. Section includes:

1. Combination full voltage, non-reversing Motor Controllers.
2. Combination Soft Start Motor Controllers

C. Related Requirements:

1. Refer to Section 260500 “Common Work Results for Electrical Systems” for additional requirements related to motors connections.
2. Refer to Section 262726 “Wiring Devices” for information on manual motor controllers.
3. Refer to Division 25 for coordinating requirements related to control system interface points.

1.3 REFERENCES

A. Abbreviations

1. FVNR: Full Voltage Non Reversing
2. MCP: Motor Circuit Protector
3. OCPD: Overcurrent protective device
4. SCCR: Short Circuit Current Rating
5. SCPD: Short-circuit protective device
6. SCR: Silicon Controlled Rectifier

B. Definitions

1. Soft Starter: Solid state reduced voltage non-reversing motor controller

1.4 SEQUENCING

A. Submit the preliminary power system study prior to receiving final approval of equipment and system protective devices submittals and prior to release of equipment drawings for manufacturing. Adjust equipment sizes, frame sizes, and trip units as necessary to achieve performance requirements outlined in Section 260573, “Power Systems Studies”.

1.5 SUBMITTALS:

A. Product Data: For each type of product.

B. Shop Drawings: For each type of product.

1. Include wiring diagrams for signal and control wiring. Clearly identify manufacturer-installed and field installed wiring.
2. Include features and factory settings of individual protective devices and auxiliary components.

C. Closeout Submittal:

1. Operation and Maintenance Data: For motor controllers to include in operation and maintenance manuals.
2. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
   a. Routine maintenance requirements for magnetic controllers and installed components.
   b. Manufacturer's written instructions for testing and adjusting circuit breaker and motor circuit protector trip settings.
   c. Manufacturer's written instructions for setting field-adjustable overload relays.
   d. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.6 MAINTENANCE MATERIAL

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to one spare for every 10 installed units, but not less than 5 units for each size and type.
2. Overloads: Equal to one spare for every 9 installed units, but not less than 3 units for each size and type.

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace enclosures, starters, overcurrent protective devices, accessories, and factory installed interconnection wiring that fail in materials or workmanship within 12 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS:

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency acceptable to authorities having jurisdiction and marked for intended location and application.

B. UL Compliance and Labeling: Fabricate and label motor controllers to comply with UL 508.

C. NEC Compliance: Comply with NEC as applicable to wiring methods, construction, and installation of motor starters.

D. NEMA Compliance: Comply with applicable portions of NEMA standards pertaining to motor controllers/starters and enclosures.

2.2 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide products from one of the following:

1. ABB/General Electric
2. Allen Bradley Co.
3. Eaton
4. Siemens.
5. Square D. Co.

2.3 MANUAL MOTOR CONTROLLERS

A. Refer to Section 262726 “Wiring Devices” for manual motor controller requirements.

2.4 COMBINATION FULL VOLTAGE MOTOR CONTROLLER

A. Description: Factory-assembled, combination full-voltage, non-reversing magnetic motor controller consisting of the controller, indicated disconnecting means, SCPD, OCPD, pushbuttons, selector switch(es), and indicator lights in a single enclosure.

B. All combination starter/disconnect switches shall have low-voltage protection, solid state overloads, start / stop pushbuttons, Hand-Off-Auto selector switch and Red and Green pilot lights.

C. All combination starter/disconnect switches shall be Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Combination motor starters shall be rated in accordance with NEMA sizes and horsepower ratings. No starter shall be listed as a fractional size. Contactor contacts shall be silver alloy, double break, and shall allow for inspection on NEMA Sizes 00 through 4 without the use of tools. Size 5 and larger shall allow for inspection utilizing standard tools. They shall be replaceable without removing the line, load, or control wiring from the starter, and replaceable without removing the starter from the enclosure.

E. Contactor coils shall be the encapsulated type and shall be replaceable on NEMA Sizes 00 through 4 without the use of tools. Size 5 and larger shall be replaceable with standard tools. They shall be replaceable without removing the line, load, or control wiring from the starter, and replaceable without removing the starter from the enclosure.

F. Overload protection shall be provided by solid state electronic overload relay. Single-phase starters shall provide one- or two-leg overload protection; three-phase starters shall provide three-leg overload protection. Overload protection shall be class 10/20 selectable, have visible trip indicator, and manual or remote reset function.

G. Starter shall include phase failure relay with under-voltage protection.

H. Starter shall have integral controls transformer with primary and secondary fusing.

I. Starter to have two normally closed and two normally open auxiliary contacts.

J. Combination starter shall be suitable for straight through wiring.

K. Fusible Disconnecting Means: Heavy Duty, quick-make, quick-break, load break rated, such that during normal operation of the switch, the operation of the contacts shall not be capable of being restrained by the operating handle after the closing and opening action of the contacts has started. The handle and mechanism shall be an integral part of the box (not cover) with facilities for pad locking in the open or closed position with up to three padlocks. Switch doors shall be interlocked with switch handle so that the door can only be opened when the switch is in the "OFF" (open) position.

L. All safety switches shall have a factory installed neutral lug, when a neutral is necessary.

M. All current carrying parts shall be plated by an electrolytic process to resist corrosion and to promote cooling.

N. Provide the following Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.5 COMBINATION SOFT START MOTOR CONTROLLER

A. Description: Factory Assembled, Solid state, reduced voltage, non-reversing motor controller consisting of controller, disconnecting means, protection devices, microprocessor with digital keypad in a single enclosure.

B. Enclosure shall include a door mounted digital keypad for adjusting the soft starter parameters and viewing process values and viewing the motor and soft starter status without opening the enclosure door. Provisions shall be available for padlocking the enclosure door.

C. The enclosed product shall be provided with molded case disconnect switch and in-line fuse block for Class J power fuses from 10 to 600A or Class L power fuses from 601 to 1600A for Type 1 short circuit protection.

D. The motor must be automatically protected from solid state component failure by an isolation contactor that opens when the motor is stopped or when the controller detects a fault condition including a shorted SCR.

E. The soft starter shall utilize an SCR bridge consisting of at least two SCRs per phase to control the starting and stopping of industry standard motors.

F. The soft start shall provide torque control for linear acceleration independent of motor load or application type without external feedback. The gating of the SCRs will be controlled in such a manner to ensure stable and linear acceleration ramp.

G. The soft starter shall be controlled by a microprocessor that continuously monitors the current and controls the phasing of the SCRs. Analog control algorithms shall not be allowed.

H. A shorting contactor shall be standard on soft starters in all enclosure configurations. Protective features and deceleration control options integral to the soft starter shall be available even when the shorting contactor is engaged.

I. The SCRs shall have a minimum P.I.V. rating of 1800 Vac. Lower rated SCRs with MOV protection are not acceptable.

J. All programming/configuration devices, display units, and field control wiring terminals shall be accessible on the front of the control module. Exposure to control circuit boards or electrical power devices during routine adjustments is prohibited.

K. Digital indication shall provide, as a minimum, the following conditions:

1. Soft starter status - ready, starting/stopping, run.
2. Motor status - current, torque, thermal state, power factor, operating time, power in kW.
3. Fault status - Motor thermal overload, soft starter thermal fault, loss of line or motor phase, line frequency fault, low line voltage fault, locked rotor fault, motor underload, maximum start time exceeded, external fault, serial communication fault, line phase reversal fault, motor overcurrent fault.

L. The soft starter must be preset to the following for adjustment-free operation in most applications:

1. Linear (torque-controlled) acceleration ramp of 15 seconds.
2. Current limitation to 400% of the motor full load current rating.
3. Class 10 overload protection.
4. Motor current preset per NEC / NFPA 70 table 430.150 for standard hp motors.

M. A digital keypad shall be utilized to configure operating and controller parameters such as FLA, acceleration ramp, torque, braking type, thermal overload Class, reset functions, etc.

N. Provide output relays to provide the following status indications:

1. One Form A (N.O.) minimum for indication of fault.
2. One Form A (N.O.) for indication that acceleration ramp is complete, and current is below 130% motor FLA (end of start).
3. One Form A (N.O.) assignable to one of the following functions: motor thermal alarm, motor current level alarm, and motor underload alarm.

O. A microprocessor-based thermal protection system shall be included which continuously calculates the temperature-rise of the motor and soft starter and provides:

1. A motor overload pre-alarm that indicates by relay contact or logic output that the motor windings have exceeded 130% of its rated temperature rise. This function shall be for alarm only.
2. A motor overload fault will stop the motor if the windings have exceeded 140% of temperature-rise.
3. An electronic circuit with a time-constant adjustable to the motor's thermal cooling time-constant ensuring the memorization of the thermal state even if power is removed from the soft starter.
4. The soft starter shall provide line and motor phase loss, phase reversal, underload, stall, and jam protection.
5. The integral protective features shall be active even when the shorting contactor is used to bypass the SCRs during steady state operation.
6. The soft starter control circuit shall be fed from the line supply and be completely independent of the power circuit and separate from the control logic.

P. The peripheral soft starter control circuitry shall be operated at 120 Vac 60 Hz from a control power transformer included within the enclosure.

Q. Operator devices shall be door mounted and shall be:

1. Red STOP and black START push buttons.
2. Three position H-O-A switch which provides for manual (HAND) start or remote signal (AUTO) start from user-supplied relay contacts.

3. Three position FWD-OFF-REV switch provides forward, off and reverse selector switch mounted on the door (available with reversing starter only).
4. Red RUN pilot light illuminated whenever the soft starter is provided a run command and no fault condition is present.
5. Green OFF pilot light illuminated whenever the soft starter is supplied with control power and no run command is present.
6. All operator devices shall be remote mounted using supplied 120 Vac control logic. Clearly labeled terminals shall be provided for field installation.

R. Provide a shorting contactor that shall close, shorting the SCRs after the acceleration ramp is compete and motor current is below 130% of motor FLA, and open on a stop command to allow a deceleration ramp. Overload protection integral to the soft starter shall continue to protect the motor when shorting is engaged. A microprocessor shall control the operation of the shorting contactor via an output relay.

S. Provide full voltage bypass starter with overload protection to provide motor operation in the event of soft starter failure. Provide "NORM/BYPASS" selector switch on enclosure door.

PART 3 - EXECUTION

3.1 MOTOR CONTROLLER APPLICATION

A. FVNR and Soft Starter type motor controllers shall be combination type starter and disconnect switch unless noted otherwise on plans.

B. Starters smaller than 10HP shall be full voltage non-reversing type (FVNR). Starters 10HP and larger shall be soft starters.

C. SCCR ratings shall exceed the available fault current calculated by the power system study as required by Section 260573, "Power System Studies".

D. The starter shall be designed to operate in the environment in which installed including ambient temperature, humidity, and elevation.

E. Enclosure:

1. Type of each starter to comply with environmental conditions at installed location:
   a. Indoor, Dry and Clean Locations: NEMA 250, Type 1
   b. Outdoor Locations: NEMA 250, Type 3R.
   c. Kitchen and Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
2. Provide provisions for padlocking the enclosure door.

3.2 EXAMINATION

A. Examine elements and surfaces to receive motor starters for compliance with installation tolerances, relationship to motors, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 INSTALLATION OF MOTOR CONTROLLERS:

A. Install motor starters as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC, NEMA, and NECA standards, and in compliance with recognized industry practices to ensure that products fulfill requirements.

B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

C. Securely fasten each switch, circuit breaker and combination starter to the supporting structure or wall, utilizing a minimum of four (4) 1/4 inch bolts.

D. Maintain minimum clearances and workspace at equipment according to manufacturer’s written instructions and NEC. Do not mount in an inaccessible location or where the passageway to the switch may become obstructed.

E. Install fuses in fusible devices in accordance with Section 262813, “Fuses”.

F. Select and set overloads on the basis of full-load current rating as shown on motor nameplate.

G. Verify that overcurrent and overload protection devices are properly matched to actual motor nameplate data and service class.

H. Provide conductor reducers, taps and splices, as required, for proper termination of all branch circuits and feeders at disconnect switches, panelboards, motor starters, VFDs, etc. This shall include where conductors have been oversized to accommodate voltage drop, motor circuit conductor protection, and all instances where conductors are unable to terminate at factory lugs.

I. Final 18 inch of power wiring to motor shall be in liquid tight flexible conduit.

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B. Where a tightening torque is indicated as a numeric value on equipment or in installation instructions provided by the manufacturer, use a calibrated torque tool to achieve that indicated torque value, unless the equipment manufacturer has provided installation instructions for an alternative method of achieving the required torque.

3.5 IDENTIFICATION

A. Comply with requirements in Section 260553, “Identification for Electrical Systems”

1. Identify field-installed conductors, interconnecting wiring, and components.
2. Provide Warning Signs.
3. Label each enclosure with nameplate.

3.6 FIELD QUALITY CONTROL:

A. Perform Test and Inspections:

1. Visual and Mechanical Inspection:

a. Compare equipment nameplate data with drawings and specifications.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, and grounding.
d. Verify the unit is clean.
e. Inspect contactors:
   1) Verify mechanical operation.
   2) Verify contact gap, wipe, alignment, and pressure are according to manufacturer's published data.
f. Motor Protection:
   1) Verify overload element rating is correct for its application.
   2) If motor-running protection is provided by fuses, verify correct fuse rating.
g. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench or low resistance ohmmeter. Bolt-torque levels and/or bolted connection resistance values shall be according to manufacturer's published data.
h. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

2. Electrical Tests:
   a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Insulation-resistance values shall be according to manufacturer's published data.
   b. Test motor protection devices according to manufacturer's published data.
   c. Verify voltages at the controller locations are within plus or minus 10 percent of the motor nameplate rated voltages. If outside the range for any motor, notify the design team before starting the motor.
   d. Perform operational tests by initiating control devices.
   e. Test all auxiliary devices/system interfaces and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

B. Motor controller will be considered defective if it does not pass tests and inspections.

C. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance, otherwise replace with new units and retest.

D. Prepare test and inspection reports, including a certified report that identifies motor controllers included and that describes results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION 262913

SECTION 263213 - DIESEL ENGINE GENERATOR SETS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

1.2 SUMMARY

A. Description: This Section includes packaged engine-generator sets suitable for use in stand-by applications with the features as specified and indicated. The engine generators will be used as the standby power source for the Electrical system but shall be capable of providing reliable power with no run-time limitations while the primary source of power is unavailable.

B. Section Includes:

1. Diesel engine.
2. Diesel fuel system.
3. Control and monitoring.
4. Generator overcurrent and fault protection.
5. Generator, exciter, and voltage regulator.
6. Outdoor enclosure.

C. Related Requirements:

1. Refer to Section 260500, “Common Work Results for Electrical Systems” for requirements related to equipment pads.
2. Refer to Section 263600, “Transfer Switches” for transfer switches including sensors and relays to initiate automatic-starting and stopping signals for engine generators.

1.3 REFERENCES

A. Abbreviations and Acronyms

1. ECM: Engine Control Module
2. EPS: Emergency Power Supply.
3. EPSS: Emergency Power Supply System.

B. Definitions

1. Emergency Standby Power: The maximum power available during a variable electrical power sequence, under the stated operating conditions, for which a generating set is capable of delivering in the event of a utility power outage or under test conditions for up to 200 hours of operation per year with the maintenance intervals and procedures being carried out as prescribed by the manufacturers.
2. Essential Electrical System: A system comprised of alternate sources of power and all connected distribution systems and ancillary equipment, designed to ensure continuity of electrical power to designated areas and functions of a health care facility during disruption of normal power sources, and also to minimize disruption within the internal wiring system.

3. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

C. Reference Standards

1. National Electrical Contractors Association (NECA)
   a. NECA 404, Standard for Installing Generator Sets.
2. National Electrical Manufacturers Association (NEMA)
   a. NEMA MG 1, Motors and Generators
   b. NEMA MG2, Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators
3. Underwriters Laboratories Inc (UL)
   a. UL2200, “Standard for Stationary Engine Generator Assemblies”.
   b. UL6200, “Standard for Safety Controllers for Use in Power Production”.

1.4 SEQUENCING

A. Submit the preliminary power system study prior to receiving final approval of equipment and system protective devices submittals and prior to release of equipment drawings for manufacturing. Adjust equipment sizes, frame sizes, and trip units as necessary to achieve performance requirements outlined in Section 260573, “Power Systems Studies”.

1.5 SUBMITTALS

A. Product Data: Submit for each type of product specified.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties, auxiliary components, and accessories.
2. Include thermal damage curve and locked rotor starting curve for generator.
3. Include time-current characteristic curves for generator protective device.
4. Include fuel consumption in cubic feet per hour (cubic meters per hour) at 0.8 power factor at 0.5, 0.75-, and 1.0-times generator capacity.
5. Include generator efficiency at 0.8 power factor at 0.5, 0.75-, and 1.0-times generator capacity.
6. Include air flow requirements for cooling and combustion air in cfm at 0.8 power factor, with air supply temperature of 70 deg F. Provide drawings showing requirements and limitations for location of air intake and exhausts.
7. Include generator characteristics, including, but not limited to, kilowatt rating, efficiency, reactance’s, short-circuit current capability, and transient voltage and frequency response based on project conditions and loads.
8. Sound test data, based on a free field requirement.

B. Shop Drawings: Provide the following.

1. Include plans and elevations for engine generator and other components specified.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include details of concrete pad requirements. Indicate layout and stub-up locations for electrical and fuel systems.
4. Identify fluid drain ports and clearance requirements for proper fluid drain.
5. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
6. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights.

7. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for EPS equipment and functional relationship between all electrical components.

C. Sample Warranty

D. Qualification Data: For qualified manufacturer and installer.

E. Seismic Certificates: for engine generator, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: With engine and generator mounted on rails, identify center of gravity and total weight, including the supplied enclosure, silencer, sub base mounted fuel tank, and each piece of equipment not integral to the engine generator, and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Source quality-control reports: Including, but not limited to, the following:

1. Certified summary of prototype-unit test report.
2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
5. Report of sound generation.
6. Report of exhaust emissions showing compliance with applicable regulations.
7. Certified torsional and vibration compatibility.

G. Field quality-control reports.

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

H. Closeout Submittals

1. Operation and Maintenance Data: For Generators and components to include in operation and maintenance manuals.
2. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
   a. Operating instructions laminated and mounted adjacent to generator location.
   b. Maintenance instructions, including lubrication procedures, motor and drive replacement, and spare parts lists.

1.6 MAINTENANCE MATERIAL

A. Extra Stock Materials: Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.

4. Tools: Each tool listed by part number in operations and maintenance manual.

1.7 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer whose products have been in satisfactory use in similar service for not less than 10 years. Certified to ISO 9001 International Quality Standard with third-party certification verifying quality assurance in design/development, production, installation, and service.

1. Maintain, within 100 miles of Project site, a 24/7/365 service center capable of providing training, parts, maintenance, and emergency repairs to equipment.
2. Employ service technicians specifically trained and certified by the generator set and transfer switch manufacturer.
3. The service center shall maintain a complete inventory of critical power system replacement parts.
4. The manufacturer shall maintain model and serial number records of each transfer switch provided for a minimum of 20 years.

B. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project, with a minimum of 5 years successful installation experience on Projects of similar size and complexity.

1.8 FIELD CONDITIONS

A. Environmental Conditions: Engine generator system shall withstand the following environmental conditions, while operating under full load, without mechanical or electrical damage or degradation of performance capability. Increase performance ratings for individual system components where indicated herein.

1. Ambient Temperature: 0 deg F (-18 deg C) to 104 deg F (40 deg C).
2. Relative Humidity: 0 to 95 percent.
3. Altitude: Sea level to 1000 feet.

1.9 COORDINATION

A. Coordinate sizes and locations of concrete bases with dimensions of actual equipment provided.

B. Equipment sizes and equipment layouts shall be considered basis of design. Equipment sizes vary by manufacturer. If proposed equipment is larger than the sizes illustrated, the burden shall be on the Contractor to provide equipment which fits in the space allotted while maintaining all code-required and manufacturer-recommended clearances.

C. Drawings indicate space available for electrical equipment, including clearances between equipment and adjacent surfaces and other items. Equipment installed must comply with all clearance, access and replacement working space requirements of the NEC and Owner.

1.10 WARRANTY

A. Comprehensive Manufacturer’s Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and all associated components that fail in materials or workmanship within 5 years from the date of Substantial Completion. Comprehensive warranty shall include all parts, supplies, labor, and travel associated with repairs.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products from one of the following:

1. Caterpillar
2. Cummins
3. Kohler
4. Generac

B. Source Limitations: Obtain packaged generator sets, transfer switches, and auxiliary components through one source.

2.2 GENERAL REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a qualified testing agency acceptable to authorities having jurisdiction and marked for intended use.

B. Provide generators that are constructed to withstand seismic forces specified in Section 260548.16 "Seismic Controls for Electrical Systems."

C. NFPA Compliance:

1. Comply with NFPA 37.
2. Comply with NFPA 70. Equipment shall be suitable for use in systems in compliance with Articles 517, 700, 701, and 702.
3. Comply with NFPA 99.
4. Comply with NFPA 101.
5. Comply with NFPA 110 requirements for Level 1 EPSS.

D. Comply with UL 2200.

E. NEMA Compliance: Comply with NEMA MG1 and NEMA MG2.

F. Engine Exhaust Emissions: Comply with EPA requirements and applicable state and local government requirements.

G. Noise Emissions: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by engine generator including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

2.3 ENGINE-GENERATOR SET

A. Factory-assembled and -tested, engine generator and accessories.

B. Mounting Frame: Structural-steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

1. Rigging Diagram: Indicate location and lifting capacity of each lifting attachment, generator-set center of gravity, and total package weight.

C. Capacities and Characteristics:

1. Power Output: Nominal rating as indicated on drawings for continuous standby operation, at 0.8 lagging power factor, excluding power required for the continued and repeated operation of the unit and accessories.
2. Voltage and Phase: As indicated on drawings.
3. Frequency: 60 Hz.
4. Alternator shall be capable of accepting loads indicated on drawings in a single step.
5. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of components. The engine-generator nameplate shall include information of the power output rating of the equipment.

D. Generator Set Performance:

1. Steady-State Voltage Operational Bandwidth: 0.5 percent of rated output voltage from no load to full load.
2. Transient Voltage Performance: Not more than 15 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 5 seconds. On application of a 100% load step the generator set shall recover to stable voltage within 10 seconds.
3. Steady-State Frequency Operational Bandwidth: 0.25 percent of rated frequency, from no load to full load.
4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
5. Transient Frequency Performance: Not more than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within 5 seconds. On application of a 100% load step the generator set shall recover to stable frequency within 10 seconds.
6. Output Waveform: At full load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for any single harmonic. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components. For a 1-phase bolted short circuit at system output terminals, system shall regulate both voltage and current to prevent over-voltage conditions on the non-faulted phases.
8. Start Time: Comply with NFPA 110, Level 1, Type 10, system requirements.
9. Noise Output: Engine generator shall be tested by the manufacturer per ANSI S12.34.

2.4 DIESEL ENGINE

A. Fuel: ASTM D975, #2 diesel fuel.

B. Rated Engine Speed: 1800 RPM.

C. Lubrication System: Engine or Skid mounted.

1. Lube oil pump: positive displacement, mechanical, full pressure pump.
2. Filter and Strainer: Provided by the engine manufacturer to provide adequate filtration for the prime mover to be used. Replaceable spin-on filters and dipstick oil level indicator.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

D. Governor: Adjustable isochronous, with speed sensing. The governing system dynamic capabilities shall be controlled as a function of engine coolant temperature to provide fast, stable operation at varying engine

operating temperature conditions. The control system shall actively control the fuel rate as appropriate to the state of the engine generator. Fuel rate shall be regulated as a function of starting, accelerating to start disconnect speed, accelerating to rated speed, and operating in various isochronous states. The governor control shall be suitable for use in future paralleling applications without component changes.

E. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Size as recommended by manufacturer to comply with NFPA 110 requirements for Level 1 equipment and with UL 499 for heater capacity and performance.

1. Designed for operation on a single 120VAC or 208VAC, Single phase, 60Hz power connection.
2. Installed with isolation valves and quick disconnect couplers to isolate the heater for replacement of the element without draining the engine cooling system or significant coolant loss.
3. Provided with a 24VDC thermostat, installed at the engine thermostat housing.

F. Cooling System: Closed loop, liquid cooled, skid mounted radiator.

1. Prototype tested with specific hardware proposed demonstrating the assembly can operate at rated standby load in an outdoor ambient condition up to 50 deg C.
2. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
3. Size of Radiator Overflow Tank: Adequate to contain expansion of total system coolant, from cold start to 110 percent load condition.
4. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant-system pressure for engine used. Equip with gage glass and petcock.
5. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
6. Coolant Hose: Flexible silicone assembly with aging-, UV-, and abrasion-resistant cover. Provide steel tubing for connections to the engine coolant system wherever the length of the pipe run exceeds 12 inches.

G. Muffler/Silencer: Minimum critical grade with a minimum sound attenuation of 25dB at 500Hz, sized as recommended by engine manufacturer, selected to meet sound performance requirements of the application, and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements. Located inside the housing enclosure unless noted otherwise.

1. Mounted so that its weight is not supported by the engine nor will exhaust system growth due to thermal expansion be imposed on the engine.

H. Air-Intake Filter: Engine-mounted air cleaner with replaceable dry-filter element and restriction indicator.

I. Starting System: 24VDC electric, as recommended by the engine manufacturer; with negative ground.

1. Components: Sized so they are not damaged during a full engine-cranking cycle, with ambient temperature at maximum specified in "Environmental Conditions" Article.
2. Cranking Cycle: As required by NFPA 110 for system level specified. Capable of either one 45 second continuous cranking cycle or three 15 second cranking cycles with 15 second rest between without overheating.
3. Battery: Lead Acid type, 24-volt DC, sized as recommended by the engine manufacturer, complete with battery cables and connectors.
4. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
5. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation.
6. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation. The battery charging alternator shall have sufficient capacity to recharge the batteries with all parasitic loads connected within 4 hours after a normal engine starting sequence.
7. Battery Charger: Fully regulated, constant voltage, current limited, battery charger for each battery bank. Comply with NFPA 110, UL 1236, and include the following features:

a. Operation: Equalizing-charging rate based on generator set manufacturer's recommendations shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 20 deg C to plus 40 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
d. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
e. Provide LED indication of general charger condition, including charging, faults, and modes. Provide a LCD display to indicate charge rate and battery voltage. Charger shall provide relay contacts for fault conditions as required by NFPA110.
f. Enclosure and Mounting: NEMA, Type 1, cabinet.
g. Charger shall include an Analog DC voltmeter and ammeter, 12-hour equalize charge timer, and AC and DC fuses. Operational monitors shall provide visual output along with individual form C contacts for remote indication of:
    1) Loss of AC power - red light
    2) Low battery voltage - red light
    3) High battery voltage - red light
    4) Power ON - green light (no relay contact)

2.5 DIESEL FUEL-OIL SYSTEM

A. Comply with NFPA 30 and NFPA 37.

B. Engine Fuel System: The engine fuel system shall be installed in strict compliance to the engine manufacturer's instructions.

C. Main Fuel Pump: Mounted on engine to provide primary fuel flow under starting and load conditions. Engine driven, mechanical, positive displacement fuel pump.

D. Fuel Filtering: Replaceable spin-on canister element with water separator.

E. Fuel Cooler: Suitable for operation of the generator set at full rated load in the ambient temperature specified shall be provided if required for operation due to the design of the engine and the installation.

F. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

G. Day Tank: Comply with UL 142, freestanding, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump and the following features:

1. Allocation: Provide a separate day tank for each engine generator.
2. Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of day tank.
    a. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day-tank leak.
3. Tank Capacity: As recommended by engine manufacturer for an uninterrupted period of 2 hours operation at 100 percent of rated power output of engine generator system without being refilled.
4. The tank shall be equipped with a heavy-duty float switch with pump running lights and a press to test switches to operate a remote supply pump. Arrange the float switches to activate the supply

pump on at 86% and deactivate the supply pump off when the day tank level reaches 100%. A normally closed solenoid valve shall be installed on the tank inlet and work in conjunction with the float switches to open upon the demand for fuel and close when the day tank is full. Provide a second set of float switches and plumbing arrangement to act as overflow return pump to return fuel back to the above ground main storage tank in the event of an overflow condition. The overflow return pump shall be rated at 8 gpm. Arrange the overflow return float switch to activate the pump at 101% and deactivate the pump at approximately 92%. Return pump assembly shall be mounted on the tank and protected by a removable cover.

~~5.~~ The day tank shall include alarm lights, independent level sensors and remote dry contacts for high fuel level set at 102%, low fuel level set at 75%, and leak / rupture detection. The rupture / leak alarm when activated shall disable the supply pump's and de-energize the normally closed solenoid valve.

6. The day tank shall include independent level sensors and remote dry contacts for a critical high fuel shutdown. The alarm condition activates a red light on day tank control panel, coil on a relay for remote annunciation and closes a normally open solenoid valve in the fuel inlet piping.
7. All alarms and level controls shall be factory assembled and wired so that only a 115 VAC power supply need be applied to make the day tank system functional. The remote alarm dry contacts will require separate wiring and power supply.
8. A fuel strainer shall be provided and installed up stream of all solenoid valves in the fuel inlet piping.
9. Include a vent line termination vent kit type for the normal vent opening and a pressure relief vent for the emergency vent opening. The design and labeling of the emergency vent cap shall comply with the requirements of NFPA 30.
10. Include engine supply line fuel oil supply 24VDC solenoid valve with manual bypass means at the day tank and swing style check valve in the engine fuel oil return line at the top of the day tank for anti-siphon protection.
11. Piping Connections: Installed fuel supply and return lines from tank to engine; local fuel fill, and vent lines in compliance with local code requirements.

H. Subbase-Mounted, Double-Wall, Fuel-Oil Tank: Factory installed and piped, complying with UL 142 fuel-oil tank. Features include the following:

1. Electrical stub up(s).
2. Mechanical fuel level gauge: Direct reading, UL-listed, magnetic with a hermetically sealed, vacuum tested dial.
3. High and low fuel level indicators.
4. Low Fuel Alarm Contacts: for annunciation of a low fuel condition.
5. Provide means to prevent overfilling by sounding an alarm when the liquid level in the tank reaches 90 percent of capacity and by automatically stopping delivery of liquid to the tank when the liquid level in the tank reaches 95 percent of capacity.
6. Normal and emergency relief vents: for inner and outer tank, UL-listed, sized in accordance with American Petroleum Institute Standard No 2000.
7. Fuel-Tank Capacity: Minimum 133 percent of total fuel recommended by engine manufacturer for an uninterrupted period of 24 hours operation at full load without being refueled. Comply with NFPA 110.
8. Containment basin: Welded steel, sized at a minimum of 130 percent of the tank capacity to prevent escape of fuel into the environment in the event of a tank rupture.
9. Monitored leak detection in interstitial space.
10. Lockable vandal-resistant fill cap.
11. Fill port with overfill prevention valve and spill containment.
12. Integral lifting provisions.
13. Comply with requirements of authorities having jurisdiction.

2.6 CONTROL AND MONITORING

A. Provide microprocessor-based engine generator control with automatic starting, monitoring, protection, and control functions for the unit.

B. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. Switches with different configurations but equal functions are acceptable. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of the local, generator set-mounted, and/or remote emergency-stop switch also shuts down generator set.

C. Manual Starting System Sequence of Operation: Switching On-Off switch on the generator control panel to the on position starts engine generator. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms. Operation of the local, generator set-mounted, and/or remote emergency-stop switch also shuts down generator set.

D. Comply with UL 508A or UL6200.

E. Configuration: Operating and safety indications, protective devices, system controls, engine gages and associated equipment shall be grouped in a common control and monitoring panel. Mounting method shall isolate the control panel from generator-set vibration. AC output power circuit breakers and other output power equipment shall not be mounted in the control enclosure.

F. Control and Monitoring Panel

1. Digital controller with integrated graphical display, navigational devices, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup. Capable of viewing all engine status and alarm/shutdown conditions. Include integrated provisions for adjustment of the gain and stability settings for the governing and voltage regulation systems.
2. Instruments and Digital Metering: Located on the control and monitoring panel and viewable during operation. Ammeter-voltmeter displays shall simultaneously display conditions for all three phases.
    a. Engine lubricating-oil pressure gage.
    b. Engine-coolant temperature gage.
    c. DC voltmeter (alternator battery charging).
    d. Running-time meter.
    e. AC voltmeter (3-phase, line to line and line to neutral values).
    f. AC ammeter (3-phases).
    g. AC frequency meter.
    h. AC kW and kVA output (total and for each phase). Display shall indicate power flow direction.
    i. AC Power factor (total and for each phase). Display shall indicate leading or lagging condition.
    j. Generator-voltage and frequency digital raise/lower switches. Rheostats for these functions are not acceptable. The control shall adjustment of these parameters in a range of plus or minus 5% of the voltage and frequency operating set point (not nominal voltage and frequency values).
3. Controls and Protective Devices: Controls, shutdown devices, and common visual alarm indication as required by NFPA 110 for Level indicated, including the following:
    a. Run-Off-Auto Switch: The mode select switch shall initiate the following control modes. When in the RUN or Manual position the generator set shall start and accelerate to rated

speed and voltage as directed by the operator. In the OFF position the generator set shall immediately stop, bypassing all time delays. In the AUTO position the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.

b. Include adjustable time delay start and time delay stop functions.

c. Emergency Stop Switch: Switch shall be a red "mushroom head" pushbutton device complete with lock-out/tag-out provisions. Depressing switch shall cause the generator set to immediately stop the generator set and prevent it from operating or automatically restarting.

d. Fault Reset Switch: Supply a dedicated control switch to reset/clear fault conditions.

e. AC Protective Equipment: The control system shall include over/under voltage, over current, short circuit, loss of voltage reference, and over excitation shut down protection. There shall be an overload warning, and overcurrent warning alarm. The system shall initiate shutdown of the generator set when alternator output voltage exceeds 110% of the operator-set voltage level for more than 10 seconds, or with no intentional delay when voltage exceeds 130%. Under voltage shutdown shall occur when the output voltage of the alternator is less than 85% for more than 10 seconds.

f. Status LED indicating lamps to indicate remote start signal present at the control, existing alarm condition, not in auto, and generator set running.

g. Include sender failure monitoring logic for speed sensing, oil pressure, and engine temperature which is capable of discriminating between failed sender or wiring components, and an actual failure condition.

h. Integrated provisions for adjustment of the gain and stability settings for the governing and voltage regulation systems.

i. Cycle cranking control: Allow for user selected crank time, rest time, and number of cycles. Initial settings shall be for 3 cranking periods of 15 seconds each, with 15 second rest period between cranking periods.

j. Idle Mode Control: allows the engine to run in idle mode in the RUN position only. In this mode, the alternator excitation system shall be disabled.

k. Panel lighting system to allow viewing and operation of the control when the generator room or enclosure is not lit.

l. DC control Power Monitoring: The control system shall continuously monitor DC power supply to the control and annunciate low or high voltage conditions. It shall also provide an alarm indicating imminent failure of the battery bank based on degraded voltage recover on loading (engine cranking). During engine cranking (starter engaged), the low voltage limit shall be disabled.

m. Fuel tank derangement alarm.

n. Fuel tank high-level shutdown of fuel supply alarm.

o. Lamp test: Depressing the panel lamp switch shall cause the entire panel to be lighted with DC control power. The panel lamps shall automatically be switched off 10 minutes after the switch is depressed, or after the switch is depressed a second time

p. Provisions shall be made for indication of four customer-specified alarm or shutdown conditions. Labeling of the customer-specified alarm or shutdown conditions shall be of the same type and quality as the above specified conditions. The non-automatic indicating lamp shall be red and shall flash to indicate that the generator set is not able to automatically respond to a command to start from a remote location.

4. Data Logging: The control system shall log the latest 20 different alarm and shut down conditions, the total number of times each alarm or shutdown has occurred, and the date and time the latest of these shutdown and fault conditions occurred.

G. Connection to Building Automation

1. A separate terminal block, factory wired to minimum four Form C dry contacts, for each alarm and status indication.

2. Provide connections for datalink transmission of indications to remote data terminals. Refer to HVAC Control Specifications and Points List for values to be reported and coordination of

communications protocol. At a minimum, include all NFPA-110 required alarms, complete power and voltage data (per phase and three phase), basic engine, fuel, and lubricant system status and alarms, and all functions common to the system Generator Alarm Annunciator(s).

3. Allow for remote sequencing and operation of mechanical equipment when unit is running. Coordinate exact requirements with mechanical contractor and provide complete interface as required.

H. Remote Alarm Annunciator: Comply with NFPA 110. A LED labeled with proper alarm conditions shall identify each alarm event and a common audible signal shall sound for each alarm condition. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated. Provide number and location per plans and all necessary wiring and connections. Remote annunciators shall be powered from the engine generator battery.

I. Start Circuit Monitoring: Provide engine start circuit monitor to continuously monitor the integrity of the generator remote start circuit. Loss of integrity of the remote start circuit(s) through broken, disconnected, or shorted wires shall initiate start the generator(s) to ensure fail safe operation.

J. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation. Locate adjacent to automatic transfer switch served from the generator and as indicated on plans.

2.7 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.

B. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.

1. Tripping Characteristics: Adjustable long-time, short-time, and instantaneous delay.
2. Trip Settings: Selected to coordinate with generator thermal damage curve.
3. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
4. Mounting: Adjacent to or integrated with control and monitoring panel. Isolated from vibrations induced by the generator set.
5. Mechanical type lugs, sized for the conductors shown on drawing, shall be supplied on the load side of breaker.
6. Provide arc energy reduction maintenance switch for all overcurrent protective devices rated 1200 amps or greater or where the continuous current trip setting can be adjusted to 1200A or greater.

C. Generator Protector: Provide a UL6200 certified protective device, coordinated with the alternator, to prevent damage to the generator set on any possible overload or overcurrent condition external to the machine. The protective device shall be listed as a utility grade protective device under UL category NRGU. Protector performs the following functions:

1. Initiates a generator kW overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms.
2. Under single phase or multiple phase fault conditions, or on overload conditions, indicates an alarm conditions when the current flow is in excess of 110% of rated current for more than 10 seconds.
3. Under single phase or multiple phase fault conditions, operates to switch off alternator excitation at the appropriate time to prevent damage to the alternator.
4. The operator panel shall indicate the nature of the fault condition as either a short circuit or an overload.
5. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot greater than 120% of nominal voltage.

6. The protective system provided shall not include an instantaneous trip function.
7. The protective system shall fully protect the alternator's thermal damage curve.
8. Include load shed control, to operate a set of dry contacts (for use in shedding customer load devices) when the generator set is overloaded.

D. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

1. The control System shall include a ground fault monitoring relay. The relay shall be adjustable and include an adjustable time delay. The relay shall be for indication only, and not trip or shut down the generator set. Coordinate with system grounding and bonding arrangement and provide relay that will function correctly in system as installed.

2.8 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H

D. Temperature Rise: Maximum 125 deg C for 40 deg C ambient

E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, over speed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

F. Permanent Magnet Generator (PMG) shall provide excitation power for optimum motor starting and short circuit performance.

G. Enclosure: Drip-proof.

H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified and as required by NFPA 110. The voltage regulation system shall be microprocessor-controlled, full wave rectified, and provide a pulse-width modulated signal to the exciter. No exceptions or deviations to these requirements will be permitted.

I. The alternator shall be provided with anti-condensation strip heater in all applications where the generator set is provided in an outdoor enclosure to maintain windings above dew point.

J. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

K. Subtransient Reactance: 12 percent maximum, based on the rating of the engine generator set.

2.9 OUTDOOR GENERATOR-SET ENCLOSURE

A. Description: Vandal-resistant, weatherproof steel housing, wind resistant up to 150 mph. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Instruments, control, and battery system shall be mounted within enclosure.
1. Sound Attenuation Level: maximum of 75 dBA measured during full load at 7 meters in a free field environment with a vertical radiator discharge.

B. Hinged Doors: With padlocking provisions. Restraint/Hold back hardware to prevent door to keep door open at 180 degrees during maintenance. Rain lips over all doors.

C. Insulation: Non-hydroscopic materials as recommended by Manufacturer to comply with thermal and acoustic performance requirements.

D. Provide enclosure to allow the generator set to operate at full rated load with a static pressure drop equal to or less than 0.5 inches of water.

E. Muffler and Silencer: Located within enclosure. Include a raincap and rainshield.

F. Hardware: All hardware, fasteners, and hinges shall be corrosion resistant stainless steel.

G. Mounting Base: Suitable for mounting on housekeeping pad.

H. Air inlets shall include rain hoods.

I. Lifting: Complete assembly of engine generator, enclosure shall be designed to be lifted into place as a single unit, using spreader bars:

J. Engine-Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for two hours with ambient temperature at top of range specified in system service conditions.

1. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating. Dampers shall be of a “fail open” design to allow airflow in the event of failure.

K. Include flexible coolant and lubricating oil drain lines, that extend to the exterior of the enclosure, with internal drain valves.

L. Where center of circuit breaker handles, switch handles, or controller interface is located more than 6-foot, 7-inches above ground level or equipment pad, provide an aluminum service access platform. The platform shall be the width of the serviceable openings and shall have stairs up to the platform. Provide protective railing around platform with access stairs. Platform assembly shall comply with OSHA requirements. Increase equipment pad size as necessary to accommodate service access platform.

2.10 VIBRATION ISOLATION DEVICES

A. Provide generators with elastomeric isolator pads integral to the generator unless the engine manufacturer requires use of spring isolation.

2.11 FINISHES

A. Indoor and Outdoor Enclosures and Components: Powder-coated and baked over corrosion-resistant pretreatment and compatible primer. Manufacturer’s standard color unless indicated otherwise on the drawings.

2.12 SOURCE QUALITY CONTROL

A. Prototype Testing: Test engine-generator set as a complete assembled unit using same engine model, constructed of identical or equivalent components, and equipped with identical or equivalent accessories.

1. Tests: Comply with NFPA 110, Level 1 Energy Converters.
2. In addition, validate the capability of the design under the abnormal conditions noted in NFPA 110 by subjecting the equipment engine, skid, cooling system, and alternator to actual prototype tests. Calculations and testing on similar equipment which are allowed under NFPA 110 are not sufficient to meet this requirement.
    a. Include vibration testing conducted to validate the integrity and prolonged health of the generator assembly.
    b. Verify the torsional compatibility of the rotating equipment.

B. Factory Tests and Inspection: Before shipment, factory test engine generator and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:

1. Test generator, exciter, and voltage regulator as a unit to demonstrate compatibility and functionality.
2. Start-up testing.
3. Load Test at 25, 50, 75, and 100 percent load.
4. Maximum power.
5. Voltage regulation.
6. Transient and steady state governing at no load and full load.
7. Single-step full load pickup.
8. Simulated safety shutdowns.

C. Product will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.

B. Examine roughing-in for piping systems and electrical connections. Verify actual locations of connections before packaged engine generator installation.

C. Physically inspect equipment for damage. Repair scratches and other installation damage prior to final system testing. Thoroughly clean equipment to remove all dirt and construction debris prior to initial operation and final testing of the system.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with NECA 1 and NECA 404.

B. Comply with packaged engine generator manufacturers' written installation, application, and alignment instructions and with NFPA 70 and NFPA 110.

C. Equipment Mounting:

1. Install packaged engine generators and any access platforms on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 260500, “Common Work Results for Electrical Systems”.
2. Coordinate size and location of concrete bases for packaged engine generators and any access platforms.
3. Install units on vibration isolators in accordance with manufacturer’s recommendations.
4. Permanently fasten equipment to the pad in accordance with the manufacturer’ instructions and seismic criteria of the Project.

D. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

E. Drain Piping: Install condensate drain piping to muffler drain outlet with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe, the full size of the drain connection, with welded joints.

F. Fuel Piping: Comply with Division 23 for fuel piping, valves, and specialties for fuel distribution.

G. Install electrical devices and components that are not factory mounted.

H. Provide all interconnection wiring between system components and equipment.

3.3 CONNECTIONS

A. Coordinate with all trades for generator interface with other building systems.

B. Provide flexible connections for all connections to the generator and between its components to reduce vibrations transmitted to surrounding structures.

C. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.

D. Connect engine exhaust pipe to engine with flexible connector.

E. Fuel Connections:

1. Comply with manufacturer’s instructions.
2. Connect fuel piping to engines with a gate valve and union and flexible connector.
3. Install manual shutoff valve in a remote location to isolate fuel supply to the generator.
4. Vent gas pressure regulators outside building a minimum of 60 inches from building openings.

F. Provide raceways for all wiring according to Section 260533 “Raceways and Boxes for Electrical Systems.”

G. Install and connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

1. Provide Class D extra flexible stranded conductors for all connections to genset.
2. Control conductors installed between the transfer equipment and the emergency generator shall be kept entirely independent of all other wiring in accordance with NEC.

H. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B. Where a tightening torque is indicated as a numeric value on equipment or in installation instructions provided by the

manufacturer, use a calibrated torque tool to achieve that indicated torque value, unless the equipment manufacturer has provided installation instructions for an alternative method of achieving the required torque.

I. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.4 GROUNDING

A. Ground and bond equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

1. Install a minimum of two auxiliary grounding electrodes at outdoor generator locations. Connect the electrodes to the equipment grounding conductor and to the frame of the generator in accordance with the generator manufacturer's recommendations.
2. If the grounded neutral conductor is switched at a 4-pole transfer switch, provide a main bonding jumper between the generator's grounded terminal (neutral) and the equipment grounding terminal.

3.5 IDENTIFICATION

A. Comply with requirements in Section 260553, "Identification for Electrical Systems".

1. For non-separately derived systems, install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.6 ADJUSTING

A. Set field-adjustable circuit-breaker trip ranges and time delay settings to recommended values identified in the final approved power system study.

3.7 FIELD QUALITY CONTROL

A. Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to perform start-up and testing.

B. The factory-authorized service representative shall perform a site evaluation prior to test and inspections to verify the equipment is installed in accordance with the manufacturer's instructions. Equipment shall be initially started and operated by the authorized service representative.

C. Provide 7-day advance notice of any testing to allow The Engineer and Owner's Representative the option to witness the tests.

D. Provide fuel, engine fluids, and load bank required for testing and commissioning of the engine generator. At completion of the testing, completely fill all fuel tanks in accordance with manufacturer's recommendations prior to system turn-over.

E. Pre-Operational Tests and Inspections

1. Visual and Mechanical Inspection:

a. Examine equipment nameplate data and confirm proper identification.
b. Inspect the physical, electrical, and mechanical condition of the equipment and all components in accordance with the manufacturers' instructions.
c. Inspect anchorage, alignment, and grounding.

d. Verify the unit is clean.
e. Inspect bolted electrical connections and terminations for high resistance by verifying tightness with calibrated torque-wrench method in accordance with manufacturer's published data.
f. Exercise all active components.
g. Inspect all mechanical indicating devices for correct operation.
h. Physically test key interlock systems to check for proper functionality prior to energizing.

2. Electrical and Mechanical Tests:

a. Perform insulation-resistance tests in accordance with IEEE 43.

1) Machines larger than 200 hp. Test duration shall be 10 minutes. Calculate polarization index.
2) Machines 200 hp or less. Test duration shall be one minute. Calculate the dielectric-absorption ratio.

b. Test protective relay devices.
c. Verify phase rotation, phasing, and synchronized operation as required by the application.
d. Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
e. Verify correct functioning of the governor and regulator.

F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.

G. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.

H. Functional Acceptance Testing:

1. Test the complete automatic transfer switch system and generator control system concurrently to ensure proper operation of the individual components and correct overall sequence of operation and to ensure that the operating transfer time, voltage, frequency, and time delay settings are in compliance with the specification requirements.
2. Perform tests required by NFPA 110 and additional testing specified herein.
   a. Provide resistive load bank and temporary connections as required to supplement building load equal to 100 percent of the nameplate kW rating.
   b. Factory test data showing run-test loads is not acceptable.
   c. Record fuel consumption, coolant temperature, lube oil pressure, output voltage (each phase), output current (each phase), room temperature at 15-minute intervals during testing.
3. Cold start test: Demonstrate the engine generator set will attain proper voltage and frequency within the specified time limit from a cold start after the closing of a single contact.
4. Full load one step pickup: Verify system can achieve full nameplate kW rating in one step and achieve acceptable steady state operation.
5. Full load operation test: Run the generator for a minimum of two hours while delivering the full nameplate kW rating.
6. Transient Test: Verify voltage and frequency deviations are within acceptable limits while adding and dropping each step load.
   a. Verify ability to allow starting and running the largest motor load at its full load current rating while supplying all other simultaneous loads.
7. Power Failure Testing: Open the power supply from the utility service(s) and observe proper sequence of operation of the system. Where multiple sources and/or generators are included in the project, simulate all possible power failure scenarios. Coordinate timing and obtain approval for start of test with site personnel.

I. Test instruments shall have been calibrated within the last 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.

J. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

K. Remove and replace malfunctioning units and retest as specified above.

L. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

M. Report results of tests and inspections in writing. Record adjustable settings, measured values, and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.8 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by the manufacturer service manual and any calibration required for proper operation. Include emergency service. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

B. Training shall consist of not less than eight hours of hands-on instruction for a minimum of four attendees. Training shall cover the following topics at a minimum:

1. Theory of operation
2. Operation of Generator and components
3. Maintenance and configuration
4. Troubleshooting and Repair
5. Replacement of components.

END OF SECTION 263213

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SECTION 263600 - TRANSFER SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Automatic Transfer Switch
2. Bypass/Isolation Switch
3. Portable Generator Docking Station

B. Related Requirements:

1. Refer to Section 263213 “Gas Engine Generator Sets” for requirements related to packaged engine generator sets.

1.3 REFERENCES

A. Abbreviations and Acronyms

1. EPS: Emergency Power Supply.
2. EPSS: Emergency Power Supply System.

B. Definitions

C. Reference Standards

1. National Electrical Contractors Association (NECA)
2. National Electrical Manufacturers Association (NEMA)
   a. NEMA ICS 1, “Industrial Control and Systems General Requirements”
3. Underwriters Laboratories Inc (UL)
   a. UL1008, “Transfer Switch Equipment”.

1.4 SUBMITTALS

A. Product Data: Submit for each type of product specified.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for transfer switches.
2. Include rated capacities, weights, operating characteristics, electrical characteristics, and accessories.

B. Shop Drawings: Provide the following

1. Include plans, elevations, sections, details showing minimum clearances, conductor entry provisions, gutter space, and installed features and devices.
2. Include material lists for each switch specified.
3. Wiring Diagram: Show connections between transfer switch, any bypass/isolation switch, power sources, loads, and show any interlocking provisions.
4. Control Diagrams: Show interconnection wiring between transfer switches, generators, and any bypass/isolation switches, annunciators, and control panels.

C. Qualification Data: For qualified installer.

D. Seismic Certificates: for transfer switches, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Closeout Submittals

1. Operation and Maintenance Data: For Generators and components to include in operation and maintenance manuals.
2. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
   a. Features and operating sequences, both automatic and manual.
   b. List of all factory settings and calibration instructions, including software, where applicable.

1.5 MAINTENANCE MATERIAL

A. Extra Stock Materials

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer whose products have been in satisfactory use in similar service for not less than 10 years. Maintain, within 100 miles of Project site, a 24/7/365 service center capable of providing training, parts, and emergency maintenance repairs. The service center shall maintain a complete inventory of critical power system replacement parts. The manufacturer shall maintain model and serial number records of each transfer switch provided for at least 20 years.

B. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project, with a minimum of 5 years successful installation experience on Projects of similar size and complexity.

1.7 WARRANTIES

A. Manufacturer Warranty: Manufacturer agrees to repair or replace components of transfer switch and all associated components that fail in materials or workmanship within 5 years of Substantial Completion

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency acceptable to the authority having jurisdiction and marked for intended location and application.

B. Comply with NEMA ICS 1.

C. Comply with UL 1008.

D. Comply with NFPA 99 and NFPA 110.

E. Provide transfer switches that are constructed to withstand seismic forces specified in Section 260548.16 "Seismic Controls for Electrical Systems."

2.2 GENERAL REQUIREMENTS

~~A.~~ Fault-Current Closing and Withstand Ratings: UL 1008 WCR ratings must be specifically listed as meeting the requirements for use with protective devices at installation locations, under specified fault conditions. Withstand and closing ratings shall be based on use of the same set of contacts for the withstand test and the closing test.

B. Solid-State Controls Accuracy: All settings shall be accurate to plus or minus 2 percent or better over an operating temperature range of minus 40 to plus 140 deg F.

C. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.62. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

D. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism. Switches for emergency or standby purposes shall be mechanically and electrically interlocked in both directions to prevent simultaneous connection to both power sources unless closed transition. Mechanical interlock is not required for closed transition switches.

E. Enclosure: Surface or Floor mounted, Certified for compliance to NEMA ICS 6 and UL 508.
   1. Rated for environmental conditions at installed location.
      a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
      b. Outdoor and Wet Locations: NEMA 250, Type 3R.
      c. Corrosive Environments: NEMA 250, Type 4X.
   2. Hinged door with permanently mounted key-type latches. All lock assemblies shall be keyed alike.

F. Service-Rated Transfer Switch:
   1. Comply with UL 869A and UL 489.
   2. Provide terminals for bonding the grounding electrode conductor to the grounded service conductor.
   3. In systems with a neutral, the bonding connection shall be on the neutral bus.
   4. Provide removable link for temporary separation of the service and load grounded conductors.
   5. Provide surge protective device in accordance with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
   6. Service Disconnecting Means: Externally operated, manual mechanically actuated.

2.3 AUTOMATIC TRANSFER SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide product from one of the following:
   1. Caterpillar
   2. Cummins Onan
   3. Kohler
   4. Asco
   5. Russelectric

B. Source Limitations: Source Limitations: Obtain automatic transfer witches and auxiliary components through one source from a single manufacturer. The generator set manufacturer shall warrant transfer switches to provide a single source of responsibility for products provided.

C. Comply with NFPA 110 requirements for Level 1 EPSS.

D. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

   1. Limitations: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are unacceptable unless noted otherwise.
   2. Switch Action: Double throw; mechanically held in both directions.
   3. Contacts: High-pressure silver alloy for load-current switching. Contact assemblies shall have arc chutes for positive arc extinguishing. Arc chutes shall have insulating covers to prevent inter-phase flashover. Contactor-style automatic transfer-switch units, rated 600 A and higher, shall have separate arcing contacts.
   4. Contacts shall be operated by a high-speed electrical mechanism that causes contacts to open or close within three electrical cycles from signal.
   5. The transfer switch operation shall include the ability to switch to an open position (both sources disconnected) for the purpose of load shedding from the generator set.
   6. Transfer switch shall be provided with flame retardant transparent covers to allow viewing of switch contact operation but prevent direct contact with components that could be operating at line voltage levels.
   7. Conductor Connectors: Suitable for use with conductor material and sizes.
   8. Material: Hard-drawn copper, 98 percent conductivity.
   9. Main and Neutral Lugs: Mechanical type.
   10. Ground Lugs and Bus-Configured Terminators: [Compression] [Mechanical] type.
   11. Connectors shall be marked for conductor size and type according to UL 1008.

A. Neutral Switching:
   1. Transfer switches designated on the drawings as 4-pole shall be provided with a switched neutral pole. The neutral pole shall be of the same construction and have the same ratings as the phase poles. All poles shall be switched simultaneously using a common crossbar.
   2. Transfer switches that are designated on the drawings as 3-pole shall be provided with a neutral bus and lugs. The neutral bus shall be sized to carry 100% of the current designated on the switch rating.

B. Automatic Delayed-Transition Transfer Switches: Pauses or stops in intermediate position to momentarily disconnect both sources, with transition controlled by programming in the automatic transfer-switch controller. Interlocked to prevent the load from being closed on both sources at the same time.

   1. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals for alternative source. Adjustable from 0 to 60 seconds, and factory set for one second.
   2. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.
   3. Fully automatic break-before-make operation with center off position.

C. Automatic Closed-Transition Transfer Switches: Connect both sources to load momentarily. Transition is controlled by programming in the automatic transfer-switch controller.

1. Fully automatic make-before-break operation when transferring between two available power sources.
2. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.
3. Initiation of No-Interruption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.
   a. Initiation occurs without active control of generator.
   b. Controls ensure that closed-transition load transfer closure occurs only when the two sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.
4. Failure of power source serving load initiates automatic break-before-make transfer.

D. Electromechanical Manual (Non-Automatic Switch) Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternative Source" and coordinated with control function. Switch shall be capable of transferring load in either direction with either or both sources energized, under load, and with enclosure door closed.

E. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

F. Automatic Transfer-Switch Controller Features:

1. Microprocessor based, password protected, LCD digital display mounted on and operational from enclosure door, with integral pushbuttons and LED status indicators.
   a. Provide LED status indicators for switch position, source availability, non-automatic operation, control disable, and test/exercise modes. Provide green indicator lights for normal power supervision and red lights for emergency power supervision.
   b. Provide pushbuttons to enable user to activate programmed test sequences, override time delays, reset/clear faults, and test LED indicators.
   c. All settings shall be configurable locally through display or remotely through serial communications port.
2. Power failure: Controller operates through a period of loss of control power. Incorporate non-volatile memory. Should power be interrupted and subsequently restored, control settings and parameters saved in protected memory shall not be lost and should restore system to its last operating state without requiring user input.
3. Voltage and Frequency Sensing: for both normal and emergency sources, continuously monitored, field adjustable in 1 percent increments.
   a. Undervoltage:
      1) Pickup: 85 to 100 percent of nominal.
      2) Dropout: 75 to 98 percent of nominal.
   b. Overvoltage:
      1) Pickup: 95 to 99 percent of dropout
      2) Dropout: 105 to 135 percent of nominal
   c. Underfrequency
      1) Pickup: 86 to 100 percent of nominal
      2) Dropout: 85 to 98 percent of nominal
   d. Overfrequency
      1) Pickup: 95 to 99 percent of dropout
      2) Dropout: 101 to 111 percent of nominal
   e. Dropout Time Delay: 0.1 to 1.0 seconds.
4. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.

5. Adjustable Time Delays:
   a. Engine Start: 0 to 120 seconds.
   b. Transfer to Emergency Source: 0 to 120 seconds.
   c. Retransfer to Normal Source: 0 to 30 minutes. Override shall automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
   d. Engine Stop/Cooldown: 0 to 30 minutes.
   e. Programmed Transition: 0 to 60 seconds.
6. Re-Transfer Inhibit Switch: Overrides automatic retransfer control so transfer switch will remain connected to emergency power source regardless of condition of normal source. LED indicates override status.
7. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 250-V ac.
8. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 5 A at 32-V dc minimum.
9. Engine Shutdown Contacts:
10. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval shall be adjustable from 0 to 60 seconds and coordinated with any elevator equipment provided for the project.
11. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods shall be adjustable from 10 to 30 minutes. Factory settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
    a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
    b. Push-button programming control with digital display of settings.
    c. Integral battery operation of time switch when normal control power is unavailable.

2.4 BYPASS/ISOLATION SWITCHES

A. Source Limitations: Same manufacturer as transfer switch in which installed.

B. Comply with NFPA 110 requirements for Level 1 EPSS.

C. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined automatic transfer switch and bypass/isolation switch:

1. Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. Interlocks shall prevent transfer-switch operation, except for testing or maintenance, while automatic transfer switch is isolated.
2. Provide means to make power available to transfer-switch control circuit for testing and maintenance purposes.
3. Drawout Arrangement for Transfer Switch: Provide physical separation from live parts and accessibility for testing and maintenance operations. Transfer switch and bypass/isolation switch shall be in isolated compartments.
4. Transition:
   a. Provide closed-transition operation when transferring from main transfer switch to bypass/isolation switch on the same power source.

5. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.
6. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.
7. Automatic and Nonautomatic Control: Automatic transfer-switch controller shall also control the bypass/isolation switch.
8. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.
9. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.

D. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.

2.5 PORTABLE GENERATOR DOCKING STATION

A. Manufacturers: Subject to compliance with requirements provide product from one of the following:

1. Asco
2. Eaton
3. ESL
4. Trystar

B. Manual Switch Operation: Manual handle provides quick-make, quick-break manual-switching action. Switch shall be capable of manually transferring load in either direction with either or both sources energized.

C. Transfer Switches Based on Molded-Case-Switch Components: Comply with UL 489 and UL 869A.

D. Auxiliary Contacts: Switch shall have one set of normally closed contacts for each switch position, rated 10 A at 240-V ac.

E. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Switch Action: Double throw; mechanically held in both directions.
2. Contacts: Silver composition or silver alloy for load-current switching.
3. Conductor Connectors: Suitable for use with conductor material and sizes.
4. Material: Hard-drawn copper, 98 percent conductivity.
5. Main and Neutral Lugs: Mechanical type.
6. Ground Lugs and Bus-Configured Terminators: Mechanical type.
7. Connectors shall be marked for conductor size and type according to UL 1008.

2.6 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect components, assembled switches, and associated equipment according to UL 1008. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

B. Prepare test and inspection reports.

1. For each of the tests required by UL 1008, performed on representative devices, for emergency and legally required systems. Include results of test for the following conditions:

a. Overvoltage.

b. Undervoltage.
c. Loss of supply voltage.
d. Reduction of supply voltage.
e. Alternative supply voltage or frequency is at minimum acceptable values.
f. Temperature rise.
g. Dielectric voltage-withstand; before and after short-circuit test.
h. Overload.
i. Contact opening.
j. Endurance.
k. Short circuit.
l. Short-time current capability.
m. Receptacle withstand capability.
n. Insulating base and supports damage.

C. Product will be considered defective if it does not pass tests and inspections.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Transfer Switch Mounting: Install floor mounted transfer switches on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Division 03 and Section 260500, “Common Work Results for Electrical Systems.”

1. Install conduits entering underneath the Transfer Switch, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches above concrete base after switchboard is anchored in place.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to Transfer Switch.

C. Annunciator and Control Panel Mounting: Flush in wall unless otherwise indicated.

3.2 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

3.3 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B. Where a tightening torque is indicated as a numeric value on equipment or in installation instructions provided by the manufacturer, use a calibrated torque tool to achieve that indicated torque value, unless the equipment manufacturer has provided installation instructions for an alternative method of achieving the required torque.

B. Wiring to Remote Components: Match type and number of cables and conductors to generator sets, control, and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary, to accommodate required wiring.

3.4 ADJUSTING

A. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

B. Transfer switches will be considered defective if they do not pass tests and inspections.

C. Remove and replace malfunctioning units and retest as specified above.

D. Prepare test and inspection reports.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment.

B. Coordinate training with that for generator equipment.

END OF SECTION 263600

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SECTION 264100 - FACILITY LIGHTNING PROTECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

1.2 SUMMARY

A. Section includes requirements for providing a complete UL master labeled traditional lightning protection system for ordinary structures.

B. Related Requirements:

1. Refer to Section 260526, “Grounding and Bonding for Electrical Systems” for additional requirements related to grounding electrodes and connections.
2. Refer to Section 264300, “Surge Protection Devices” for additional requirements related to surge suppression.

1.3 REFERENCES

A. Abbreviations

1. LPI: Lightning Protection Institute
2. LPS: Lightning Protection System

B. Definitions

1. Grounding: Establishing a direct or indirect connection to Earth or some conducting body that serves in place of Earth.
2. Bonding: Method by which all non-energized conductive materials are effectively interconnected to create a low impedance path.

C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.

1. National Fire Protection Association (NFPA)
    a. NFPA 780, Standard for the Installation of Lightning Protection Systems
2. Underwriters’ Laboratories (UL)
    a. UL 96, Standard for Lightning Protection Components

1.4 COORDINATION

A. Where the new lightning protection system connects to an existing lightning protection system with or without a UL master label, the new portion of the lightning protection system requires UL inspection and a Letter of Findings.

B. Coordinate system scope and layout requirements, attachment methods, and envelope penetrations with architectural roof plans, elevations, and sections.

1.5 PREINSTALLATION MEETINGS

A. Schedule preconstruction conference with Architect, Owner, and all affected trades. Agenda topics should include, but are not limited to, the following:

1. System Installation Schedule.
2. Planned down conductor routing.
3. Planned building enclosure penetrations.
4. Building material compatibility.
5. Cutting and patching requirements.
6. Surge protection requirements.

1.6 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by qualified professional responsible for their preparation.

1. Include layouts of the lightning protection system, with details of the components to be used in the installation.
2. Include raceway locations needed for the installation of conductors.
3. Details of air terminals, ground rods, ground rings, conductor supports, splices, and terminations, including concealment requirements.
4. Include roof attachment and penetration details, coordinated with roof installation warranty.
5. Calculations required by NFPA 780 for bonding of metal bodies.

C. Delegated Design: For system layout, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by qualified professional responsible for their preparation.

D. Qualification Data: For Installer.

E. Product Certificates: For each type of roof adhesive for attaching the roof-mounted air terminal assemblies, approved by the roofing-material manufacturer.

F. Sample Warranty.

G. Closeout Submittals

1. Operation and Maintenance Data: For lightning protection system to include in maintenance manuals.
2. In addition to items specified in Division 01 and Section 260010 “General Requirements for Electrical Systems” include the following:

a. A system testing and inspection record, listing the results of inspections and ground resistance tests, as recommended by NFPA 780, Annex D.

3. As-Built Data: Dimensioned site plan showing dimensioned route of the grounding electrodes.

H. Completion Certificate:

1. UL Master Label Certificate suitable for fastening to building for display.

1.7 QUALITY ASSURANCE

A. Manufacturer Qualifications: Regularly engaged in manufacturer of lightning protection equipment, of types, sizes and ratings required, whose products have been satisfactorily used in similar service for not less than 5 years. The firm shall be a member of and certified by the Lighting Protection Institute.

B. Installer Qualifications: A firm with at least 3 years of successful installation experience on projects with lightning protection work similar to that required for project.

1. The System Design shall be completed, and the shop drawing stamped by an LPI Certified Master Installer – Designer of Lightning Protection Systems.
2. The installing contractor shall be listed with the Lightning Protection Institute, and Underwriters' Laboratories, Inc.
3. The installation contractor shall have personnel on staff Certified by the LPI as a Master Installer – Designer of lightning protection systems.
4. LPI qualified staff, Journeyman or higher, shall provide on-site supervision of the installation.

1.8 WARRANTY

A. Furnish a 10-year adhesion warranty for all adhesives.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products from one of the following:

1. East Coast Lightning Protection
2. Harger
3. nVent Erico
4. Thompson Lightning Protection
5. VFC/Lyncole

B. Source Limitations: Obtain components through one source from a single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. NFPA Lightning Protection Standard: Comply with NFPA 780 requirements for Class I materials on structures not exceeding 75ft and Class II materials on structures or portions of structures exceeding 75ft.

B. Lightning Protection Components, Devices, and Accessories: Listed and labeled by a qualified testing agency suitable to the Authority Having Jurisdiction as complying with UL 96 and marked for intended location and application.

C. Surge Suppression products for the electrical service entrance and communication services shall comply with NFPA 780 and UL 1449

2.3 MATERIALS

A. Comply with minimum Class I and Class II material requirements as listed in NFPA 780.

B. Air Terminals:

1. Aluminum unless otherwise required due to adjacent materials or existing conditions.
2. Safety tip.
3. Threaded base support: Adhesive type for membrane roof, non-penetrating clamp for standing seam metal roof.

C. Main and Secondary Conductors:

1. Aluminum unless otherwise required due to adjacent materials or existing conditions.
2. Smooth weave cable for Class I materials and Concentric or Ropelay for Class II materials
3. Cable Fastener: Adhesive type for membrane roof, non-penetrating clamp for standing seam metal roof.

D. Underground Conductors: Tinned copper.

E. Ground Rods:

1. Material: Copper-clad steel.
2. Diameter: 3/4 inch.
3. Rods: not less than 120 inches long.

F. Conductor Splices and Connectors for aboveground applications:

1. Suitable configuration and class type for the intended application and of the same material as the conductors or of electrolytically compatible materials

G. Adhesives: High performance, solvent free, UV resistant, for durable bond with substrate. All adhesives must be compatible with the roofing material and approved by the roofing system manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install lightning protection components and systems according to NFPA 780.

B. Install conductors with direct paths from air terminals to ground connections without excessive splices. Maintain a horizontal or downward route along the entire path to ground. Avoid bends less than 90 degrees and 8 inches in radius and narrow loops.

C. Rigidly fasten exposed conductors at intervals not exceeding 3 feet.

D. Conceal conductors within normal view from exterior locations at grade within 200 feet of building. Comply with requirements for concealed systems in NFPA 780.

1. Roof penetrations required for down conductors and connections to structural-steel framework shall be made using listed through-roof fitting and connector assemblies with solid bars and

appropriate roof flashings. Use materials approved by the roofing manufacturer for the purpose. Conform to the methods and materials required at roofing penetrations of the lightning protection components to ensure compatibility with the roofing specifications and warranty.

2. Install conduit where necessary to comply with conductor concealment requirements.
3. Structural elements and design features shall be used whenever possible to minimize the visual impact of exposed conductors.
4. Coordinate sequence of installation with other trades to avoid coring, cutting, and patching.
5. Do not install conductors in gutters, downspouts, or on surfaces where water is retained.

E. Where conductors are exposed to potential damage or environmental hazards at grade level, provide guards to protect the conductors to a point 10 feet above grade. Bond down conductors to guards or conduit at both ends.

F. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.

G. Provide Ground Ring Electrode for structures exceeding 60 feet. The conductor shall not be less than the main-size lightning conductor.

H. Where local conditions such as soil material, earth resistivity, or limited project boundary require the use of other grounding electrode configurations, refer to grounding electrode requirements in Section 260526, “Grounding and Bonding for Electrical Systems”.

I. Provide bonding between the LPS grounding electrode system and the Building grounding electrode system in accordance with NEC and NFPA 780 requirements.

J. Install surge suppression at all power service entrances and at all entrances of conductive communications systems.

K. Provide cutting and patch as necessary for installation of work in existing structures. Refer to Section 260500, “Common Work Results for Electrical Systems”.

3.2 CONNECTIONS

A. All connections to down conductors and connections in earth or concrete: Exothermic weld.

B. Aboveground concealed connections: Exothermic welds or high-compression fittings listed for the purpose.

C. Aboveground exposed connections shall be done using the following types of connectors, listed, and labeled for the purpose: bolted connectors, exothermic weld, high compression, or crimp type.

D. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

E. Follow manufacturer’s temperature and substrate requirements for installation of adhesives.

3.3 CORROSION PROTECTION

A. Coordinate lightning protection materials with building materials to assure compatibility.

B. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

C. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

D. Provide bimetallic connectors and fittings for splicing or bonding dissimilar metals.

E. Do not install aluminum materials in the following locations:

1. Embedded in or in direct contact with concrete, masonry, limestone, plaster, or mortar.
2. On copper surfaces or in locations exposed to direct water run-off from copper surfaces.
3. On a building surface coated with alkaline based paint.
4. In direct contact with earth or within 18-inches of the point where a conductor comes into contact with the earth.

F. Do not install copper materials in the following locations:

1. On aluminum surfaces or on exterior sheet metal surfaces.

3.4 FIELD QUALITY CONTROL

A. Testing: Upon completion of installation of lightning protection system, test resistance-to-ground with resistance tester. Where tests show resistance-to-ground is over 25 ohms, take appropriate action to reduce resistance to 25 ohms, or less, by driving additional ground rods.

B. Engage a third-party inspector to perform inspections required to obtain a UL Master Label for system.

C. Prepare detailed test and inspection reports with corresponding test results and photos.

END OF SECTION 264100

SECTION 264300 - SURGE PROTECTION DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

1.2 SUMMARY

A. Description: The Contractor shall provide the necessary labor, materials, wiring and services necessary to provide the complete electrical surge protection systems as specified herein. This work shall include but is not necessarily limited to provision of Surge Suppression Units at certain points in the power distribution network and proper installation in accordance with manufacturer’s instructions.

B. Section includes:

1. Requirements for both field-mounted SPDs (externally mounted), and integrated SPDs (installed from the factory) for low voltage power distribution and control equipment.

1.3 REFERENCES

A. Abbreviations

1. MCOV: Maximum continuous operating voltage.
2. OCPD: Overcurrent protective device.
3. SCCR: Short-circuit current rating.
4. SPD: Surge protective device.
5. VPR: Voltage protection rating.

B. Definitions

1. Inominal: Nominal discharge current.
2. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.
3. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.
4. Type 1 SPDs: Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service disconnect overcurrent device.
5. Type 2 SPDs: Permanently connected SPDs intended for installation on the load side of the service disconnect overcurrent device, including SPDs located at the branch panel.
6. Type 3 SPDs: Point of utilization SPDs.

C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest date as of the date of the Contract Documents, unless otherwise specified.

1. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

a. ANSI/IEEE C62.41.1, “Guide on the Surges Environment in Low Voltage (1000 V and Less) AC Power Circuits.”

b. ANSI/IEEE C62.41.2, “Recommended Practice on Characterization of Surges in Low Voltage (1000 V and Less) AC Power Circuits.”
c. ANSI/IEEE Standard C62.45, “Guide on Surge Testing for Equipment Connected to Low-Voltage Ac Power Circuits”

2. Underwriters Laboratories, Inc. (UL)

a. UL 1283, “Standard for Safety for Electromagnetic Interference Filters.”
b. UL 1449, “Standard for Surge Protective Devices.”

1.4 SUBMITTALS

A. Product Data: For each type of product.

1. Indicate all capacity ratings, clamp times, maximum capacities, physical characteristics and listing agency approvals.
2. Copy of UL certification, as a minimum, listing the tested values for VPRs, Inominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.
3. Wiring diagram showing all manufacturer installed wiring including wire size, type, routing, and exact length of conductors.

B. Product Schedule: Indicate where each type of SPD is installed.

C. Closeout Submittal

1. Operation and Maintenance Data: For surge protection devices and components to include in emergency, operation, and maintenance manuals.

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to replace or replace SPDs that fail in materials or workmanship within a period of ten years from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB/General Electric Company.
2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
3. Siemens.
4. Square D; a brand of Schneider Electric.

B. Source Limitations: SPDs installed internal to the distribution system shall be of the same manufacturer as the equipment. The equipment shall be fully tested and certified in accordance with UL standards.

2.2 GENERAL SPD REQUIREMENTS

A. SPD with Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.

B. SPDs: Comply with UL 1449

1. Provide Type 1 SPDs installed on the line side of the service entrance OCPD and Type 2 SPDs installed on the load side of the service entrance OCPD.

C. Electrical Noise Filter: Comply with UL 1283 for Type 2 SPDs.

1. Each Type 2 unit shall include a high-performance EMI/RFI noise rejection filter. Noise attenuation for electric line noise shall be up to 50 dB from 10 kHz to 100 MHz

D. Unit Operating Voltage: Refer to drawings.

E. MCOV of the SPD shall not be less than 115% of the nominal system voltage.

F. The suppression system shall incorporate thermally protected MOVs as the core surge suppression component for all distribution levels. Each MOV shall be individually fuse-protected to avoid cascading faults. The thermal protection assembly shall disconnect the MOV(s) from the system in a fail-safe manner should a condition occur, that would cause them to enter a thermal runaway condition.

G. SPDs shall be provided with the following features and accessories:

1. Integral disconnect switch for externally mounted SPDs. SPDs integrated into factory supplied equipment shall have an input disconnect switch or circuit breaker unless indicated on the equipment drawings/data sheets.
2. Internal fusing that disconnects the SPD before damaging internal suppressor components.
3. Indicator light display (Red and Green) for power and protection status with push-to-test capabilities.
4. Audible alarm with silencing switch. Alarm shall activate when any one of the surge current modules has faulted or reached an end-of-life condition.
5. Form-C contacts, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device.
6. Surge counter with LCD display, reset switch, non-volatile memory, and battery backup to retain memory upon loss of AC power.

H. All SPDs shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category C, B, and A environments.

I. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than the following values. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

1. Category C, Service Entrance larger than 1200A: 400 kA/phase.
2. Category C, Service Entrance 1200A and below: 240 kA/phase.
3. Category B, Distribution larger than 1200A: 300 kA/phase.
4. Category B, Distribution 1200A and below: 160 kA/phase.
5. Category B, Branch: 120kA/phase.

J. Protection modes and UL 1449 VPR for grounded wye circuits shall not exceed the following:

1. Line to Neutral: 1200 V for 480Y/277 V and 700 V for 208Y/120 V.
2. Line to Ground: 1200 V for 480Y/277 V and 700 V for 208Y/120 V.
3. Neutral to Ground: 1200 V for 480Y/277V and 700 V for 208Y/120 V.
4. Line to Line: 2000 V for 480Y/277 V and 1200 V for 208Y/120 V.

K. SCCR: The short circuit current rating of the SPD shall be a minimum of 200kA and equal to or greater than the available short circuit current at the point on the system where installed.

L. Minimum Inominal Rating: 20 kA

2.3 SURGE SUPPRESSORS FOR OTHER SYSTEMS

A. Refer to specific specification sections for additional information on surge suppressors related to other building systems.

2.4 ENCLOSURES

A. Enclosure shall meet or exceed the ratings for the environment to be installed as indicated on drawings.
1. Indoor locations: NEMA 250, Type 1.
2. Outdoor or wet locations: NEMA 250, Type 3R.
3. Corrosive Environments: NEMA 250, Type 4X.

2.5 CONDUCTORS AND CABLES

A. Power Wiring: Provide sizes to match SPD leads, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Factory install integral SPDs as part of the distribution equipment and connect through a disconnect.

1. SPDs shall be installed immediately following the load side of the main breaker. SPDs installed in main lug only panelboards shall be installed immediately following the incoming main lugs.

C. Install external SPDs as indicated and in accordance with equipment manufacturer's written instructions, in compliance with applicable requirements of NFPA, local prevailing codes and with UL lightning and power surge protection standards to ensure that surge suppression systems comply with requirements.

1. Comply with manufacturer’s guidelines for physical routing, length limitations, and connections of conductors to ensure proper performance of surge suppression units.

D. Provide a minimum 30A circuit breaker as required to comply with the UL listing of the SPD.

E. Install SPDs with properly rated conductors between suppressor and points of attachment as short and straight as possible with no sharp bends and adjust circuit-breaker positions to achieve shortest and straightest leads.

F. Do not splice and extend SPD leads unless specifically permitted by manufacturer.

G. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.

H. Twist input conductors together to reduce the input inductance.

I. Use crimped connectors and splices only. Wire nuts are not acceptable.

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Compare equipment nameplate data for compliance with Drawings and Specifications.
2. Inspect anchorage, alignment, grounding, and clearances.
3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

B. An SPD will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.3 STARTUP SERVICE

A. Complete startup checks according to manufacturer's written instructions.

B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests and reconnect them immediately after the testing is over.

C. Energize SPDs after power system has been energized, stabilized, and tested.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to operate and maintain SPDs.

END OF SECTION 264300

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SECTION 265000 - LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

1.2 SUMMARY

A. This section is intended to specify in conjunction with the Light Fixture Schedule, the interior and exterior luminaires, supports, accessories, specialties, and related items necessary to complete the work as shown on the drawings.

B. Section Includes:
1. Interior and exterior light fixtures including building mounted
2. Exit signs
3. Emergency lighting units
4. Lamps, ballasts, and drivers
5. Light fixture supports and accessories
6. Light fixture poles and bases

1.3 DESCRIPTION OF WORK

A. This work consists of providing all labor, materials, accessories, mounting hardware and equipment necessary for an operationally and aesthetically complete installation of all luminaires, including power wiring, control wiring and accessories, in accordance with the contract documents.

B. Contractor shall coordinate with Vendors and other trades, in advance of installation work, to define all infrastructure and installation requirements. Contractor shall coordinate all infrastructure requirements with all approved lighting equipment prior to infrastructure installation. This includes, but not limited to, appropriately sized, positioned, and located junction boxes, structural supports, feeds, power conduits and control conduits, and remote code-compliant power-supply enclosures.

C. Contractor shall provide all luminaires, as herein specified, complete with lamps, drivers, power supplies, ballasts, and accessories for safe and effective operation. All fixtures shall be installed and left in an operable condition with no broken, damaged, or soiled parts.

D. Contractor shall coordinate all infrastructure requirements with all approved lighting equipment prior to infrastructure installation, including, but not limited to appropriately sized, positioned and located junction boxes, structural supports, feeds, power and control conduits, and remote code-compliant power-supply enclosures.

E. All luminaires, items, equipment, and parts furnished and specified herein shall bear the “UL Approved” label (or other NRTL label) to indicate compliance with UL requirements. All luminaires shall be manufactured in strict accordance with the appropriate and current requirements of the National Electrical Code as verified by Underwriters Laboratories, Inc. (UL), or tested to UL standards by other nationally recognized testing laboratory (NRTL) as acceptable to Building Officials and Code Administrators

International (BOCAI); the International Conference of Building Officials (ICBO); or other relevant code authority recognized by the local jurisdiction within which the project is being constructed. Such a listing shall be provided for each luminaire type, and the appropriate label or labels shall be affixed to each luminaire in a location as required by code or law. All luminaires shall be UL/NRTL listed and labeled for installation in fireproof or non-fireproof construction, dry, damp, or wet locations, as required.

F. All available finishes and colors, for each luminaire, shall be submitted to the Architect for selection during shop drawing review. Premium finishes, where indicated, shall be provided at no additional cost premium.

G. Specifications and drawings are intended to convey all salient features, functions, and characteristics of the luminaires only, and do not undertake to illustrate or set forth every item or detail necessary for the work. Minor details, not usually indicated on the drawings nor specified, but that are necessary for proper execution and completion of the luminaries, shall be included, the same as if they were herein specified or indicated on the drawings.

H. The Owner, Architect and Engineer shall not be held responsible for the omission or absence of any detail, construction feature, etc. which may be required in the production of the light fixtures. The responsibility of accurately fabricating the light fixtures to the fulfillment of the specification rests with the Contractor.

I. Refer to architectural details, as applicable, for recessed soffit fixtures or wherever fixture installations depend upon work of other trades. Coordinate all installations with other trades. Verify dimensions of spaces for fixtures, and if necessary, adjust lengths to assure proper fit and illumination of diffuser and/or area below.

J. In accordance with the above and the criteria established herein, the Contractor is responsible for assuring the final design, fabrication and installation which fulfills the requirements of the Contract Documents.

1.4 REFERENCES

A. Abbreviations and Acronyms

1. CCT: Correlated color temperature
2. CRI: Color-rendering index
3. CU: Coefficient of utilization
4. IECC: International Energy Conservation Code
5. LER: Luminaire efficacy rating, which is calculated according to NEMA LE 5.
6. NRTL: Nationally Recognized Testing Laboratory
7. SPD: Surge Protective Device
8. RCR: Room cavity ratio.
9. UL: Underwriters Laboratory

B. Definitions

1. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE 100 and IESNA 10th Edition Handbook.
2. Light Fixture (Luminaire): Complete lighting unit consisting of a lamp(s) and driver(s)/ballast(s) (when applicable) together with the parts designed to distribute the light, to position and protect the lamp(s), and to connect the lamps to the power supply.
3. Lumen: Delivered output of luminaire.
4. Color-rendering index (CRI): Measure of the degree of color shift that objects undergo when illuminated by a lamp, compared with those same objects when illuminated by a reference source of comparable correlated color temperature (CCT)
5. Total harmonic distortion (THD): The root mean square (RMS) of all the harmonic components divided by the total fundamental current.
6. Pole: Luminaire support structure, including tower used for large area illumination.

7. Standard: Same definition as "Pole" above.

C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version (including amendments, addenda, revisions, supplements, and errata) as of the date of the Contract Documents, unless otherwise specified.

1. American National Standards Institute (ANSI)
2. American Society for Testing and Materials (ASTM)
3. Certified Ballast Manufacturers Association (CBM): Requirements for Ballast Certification.
4. Federal Communications Commission (FCC)
5. Entertainment Services and Technology Association: ESTA E1.3 - Entertainment Technology - Lighting Control System - 0 to 10V Analog Control Protocol
6. International Electrotechnical Commission (IEC)
7. Illuminating Engineering Society of North America (IESNA)
8. Institute of Electrical and Electronic Engineers (IEEE): C62.41-91 - Recommended Practice on Surge Voltage in Low Voltage AC Power Circuits
9. National Fire Protection Association (NFPA):
   a. NFPA 70 - National Electrical Code (NEC), National Fire Protection Association
   b. NFPA 101 - Life Safety Code, National Fire Protection Association
10. National Electrical Manufacturer's Association (NEMA)
11. OSHA 29CFR1910.7 – Luminaires shall be listed by National Recognized Testing Laboratory Approved by United States Department of Labor.
12. Underwriters Laboratories, Inc. (UL)

1.5 SUBMITTALS

A. Product Data: For each type and model of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:

1. Physical description of lighting fixture including dimensions.
2. Emergency lighting units including battery and charger.
3. All available finishes and colors for each luminaire type shall be submitted to the Architect for selection during review.
4. Life, output (lumens, CCT, and CRI), and energy-efficiency data for light fixtures.
5. Dimensions, effective projected area (EPA), accessories, installation details and construction details.
6. Poles: Include dimensions, materials, wind load determined in accordance with AASHTO, pole deflection, pole class, and other applicable information.
7. Distribution data according to IESNA classification type as defined in IESNA HB-10.
8. Anchor bolts.
9. US DOE LED Lighting Facts Label and IESNA L70 rated life.
10. Amount of shielding on luminaires.
11. Control type: 0-10V, DMX, bi-level, etc.

B. Shop Drawings: Including plans, elevations, sections, details, and attachment to other work.

1. Include detailed equipment assemblies and indicate electrical ratings, dimensions, emergency section, control type, wiring, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.
3. Anchor-bolt templates keyed to specific poles and certified by manufacturer.

C. Pole and Support Component Certification Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements in AASHTO LTS and that load imposed by luminaire

and attachments has been included in design. The certification shall be based on design calculations by a professional engineer.

D. Sample Warranty

E. Closeout Submittals
1. Maintenance Contract
2. Operation and Maintenance Data
3. Warranty Documentation
4. Record Documentation
5. Sustainable Design Closeout Documentation
6. Software

1.6 MAINTENANCE MATERIAL

A. Furnish the following extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing content:
1. Single Sided Exit Sign: One (1) for every fifteen (15) of each type. Furnish at least two (2) of each type.
2. Double Sided Exit Sign: One (1) for every fifteen (15) of each type. Furnish at least one (1) of each type.
3. LED Drivers: One (1) for every fifty (50) of each type and rating installed. Furnish at least five (5) of each type.
4. LED Lamps/Boards: One (1) for every one-hundred (100) of each type and rating installed. Furnish at least two (2) of each type.

1.7 QUALITY ASSURANCE

A. In each of the publications referred to herein, consider the advisory provisions to be mandatory.

B. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 and NEMA, unless more stringent requirements are specified or indicated.

C. Where groups of luminaire types exhibit the same list of acceptable Manufacturers, such as downlights, accents, and wall washers, the intent is to have a final installation with the same Manufacturer's equipment across the groupings as specified for consistency of optics, aesthetics, and similarity of maintenance procedures. Mixing/matching across groups is unacceptable. This also applies to multi-phased projects with single or multiple, but related luminaire types exhibiting the same list of acceptable Manufacturers, except where products have subsequently been discontinued or significantly redesigned in size, appearance, lamping, or gear. Lamps shall be from a single manufacturer and batch.

D. Product procurement and coordination. Contractor shall:
1. Order products according to application and required voltage.
2. Confirm the proper and complete catalog number with distributor and agent.
3. Ensure wiring, driver, etc. meets the specifications and proper requirements.
4. Provide additional parts and pieces required to complete the installation in the location and manner intended by the design.

E. Comply with NFPA 70.

1.8 DELIVERY, STORAGE AND HANDLING:

A. The Contractor shall provide, receive, unload, uncrate, store, protect and install lamps, luminaires, and auxiliary equipment, as specified herein, in accordance with respective manufacturers' project conditions of temperature and humidity and with appropriate protection against dust and dirt. Lamps for miscellaneous equipment shall be provided and installed by the Contractor according to equipment manufacturers' guidelines.

B. All products shall be stored in manufacturer's unopened packaging until ready for installation.

C. Luminaire Poles: Do not store poles on ground. Support poles so they are at least one foot above ground level and growing vegetation. Support poles to prevent distortion and arrange to provide free air circulation. Retain factory-applied pole wrappings on poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

1.9 COORDINATION

A. Coordinate layout and installation of exterior lighting fixtures with all other construction including all underground utilities and geothermal well fields.

B. Coordinate layout and installation of lighting fixtures with all other construction that penetrates ceilings or is supported by them, including HVAC equipment, plumbing, fire-suppression system, and partition assemblies.

1.10 WARRANTIES

A. The equipment items shall be supported by service organizations which are reasonably convenient (less than 100 miles from project site) to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

B. All luminaries, finishes, poles, batteries, supports, accessories and all of its component parts, workmanship, and controls shall have an unconditional ten (10) year on-site replacement warranty. Warranty shall include all light fixtures, lamps, drivers, poles, finishes and all components to be free from defects in materials and workmanship for a period of ten (10) years from date of Owner's acceptance. On-site replacement includes transportation, removal, and installation of new products. Replacement of luminaries, faulty materials, and the cost of labor to make the replacement shall be the responsibility of the Contractor.

C. The Warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under provisions of the Contract Documents and shall be in addition to and run concurrently with other warranties made by the Contractor under requirements of the Contract Documents.

D. LED drivers: The warranty period shall not be less than ten (10) years from the date of substantial completion. The warranty shall state the malfunctioning LED driver shall be exchanged by the manufacturer and promptly installed by the Contractor. The replacement LED driver shall be identical to, or an improvement upon, the original design of the malfunctioning LED driver.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency acceptable to authorities having jurisdiction and marked for intended location and application.

B. Comply with NFPA 70.

2.2 MANUFACTURERS

A. Subject to compliance with requirements, provide one of the products indicated on Light Fixture Schedule. Refer to Light Fixture Schedule for manufacturers and model numbers. Basis of Design for each light fixture type shall be the first fixture manufacturer and model number for each type listed.

B. Manufacturer's catalog numbers together with the descriptions on the drawings and these specifications are indicative of required design, appearance, quality, and performance. Report any discrepancies between any of these to the Engineer for resolution prior to bid. In absence of such notice to the Engineer, provide the greater requirement as directed by the Engineer, without additional cost.

C. All luminaires shall be DLC (Design Lights Consortium) or Energy Star Certified.

2.3 EQUAL MANUFACTURERS

A. Manufacturers listed as "Equal" to the Basis of Design on the light fixture schedule shall submit product cutsheets to the Engineer ten (10) days prior to bid for final written approval. This written approval will only be issued in addendum form. "Equal" fixtures shall be of equal or better quality and performance to the fixture(s) listed with manufacturer's model numbers. Burden of proof shall be on the Contractor, Vendor, and manufacturer.

B. Upon request by Engineer, the Contractor shall submit manufacturer's computerized horizontal illumination levels using AGI32 software in footcandles at workplane (30" above finished floor), taken every 3 feet in every interior room and area. Include average maintained footcandle levels and maximum and minimum ratio.

C. Upon request by Engineer, the Contractor shall submit manufacturer's computerized horizontal illumination levels using AGI32 software in footcandles, taken every ten (10) feet at grade for the entire exterior site. Include average maintained footcandle levels and maximum and minimum ratio.

2.4 GENERAL REQUIREMENTS FOR LUMINAIRES AND COMPONENTS: Comply with the requirements specified in the Articles below and the Light Fixture Schedule:

A. Complete luminaires shall be in accordance with NFPA 70, NEMA, and UL 1598 listed and labeled.

B. Ballasts, drivers, or transformers, unless otherwise specified, shall be field replaceable and shall be serviceable while the fixture is in its normally installed position, and shall not be mounted to removable reflectors or wireway covers unless so specified.

C. Luminaires shall be entirely factory wired by the luminaire manufacturer in accordance with code and UL requirements and shall be furnished fully compatible with the project electrical wiring and controls system for smooth, continuous, dimming or on/off flicker-free operation.

D. Exterior building mounted light fixtures shall be UL classified for damp or wet locations as applicable and shall be complete with gaskets, cast aluminum outlet box and grounding. All dissimilar metal materials shall be separated by non-conductive materials to prevent galvanic action.

E. All luminaires supplied for recessing in suspended ceilings shall be supplied with pre-wired junction boxes, unless otherwise specified.

F. Metal parts: Free of burrs, sharp corners, and sharp edges.

G. Doors, frames, and other internal access: Smooth operating, free of light leakage under operating conditions. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidently during maintenance and when secured during operating position.

H. Mounting Frames and Rings: If ceiling system and luminaire type requires, each recessed and semi-recessed luminaire shall be furnished with a mounting frame or ring compatible with the ceiling in which they are to be installed as coordinated by Contractor. The frames and rings shall be one piece and of sufficient size and strength to sustain the weight of the luminaire and maintain plumb. Luminaires shall be braced such that the force required to close and/or latch lens or door frame does not lift or shift luminaire.

I. Pendant Supports: Contractor shall be responsible for coordination with Manufacturer, Architect, Structural Engineer, and related trades to ensure that proper and adequate structural reinforcement is provided within ceilings to support pendant mounted lighting equipment for a secure, neat, square, plumb appearance. Pendants shall not sag, droop, snake or otherwise appear out of plumb or alignment in finished installation with lamps, globes, lenses, lens frames or doors etc. in place.

J. Wall Bracket (Sconce) Supports: Contractor shall be responsible for coordination with Manufacturer, Architect, Structural Engineer, and related trades to ensure that proper and adequate structural reinforcement is provided within walls to support wall mounted lighting equipment for a secure, neat, square, plumb appearance. Wall brackets shall not sag, droop, snake or otherwise appear out of plumb or alignment in finished installation with lamps, globes, lenses, lens frames or doors etc. in place.

K. All lenses or other light diffusing elements shall be removable for access to lamp and electrical and electronic components and luminaire cleaning, however, they must otherwise be positively and securely held in-place, unless otherwise specified.

L. All lens door or holder trim flanges shall fit plumb and flush with the ceiling or wall surface. There shall be no light leaks around the interface between lens door or holder trim flanges and the ceiling or wall.

M. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility.

N. Recessed luminaires mounted in an insulated ceiling shall be listed for use in insulated ceilings, IC-rated or provisions made to maintain code-compliant 3” airspace around luminaires in accordance with Manufacturers' instructions.

O. Mechanical Safety: Unless otherwise specified, luminaire closures (lens doors, trim frame, hinged housings, etc.) shall be retained in a secure manner by captive screws, chains, captive hinges, or fasteners such that they cannot be accidentally dislodged during normal operation or routine maintenance.

P. Unless otherwise specified, luminaires with louvers or light transmitting panels shall have hinges, latches, and safety catches to facilitate safe, convenient cleaning and re-lamping. Vapor tight luminaires shall have stainless steel pressure clamping devices.

Q. Yokes, brackets, and supplementary supporting members necessary for mounting lighting equipment shall be furnished and installed by the Contractor and approved by the Architect. All materials, accessories, and any other equipment necessary for the complete and proper installation of luminaires, lamps, ballasts/neon transformers included in the contract shall be furnished and installed by the Contractor. All yokes, brackets and supplementary supports shall provide a neat, square, plumb, and level appearance, and shall not sag, droop, snake or otherwise appear out of plumb or alignment in finished installation with all lamps, globes, lenses, lens frames or doors etc. in place.

R. All connections shall be fixed rigid by screws, rivets and/or soldering. Screws and rivets shall not be visible except as necessary for maintenance and/or aesthetic appearance. All connections shall provide a neat, square, plumb, and level appearance, and shall not sag, droop, snake or otherwise appear out of plumb or alignment in finished installation with lamps, globes, lenses, lens frames or doors etc. in place.

S. All sheet metal work shall be free from tool marks and dents and shall have accurate angles bent as sharp as compatible with the gauges of the required metal and the luminaire styling. All intersections and joints shall be formed true and of adequate strength and structural rigidity to prevent any distortion after assembly.

T. For steel and aluminum luminaires, all screws, bolts, nuts and other fastening and latching hardware shall be a cadmium or equivalent plated. For stainless steel luminaires, all hardware shall be stainless steel. For all bronze luminaires, all hardware shall be bronze.

U. Extruded aluminum frames and trims shall be rigid and manufactured from quality aluminum without blemishes in the installed product. Miter cuts shall be accurate; joints shall be flush and without burrs and cut alignment maintained with the luminaire located in its final position.

V. Castings shall exactly replicate the approved pattern(s) and shall be free of sand pits, blemishes, scales, and rust and shall be smoothly finished, excepted as necessary for an authentic historic appearance, and as agreed by Architect. Tolerances shall be provided for any shrinkage in order that the finished castings accurately fit their locations resulting in plumb and level fit and consistently tight-seamed fittings.

W. Outdoor Luminaires: Luminaires shall be suitably gasketed and vented according to manufacturer’s instructions. All dissimilar metal materials shall be separated by non-conductive materials to prevent galvanic action.

X. Luminaires in Hazardous Areas: Luminaires shall be suitable for installation in flammable atmospheres (Class and Group) as defined in NFPA 70 and shall comply with UL 844.

Y. Each light fixture shall be packaged with complete instructions and illustrations on how to install.

Z. Each light fixture box, container, etc. shall be labeled at the factory with the type designation as indicated on the Light Fixture Schedule.

AA. Fixture whips shall be 1/2" flexible, with clamp-on steel fittings at each end, six-foot maximum length, with insulated throat bushings at each end and bonding locknuts. Wiring thru fixture whips shall be #12 AWG, with #12 AWG ground bonded to outlet at source end.

BB. All luminaires that are split-wired shall be provided with a permanently affixed lamacoid warning label on the ballast channel cover indicating two hot circuits present and indicating both normal and emergency power panel and circuit numbers.

CC. Provide factory cut custom stem lengths, as required.

DD. Contractor shall verify ceiling types prior to ordering fixtures and provide fixtures appropriate to the actual condition. This is to include specific type of lay-in ceiling grid.

EE. Exit signs and fixtures that are hatched or where the fixture type contains the suffix "E" for emergency operation, the fixture shall have an integral 90-minute battery inverter if not powered from an emergency generator.

FF. All battery powered fixtures shall have test switches factory installed integral to the reflector. Remote test switches will not be accepted.

2.5 LUMINAIRE REFLECTORS AND TRIMS

A. Alzak cones, reflectors, baffles, and louvers shall be warranted against discoloration.

B. All trims, reflectors and canopies shall fit snugly and securely to the ceiling or wall so that no light leak occurs.

C. Trims shall be self-flanged, unless otherwise specified.

D. For trimless or flangeless luminaires, Contractor shall coordinate with other Trades to achieve a trimless/flangeless installation acceptable to the Architect. Where ceilings are drywall or plaster, this involves Level 5 finishes or as otherwise directed by the Architect. In drywall, plaster, wood, or stone ceilings, special luminaire collars and exacting coordination are required of Contractor.

2.6 LIGHT EMITTING DIODE (LED) ELECTRONIC DRIVERS

A. The electronic drivers shall as a minimum meet the following characteristics:
1. LED drivers shall comply with NEMA SSL 1, NFPA 70, and UL 8750 unless otherwise specified.
2. Drivers remote from luminaires shall be housed in NEMA enclosures so rated for the driver and located in code-compliant, sound-isolated, well-ventilated, and easily accessible areas. Wire shall be sized according to run length and LED Manufacturer’s size and distance-of-run requirements and all in accordance with all code requirements.
3. Driver shall comply with UL 1310 Class 2 requirements for dry and damp locations, NFPA 70 unless specified otherwise. Drives shall be designed for the wattage of the LEDs used in the indicated application. Drivers shall be designed to operate on the voltage system to which they are connected.
4. LED driver shall withstand up to a 1,000-volt surge without impairment of performance as defined by ANSI C62.41 Category A.
5. LED driver shall tolerate ±10 percent supply voltage fluctuation with no adverse effects to driver or LEDs.
6. Drivers for luminaires controlled by dimming devices shall be as specified herein and equipped for dimming and conform to the recommendations of the manufacturer of the associated dimming devices to assure satisfactory operation of the lighting system. Contractor shall coordinate all wiring infrastructure to accommodate final-selected drivers and controls systems for smooth, continuous, and flicker-free operation.
7. Flicker: The flicker shall be less than 5 percent at all frequencies below 1000 Hz and without visible flicker.
8. Provide with short circuit, open circuit, and overload protection.
9. Drivers shall meet or exceed NEMA 410 driver inrush standard.
10. Total Harmonic Distortion shall be less than 20 percent.
11. Power Factor to be greater than 95%
12. Drivers to be reduction of hazardous substances (ROHS) compliant

2.7 LIGHT EMITTING DIODE (LED)

A. The light emitting diodes shall as a minimum meet the following characteristic:
   1. LED lamps shall comply with ANSI C78.1, IESNA LM-79 and IESNA LM-80.
   2. Light emitting diodes shall be tested under IES LM-80 standards.
   3. Color Rendering Index (CRI) shall be 84 (minimum).

2.8 SUSPENDED LUMINAIRES

A. Provide hangers capable of supporting twice the combined weight of fixtures supported by hangers. Provide with swivel hangers to ensure a plumb installation. Hangers shall be cadmium-plated steel with a swivel-ball tapped for the conduit size indicated. Hangers shall allow fixtures to swing within an angle of 45 degrees. Brace pendants 4 feet or longer to limit swinging. Single-unit suspended fixtures shall have twin-stem hangers. Multiple-unit or continuous row fixtures shall have a tubing or stem for wiring at one point and a tubing or rod suspension provided for each unit length of chassis, including one at each end. Rods shall be a minimum 0.18 inch diameter.

B. All suspended luminaires with a weight in excess of 50 pounds shall be fitted with safety cable of sufficient strength and length to meet all UL safety cable load-bearing requirements. Cable shall exhibit a finish (but not painted) compatible with that of the metal finish of the stem/chain/suspension-cable assembly or alternatively finished in black as approved by Architect. Shop drawings shall indicate luminaire weight. Contractor shall coordinate structural support/attachment requirements including independent structure for safety cable attachment with Vendor, Architect, and Structural Engineer and all respective trades. Safety cable shall exhibit sufficient length to wrap tightly and entirely around structural member at least twice before attachment subject to Vendor confirmation of UL requirements and pending Structural Engineer review. Contractor shall provide labor necessary for the stem/chain-assembly-wiring-threading and safety-cable-attachment as instructed by Vendor.

2.9 DOWNLIGHT FIXTURES AND COMPONENTS

A. Downlights shall be listed for thru-branch circuit wiring, recessing in ceilings and damp locations. Where installed in plaster or drywall or other inaccessible ceiling types, they shall be UL listed for bottom access.

B. Provide with tool-less hinged junction box access cover and thermal protection accessible from below through reflector opening.

C. Provide telescoping channel bar hangers that adjust vertically and horizontally.

2.10 EXIT SIGNS

A. General requirements: Comply with UL 924, NFPA 70, AND NFPA 101.

B. Provide single or double face as scheduled, indicated on plans or as required by the local Authority Having Jurisdiction. Adjust installation position if required for clear visibility, in accordance with applicable codes.

C. Provide directional arrows (chevrons) as indicated on floor plans and to suit the means of egress or as required by the local Authority Having Jurisdiction.

D. Where emergency backup battery packs are provided with exit lights, they shall have capacities for continuous operation per applicable codes.

E. Complete unit to be furnished in color/finish as selected by the Architect.

2.11 EMERGENCY LIGHTING UNITS

A. General Requirements for Emergency Lighting Units: Self-contained units complying with UL 924.
   1. Provide a minimum of 90 minutes of batter back-up.
   2. Battery: Sealed, maintenance-free, lead-acid type, UON.
   3. Charger: Fully automatic, solid-state type with sealed transfer relay.
   4. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
   5. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
   6. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
   7. Wire Guard: Heavy-chrome-plated wire guard protects lamp heads or fixtures. Install wire guards in gymnasiums.
   8. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.12 LUMINAIRE SUPPORT HANGERS AND COMPONENTS

A. Wires: ASTM A641/A641M, Class 3, soft temper, galvanized regular coating, 0.1055 inches in diameter (12 gage).

B. Straps: Galvanized steel, one by 3/16 inch, conforming to ASTM A653/A653M, with a light commercial zinc coating or ASTM A1008/A1008M with an electrodeposited zinc coating conforming to ASTM B633, Type RS.

C. Rod Hangers: Threaded steel rods, 3/16 inch diameter, zinc or cadmium coated.

2.13 GENERAL REQUIREMENTS FOR POLES AND SUPPORT COMPONENTS

A. Provide poles designed for site specific wind loading (minimum of 120 miles per hour) determined in accordance with AASHTO LTS while supporting luminaires and all other appurtenances indicated. The effective projected areas of luminaires and appurtenances used in calculations shall be specific for the actual products provided on each pole. Poles shall be anchor-base type designed for use with underground supply conductors. Poles shall have full base metal covers with matching finish to conceal the mounting hardware, pole-base welds, and anchor bolts.

B. Structural Characteristics: Comply with AASHTO LTS
   1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in "Structural Analysis Criteria for Pole Selection" Article.
   2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.3 to obtain the equivalent projected area to be used in pole selection strength analysis.

C. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners, unless otherwise indicated.

D. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.
   1. Materials: Shall not cause galvanic action at contact points.

2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot dip galvanized after fabrication unless otherwise indicated.
3. Anchor-Bolt Template: Plywood or steel.

E. Handhole: Oval-shaped, with minimum clear opening of 2-1/2 by 5 inches, with cover secured by stainless-steel captive screws.

F. Pole Base Concrete Foundations:
1. Cast in place, with anchor bolts to match pole-base flange. Anchor bolts shall be steel rod having minimum yield strength of 50,000 psi and shall be galvanized in accordance with ASTM A153/A153M. Concrete shall be as specified in Division 03 Specification Section, CAST-IN-PLACE CONCRETE.
2. Use 3000-psi, 28-day compressive-strength concrete unless otherwise noted. Comply with Division 03 Section "Cast-in-Place Concrete" and ACI standards for subbase requirements, concrete materials, reinforcement, placement, and cover requirements.

G. Breakaway Supports: Provide frangible breakaway supports where noted on plans, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS.

H. Brackets and Supports
1. ANSI C136.3, ANSI C136.13, and ANSI C136.21, as applicable. Pole brackets shall be not less than 1-1/4 inch secured to pole. Slip-fitter or pipe-threaded brackets may be used, but brackets shall be coordinated to luminaires provided, and brackets for use with one type of luminaire shall be identical. Brackets for pole-mounted streetlights shall correctly position luminaire no lower than mounting height indicated. Mount brackets not less than 24 feet above street. Special mountings or brackets shall be as indicated and shall be of metal which will not promote galvanic reaction with luminaire head. Detachable, cantilever, without underbrace.

I. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported cable times a 5.0 safety factor.

J. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole. Provide a pole grounding connection designed to prevent electrolysis when used with copper ground wire.

K. Finish: Same as luminaire.

2.14 FUSING

A. All luminaires shall be provided with fuse(s) and in-line fuse holder(s) sized per manufacturer’s recommendation.

B. Fuse pole mounted luminaires at handhole.

2.15 POLE ACCESSORIES

A. Duplex Receptacle: Where indicated or plans, provide 120 V, 20 A receptacle in a weatherproof assembly complying with Division 26 Section "Wiring Devices" for a weather resistant, ground-fault circuit-interrupter type. Recessed, 12 inches above pole base. Weatherproof, metal, in-use cover, color to match pole, that when mounted results in NEMA 250, Type 4X enclosure with cord opening and lockable hasp and latch that complies with OSHA lockout and tag-out requirements.

1. Minimum 1800-W transformer, protected by replaceable fuses, mounted behind access cover for poles supplied by voltage other than 120 V.

B. Base Covers: Provide Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.

2.16 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

A. Comply with UL 773 or UL 773A.

B. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc (16 to 32 lx) and off at 4.5 to 10 fc (48 to 108 lx) with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.

1. Relay with locking-type receptacle shall comply with ANSI C136.10.
2. Adjustable window slide for adjusting on-off set points.

2.17 FACTORY APPLIED FINISH

A. Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Architect’s reflected ceiling plan (RCP) indicates actual locations of all light fixtures, diffusers, and system devices. Report to the Architect/Engineer any conflicts. Do not scale plans for exact location of lighting fixtures.

B. Install luminaires in accordance with luminaire manufacturer’s written instructions, applicable requirements of NEC, NECA’s “Standard of Installation”, and NEMA standards.

C. Electrical installations shall conform to and meet IEEE C2, NFPA 70, and to the requirements specified herein.

D. Installed luminaires shall be provided with protective covering by Contractor until such time as the space(s) is cleaned and ready for occupancy.

E. Align, mount and level the luminaires uniformly. All luminaires shall be installed plumb/true and level as viewed from all directions. Luminaires shall remain plumb and true without continual adjustment.

F. Set luminaires plumb, square, and level with ceiling and walls, in alignment with adjacent lighting fixtures, and secure in accordance with manufacturers' directions and approved drawings. Obtain approval of the exact mounting for lighting fixtures on the job before commencing installation and, where applicable, after coordinating with the type, style, and pattern of the ceiling being installed.

G. Recessed, semi-recessed and surface fixtures shall be independently supported from the buildings structure. Do not support any luminaire from ceiling grid or ceiling. Ceiling grid clips are not allowed as an alternative to independently supported light fixtures. Round fixtures or fixtures smaller in size than the ceiling grid

shall be independently supported from the building structure by a minimum of four wires per fixture spaced approximately equidistant around the fixture. Do not support fixtures by ceiling acoustical panels.

H. Support lay-in ceiling light fixtures, as follows:
1. Lighting fixtures installed in suspended ceilings shall also comply with the requirements of Division 09 Specification Sections GYPSUM BOARD, ACOUSTICAL PANEL CEILINGS and SUSPENDED DECORATIVE WOOD GRIDS.
2. Support fixtures with four (4) wires with one (1) at each corner. Hanger wires shall be installed within 15 degrees of plumb or additional support shall be provided. Wires shall be attached to fixture body and to the building structure (not to the supports of other work or equipment).
3. Where building structure is located such that 15 degrees cannot be maintained, the Contractor shall provide “Uni-strut” or similar structure to meet this requirement.
4. Support Clips: Provide four (4) clips per fixture minimum. Fasten to light fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application. Contractor shall install clips per manufacturer’s requirements. If screws are required, they shall be provided. Installation shall meet applicable seismic codes.
5. Where fixtures of sizes less than the ceiling grid are indicated to be centered in the acoustical panel, support such fixtures independently and provide at least two 3/4-inch metal channels spanning, and secured to, the ceiling tees for centering and aligning the fixture.

I. Lighting Fixture Supports:
1. Shall maintain the fixture positions after cleaning and re-lamping.
2. For installation in suspended ceilings, ensure that the luminaires are supported such that there is no resultant bowing or deflection of the ceiling system.

J. Downlights, exit signs and battery pack supported by or attached to ceiling grid or tile shall be provided with one hanger wire at each end. Provide a minimum of two, located at opposite corners. Hanger wires shall be installed within 15º of plumb, maximum, or additional support shall be provided. Wires shall be attached to the fixture body and to the building structure and not to the supports of other work or equipment.

K. Luminaires installed and used for working light during construction shall be replaced prior to turnover to the Owner if more than 3 percent of their rated life has been used. Fixtures shall be tested for proper operation prior to turn-over and shall be replaced, if necessary, with new lamps from the original manufacturer.

L. Suspended fixtures shall hang plumb and shall be located with no obstructions within the 45 degree range in all directions. The stem, cable, canopy and fixture shall be capable of 45 degree swing. Suspended fixtures in continuous rows shall have internal wireway systems for end to end wiring and shall be properly aligned to provide a straight and continuous row without bends, gaps, light leaks, or filler pieces. Aligning splines shall be used on extruded aluminum fixtures to assure hairline joints. Steel fixtures shall be supported to prevent "oil-canning" effects. Fixture finishes shall be free of scratches, nicks, dents, and warps, and shall match the color and gloss specified. Pendants shall be finished to match fixtures. Aircraft cable shall be stainless steel. Canopies shall be finished to match the ceiling and shall be low profile unless otherwise shown.

M. Whenever a luminaire or its hanger canopy is installed directly to a surface mounted junction box, a finishing ring painted to match the ceiling, shall be used to conceal the junction box.

N. Rigidly align continuous rows of light fixtures for true in-line appearance.

O. Exit Signs and Emergency Lighting Units: Wire exit signs ahead of the switch to the un-switched branch circuit located in the same room or area. Connect to emergency life safety branch circuit where applicable.

P. Where emergency battery packs are provided with fixtures (if any), they shall be connected to an un-switched power line and wired in accordance with applicable codes and the manufacturer's recommendations.

Q. Light fixture whips shall be supported from the building structure. Do not clip to lay-in ceiling support wires.

R. Exterior Fixtures:
1. Exterior building mounted light fixtures shall not be installed until after the building exterior has been rinsed clean of any corrosive cleaning materials. Damaged fixtures shall be replaced by the Contractor at no cost.
2. Provide exterior rated weatherproof junction boxes for all fixtures and splices.
3. Utilize weatherproof silicone filled wire nuts and seal all junction boxes and conduit with potting compound to create waterproof barriers. Inspect all splices and fixtures for continuity prior to potting.
4. Lubricate all threaded parts with a high temperature waterproof anti-seize lubricant to prevent seizing and corrosion.
5. All low-voltage wiring to be UV resistant, UL approved for use without conduit, stranded low-voltage wire (Q-Wire by Q-Tran or equal) for use in outdoor and underground applications, gauge as appropriate to avoid voltage drop.

S. Transformers (applies to all transformers including (but not limited to) low voltage, neon, remote ballast, LED power supplies, exterior locations):
1. Electrical Contractor to locate all transformers (including low voltage, neon, remote ballasts, led power supplies, etc.) near fixtures in a well-ventilated and accessible location. Transformers must be installed (per codes) in accessible areas large enough to dissipate the heat of the transformer. Temperatures should not exceed 100°F (38°C) or that required by manufacturer if more stringent.
2. Electrical Contractor to determine wire size according to load and wire length to eliminate voltage drop. If voltage drop is a problem after installation, the Electrical Contractor is responsible for reinstallation (at no additional cost) of transformer and wire to solve problem.
3. Electrical Contractor to label front of transformer/driver. Example: “Large Display Case @ Entry to Main Dining Room.”

T. Light fixture locations in mechanical and electrical equipment rooms/areas are approximate. Locate light fixtures to avoid equipment, ductwork, and piping. Locate around and between equipment to maximize the available light. Coordinate mounting heights and locations of light fixtures to clear equipment. Request a meeting with the Engineer if uncertain about an installation.

U. Contractor shall be responsible for sealing all luminaires for wet and damp locations (i.e., all knockouts, all pipe and wire entrances, etc.) to prevent water wicking.

V. Coordinate between the electrical and ceiling trades to ascertain that approved luminaires are furnished in the proper sizes, with the proper flange details, and installed with the proper devices (hangers, clips, trim frames, flanges), to match the ceiling system being installed.

W. All reflecting surfaces, glass or plastic lenses, ballast housings, parabolic louvers, downlighting alzak cones and specular reflectors and other decorative elements shall be installed after completion of ceiling tile installation, plastering, painting and general cleanup.

X. Handle all reflecting surfaces, glass or plastic lenses, ballast housings, parabolic louvers, downlighting alzak cones and specular reflectors and other decorative elements with care during installation or lamping to avoid fingerprints or dirt deposits.

Y. Wall-mounted light fixtures shall not be attached directly to gypsum board. Mount to studs in wall or 20-guage minimum metal backing plate attached to studs.

3.2 POLE, LIGHT COLUMN AND BOLLARD INSTALLATION

A. Alignment: Align foundations, poles light columns and bollards for optimum directional alignment of luminaires and their mounting provisions on the pole.

B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on Drawings:
1. Fire Hydrants and Storm Drainage Piping: 60 inches
2. Water, Gas, Electric, Communication, and Sewer Lines: 10 feet
3. Trees: 15 feet from tree trunk.

C. Excavation: Restrict excavation in size to that which will provide sufficient working space for installation of concrete forms. Should soil conditions at the bottom of the excavation be unsuitable as a foundation, as determined by the Architect, take the excavation down to firm soil and fill to required grade with concrete or satisfactory soil materials as directed.

D. Backfill: Thoroughly compact backfill with compacting arranged to prevent pressure between conductor, jacket, or sheath and the end of conduit ell.

E. Concrete Pole Foundations:
1. Concrete materials, installation, and finishing requirements are specified in Division 03 Section "Cast-in-Place Concrete."
2. Concrete Pole Foundations shall be cast-in-place concrete, having 3000 psi minimum 28-day compressive strength.
3. Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer.
4. Formwork: Construct forms of wood, plywood, steel, or other acceptable materials fabricated to conform to the configuration, line, and grade required. Reinforce formwork to prevent deformation while concrete is being placed and consolidated. Wet or coat formwork with a parting agent before placing concrete.
5. Cast conduit into concrete pole foundations.
6. Prior to concrete pour, install a ground rod and a separate insulated equipment grounding conductor at each pole, light column, and bollard in addition to grounding conductor installed with branch-circuit conductors.
7. Finish by troweling and rubbing smooth. Round all above-grade concrete edges to approximately 0.25” radius.
8. Refer to Pole Base Detail on drawings for additional requirements.

F. Foundation-Mounted Poles:
1. Install according to pole manufacturer's instructions using a template supplied by pole manufacturer in accordance with the lighting standard manufacturer's recommendations.
2. Use galvanized steel anchor bolts, threaded at the top end, and bent 90 degrees at the bottom end, and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
3. Grout void between pole base and foundation. Use non-shrink or expanding concrete grout firmly packed to fill space.
4. Mount pole with leveling nuts and tighten top nuts to torque level recommended by pole manufacturer. Provide base covers.

G. Embedded Poles with Tamped Earth Backfill: Set poles to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.
1. Dig holes large enough to permit use of tampers in the full depth of hole.
2. Backfill in 6-inch layers and thoroughly tamp each layer so compaction of backfill is equal to or greater than that of undisturbed earth.

H. Embedded Poles with Concrete Backfill: Set poles in augured holes to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.

1. Make holes 6 inches in diameter larger than pole diameter.
2. Fill augured hole around pole with air-entrained concrete having a minimum compressive strength of 3000 psi at 28 days, and finish in a dome above finished grade.
3. Use a short piece of 1/2-inch diameter pipe to make a drain hole through concrete dome. Arrange to drain condensation from interior of pole.
4. Cure concrete a minimum of 72 hours before performing work on pole.

I. Poles and Pole Foundations Set in Concrete Paved Areas (Slabs): Install poles with minimum of 6-inch wide, unpaved gap between the pole or pole foundation and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch below top of concrete slab.

J. Raise and set poles using web fabric slings (not chain or cable). Adjust poles as necessary to provide a permanent vertical position with the bracket arm in proper position for luminaire location. Alterations to poles after fabrication will void manufacturer's warranty and shall not be allowed.

K. Bollard and light column luminaire installation:
1. Install on concrete base with top level with finished grade or surface at luminaire location. Shape base to match shape and diameter of bollard and/or light column base.

3.3 GROUND-MOUNTING LUMINAIRE INSTALLATION

A. Align units for optimum directional alignment of light distribution.

B. Install on concrete base with top 4 inches above finished grade or surface at luminaire location.

3.4 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

3.5 GROUNDING

A. Bond luminaires and metal accessories to the grounding system per NEC.

B. Ground noncurrent-carrying parts of equipment including metal poles, luminaires, mounting arms, brackets, and metallic enclosures. Where copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.

C. At each light pole, light column, light bollard, and support structures, provide a driven ground rod into the earth so that after the installation is complete, the top of the ground rod will be approximately 1 foot below finished grade. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.
1. Ground Rods: 10 mil pure electrolytic copper coating with molecular bond to high strength steel core; 3/4 inch by 10 feet with chamfered end. Ensure ground rods are die-stamped near the top with the name and trademark of the manufacturer and the length in feet.

3.6 IDENTIFICATION

A. Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Division 26 Section “Identification for Electrical Systems.”

B. Light fixtures served from multiple power sources, such as emergency fixtures fed from emergency transfer relay, shall have the following label affixed to it: “DANGER - ELECTRICAL SHOCK HAZARD - LIGHT FIXTURE HAS MULTIPLE POWER SOURCES”

C. Manufacturer's Nameplate: Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

D. Factory-Applied Labels: Provide labeled luminaires in accordance with UL 1598 requirements. All light fixtures shall be clearly marked for operation of specific LED’s and drivers according to proper type. The following characteristics shall be noted in the format "Use Only _____":
1. LED or lamp type, and nominal wattage
2. Driver or ballast type
3. Correlated color temperature (CCT) and color rendering index (CRI)
4. All markings related to lamp type shall be clear and located to be readily visible to service personnel, but unseen from normal viewing angles when lamps are in place. Drivers and ballasts shall have clear markings indicating multi-level outputs and indicate proper terminals for the various outputs.

3.7 FIELD QUALITY CONTROL:

A. The lighting and lighting controls systems shall be synchronized and fully operable to address the lighting operation in a complete and code-compliant manner.

B. Upon completion of installation, verify that equipment is properly installed, connected, and adjusted. Conduct an operating test to show that equipment operates in accordance with requirements of this section. Replace defective light fixtures, controls, lamps, ballasts, and drivers at no cost to Owner.

C. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal and emergency power sources.

D. Illumination Tests:
1. Measure light intensities at night. Use certified photometers with calibration referenced to NIST standards. Record footcandle results and furnish to the Engineer. Comply with the following IESNA testing guide(s):
   a. IESNA LM-5, “Photometric Measurements of Area and Sports Lighting Installations.”
   b. IESNA LM-50, “Photometric Measurements of Roadway Lighting Installations.”
   c. IESNA LM-52, “Photometric Measurements of Roadway Sign Installations.”
   d. IESNA LM-64, “Photometric Measurements of Parking Areas.”
   e. IESNA LM-72, “Directional Positioning of Photometric Data.”

E. Dimming Drivers. Test for full range of dimming capability. Observe for visually detectable flicker over full dimming range. Replace defective light fixtures, controls, lamps, ballasts, and drivers at no cost to Owner.

F. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal. Replace defective light fixtures at no cost to Owner.

G. Inspect each light fixture for damage. Replace damaged light fixtures at no cost to the Owner.

H. Fixtures showing dirt, dust or fingerprints shall be restored to like new condition or shall be replaced at no cost.

3.8 CLEANING

A. At completion of each phase and the time of final acceptance by the Owner, all lighting fixtures shall have been thoroughly cleaned with materials and methods recommended by the manufacturer.

B. All fingerprints, dirt, tar, smudges, drywall mud and dust, etc. shall be removed by the Contractor from the luminaire bodies, reflectors, trims, and lens/louvers prior to final acceptance. Cleaned with solvent recommended by the manufacturer to a like-new condition or replaced. All reflectors shall be free of paint other than factory-applied, if any.

3.9 CLOSEOUT ACTIVITIES

A. Submit operation and maintenance data in accordance with Division 01 Specification Section SUBMITTALS and OPERATION AND MAITENANCE, IECC and as specified herein, showing all light fixtures, control devices and all interconnecting control wire, conduit, and associated hardware.

B. Contractor shall be responsible for obtaining from his supplying light fixture manufacturers, for each type of light fixture, a recommended maintenance manual including, tools required, types of cleaners to be used and replacement parts identification list.

C. Provide at least three (3) CDs/DVDs with high resolution PDF files of all equipment product data for Owner's use in equipment identification and maintenance with recommended maintenance manuals including, at a minimum:
1. Vendor and local representative's contact information
2. Tools required
3. Types of cleaners to be used
4. Replacement parts identification lists
5. Equipment product data (high-quality reproducible copies)
6. Warranty documentation

3.10 ADJUSTING

A. All adjustable luminaires shall be aimed, focused, locked, etc., by the Contractor under the observation of the Architect and Engineer. As aiming and adjusting is completed, locking setscrews and bolts and nuts shall be tightened securely by the Contractor. All aiming and adjusting shall be performed after the entire installation is complete for each phase or area. The Contractor shall be responsible for notifying the Architect of appropriate time for final luminaire adjustment. Where possible, units shall be focused during the normal working day. However, where daylight interferes with seeing lighting effects, aiming shall be accomplished at night at no premium cost.

B. All ladders, scaffolds, lifts, gloves, cleaning cloths, access/adjustment tools, etc. required for aiming and adjusting luminaires shall be furnished by the Contractor.

C. Occupancy Adjustments: When requested within 12 months of date of Completion, provide on-site assistance in adjusting aimable luminaires to suit actual occupied conditions. Provide up to two (2) visits to Project during other-than-normal occupancy hours for this purpose. Some of this work may be required after dark.
1. Adjust aimable luminaires in the presence of Architect/Engineer.

END OF SECTION 265000

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SECTION 270001 - TECHNOLOGY INSTALLATION GUIDELINES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. The Contractor shall provide the required protection in accordance with the requirements of these specifications and NEC Refer to Current Release Available, Article 800. The protection shall be provided on both ends of all inter-building cables where required by code or otherwise indicated in the contract documents (i.e., building-to-building, building-to-modular classroom, or building-to-modular complex).

1.2 SUMMARY

A. This Section includes a Telecommunications Distribution System which is ready for the installation of active electronic equipment such as hubs, routers, bridges, switches, repeaters, adapters, etc. The system shall incorporate all requirements of this specification.

1.3 PRELIMINARY MEETING

A. An initial planning meeting will be held with the Contractor to clarify all requirements (systems, services, distribution methods, etc.), identify responsibilities, and schedule the events that will transpire during the implementation of the project. This meeting should be held within ninety (90) days of the NTP (Notice to Proceed).

B. Contractor shall prepare and provide two (2) copies of the following documentation for review and approval by WCPSS Technology Department.

1. MDF and FDE Diagrams - Include cable routing, position of all components and apparatus, detailed layout of the wall field, and a labeled cable plant drawing.
2. Work Area Floor Plans - Include detailed cable routes and labeling plan for all work areas. The Contractor may obtain floor plans from the Architect in AutoCAD format, if so desired, to aid in preparing the submittal.
3. Schedule Documentation - Provide cross-connect records for all voice and data devices. (See Attachments 27 00 00 “A through D”)
4. Backbone Distribution Plan
5. Schedule of work: See Construction Schedules and Reports Section
6. The Contractor shall provide a list of its project management staff and technical support staff to be assigned to this project together with their resumes and working experience.

C. Upon completion of the project, the Contractor shall prepare "As-Built” documentation showing actual site conditions and installation as constructed and provide copies of such documentation as per paragraph 1.3 for inspection purposes by WCPSS Technology Department. This will include a record of field test results and copies of the schedules for each IDF electronically in .dwg and .pdf file format. All test results must be subdivided, by TCOs. Test results must be in cable ID sequence.

1. The Technology Department must receive the documentation needed for the acceptance inspection thirty (30) days prior to substantial completion to ensure the network wiring system is functional at substantial completion.
2. As built cable ID numbers should be color-coded as follows:
   a. Blue for data

b. Orange for fiber

3. The cable numbers on the “As-builts” should also be color coded as noted above.

D. In addition to the engineering diagrams, the following items shall be provided by the Contractor at substantial completion after the wiring system has been inspected and accepted by WCPSS Technology Department:

1. Laminated cable schedules sized eight and one-half inch (8-1/2“) by eleven inches (11”), to be hung in the appropriate rooms in an approved manner (see Attachments 27 00 00 “A through D”). Cable schedules should also be submitted electronically in .dwg and .pdf file formats.
2. One size “E” laminated drawing of “As-Builts” and one “E” size laminated drawing of riser diagrams and outlet schedules shall be attached to the wall with approved fasteners in the MDF. Color key, copper data cabling blue, and fiber optic data cabling orange. Highlight, in some manner, the MDF/IDF/FDE rooms. Drawings shall also be submitted electronically in .dwg and .pdf file format.

E. Technical Support Staff and Experience

1. The Contractor shall utilize certified cable installers and technicians with approved vendor specific certification. The Contractor shall supply certification documentation for cable installers.
2. The Contractor shall state their nearest branch office and dealer's office in relation to the proposed site of the cabling system. If none, the location of the main office shall be stated.
3. The Contractor shall state their nearest location of their principal support center. This center shall have permanently stationed support staff that is capable of providing technical support, if required.

F. System Warranty

1. The Contractor shall provide a five (5) year warranty for both products and labor and also provide a fifteen (15) year manufacturers’ warranty on all parts installed.
2. Service must be provided within twenty-four (24) hours of notification for emergency situations and within seventy-two (72) hours for routine service.

1.4 PRODUCT SUBMITTALS

A. General: Submit the following according to Conditions of the Contract and Division 1 Specification Sections.

1. Product data for system components to WCPSS Technology Department for verification of compliance to specifications.

1.5 QUALITY ASSURANCE

A. Comply as applicable with ANSI/TIA/EIA-568-B.1, ANSI/TIA/EIA-568-B.2, and ANSI/TIA/EIA-568-B.3 "Commercial Building Telecommunications Cabling Standard," Refer to Current Release Available.

B. Comply as applicable with ANSI/TIA/EIA-569-A, "Commercial Building Standards for Telecommunications Pathways and Spaces," Refer to Current Release Available.

C. Comply as applicable with ANSI/TIA/EIA-606, "The Administration Standard for Telecommunications Infrastructure of Commercial Buildings," Refer to Current Release Available.

D. Comply as applicable with J-STD-607, "Commercial Building Grounding (Earthing) and

Bonding Requirements for Telecommunications," Refer to Current Release Available

E. Comply with NFPA 70, "National Electrical Code," Refer to Current Release Available.

F. "Nationally Recognized Testing Laboratory" (NRTL) Listing: Provide materials that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in the "National Electrical Code," Article 100.
2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.
3. FCC Regulations: Comply with FCC Part 68, Chapter 1, "US Code of Federal Regulations," Title 47 for all telephone system wire and cable connection components.

PART 2 - PRODUCTS

2.1 HORIZONTAL CABLE: Contractor shall provide all horizontal cables.

A. COPPER (Cat6) CABLE

1. All cables shall conform to or exceed the ANSI TIA/EIA-568-B.2 “Commercial Building Telecommunications Cabling Standard” - Part 2: Balanced Twisted Pair Cabling Components.
2. Other standards supported include IEEE 802.3, 1,000 BASE-T, 100 BASETX and ANSI X3T9.5 TP- PMD requirements for UTP at 250 MHz.
3. Cables shall be capable of supporting evolving high-end applications such as 155 Mbps ATM. All cables shall be composed of 4-pair 24 AWG solid copper conductors.
4. The cable shall be Underwriter’s Laboratories Inc. (UL) and/or (ETL) listed type CMR and CMP.

B. FIBER OPTIC CABLE

1. All cables shall conform to or exceed the TIA/EIA-568-B.3 Commercial Building Telecommunications Cabling Standard - Part 3: Optical Fiber Cabling Components Standard.
2. The Single-mode fiber shall comply with ANSI/TIA/EIA-492CAAA-1998, Detail Specification for Class IVa Dispersion-Unshifted Single-mode optical fibers.
3. Each fiber shall be tight buffered with color-coded PVC.
4. The fiber cable shall meet the NEC requirements for OFN, OFNR or OFNP and comply with Bellcore, FDDI, TIA/EIA-568-B.3 and ICEA standards.
5. Connectors shall be crimp-on type, pre-polished SC connectors or hot melt with a maximum loss of 3.0dB.

2.2 TELECOMMUNICATIONS OUTLET (TCO)

A. COPPER (Cat6) CABLE

1. Shall be modular, RJ45 type/8-position/8 conductor.
2. Shall be universal application/multi-vendor supportive accepting most phone and data plugs.
3. Modular connectors shall be flush with outlet faceplate.
4. Cover shall be “office-white” (or approved equivalent) in color and must contain a covered label id window slot on the faceplate.
5. For wall telephone units, provide straight in type connection and include provision for support of unit.
6. All cables shall be routed and supported around the exterior walls of the room in a consistent pattern, with all break-outs being 90-degree angled turns without any corners being cut.
7. Outlets shall be wired in a TIA/EIA-568B configuration.

a. All outlets shall utilize cross-over lead technology to address data circuit applications up to 500

MHz and conform to or exceed the TIA/EIA-568-B.2 Commercial Building Telecommunications Cabling Standard and the following:

i. Electrical specifications:

a) TIA/EIA Category (Cat6).
b) Data Rate: Compatible with 1000 Mbps Institute of Electrical and Electronics Engineers Inc, (IEEE) 802.3, 10BASE-T applications. Fully supports 1000 Mbps TP-PMD at 328-ft (100m) over UTP per ANSI X3T9.5.
c) Insulation resistance: 500-M□ minimum.
d) Dielectric withstands voltage 1,000 VAC RMS, 60 Hz minimum, contact-to-contact and 1,500 VAC RMS, 60 Hz minimum to exposed conductive surface.
e) Contact resistance: 20 m□ maximum.
f) Current rating: 1.5 A at 68□ F (20□C) per IEC Publication 512-3, Test 5b.
g) UL or ETL certified/tested and must be stamped on the outer sheathing of the cable along with being listed on the submittal specification sheets.
h) CSA Certified.
i) Comply with FCC Part 68.
j) All copper and fiber cables must be manufactured in the United States of America.

ii. Mechanical Performance:
a) Plug Insertion Life: 750 insertions.
b) Contact Force: 3.5-oz (99.2 g) minimum using FCC-approved modular plug.
c) Plug Retention Force: 30-LB (133 N) minimum between modular plug and jack.
d) Temperature Range: -40□ to 150□F (-40□ to 66□C).

2.3 PATCH PANEL

A. CATEGORY COPPER (Cat6)

1. The panel shall support the Cat6 applications and facilitate cross-connection and inter-connection using patch cords.
2. The patch panels shall be fire-retardant, molded plastic consisting of horizontal index strips for terminating conductors. These index strips shall be marked with four colors on the high teeth, separating the tip and ring of each pair, to establish pair location.
3. The panel shall be able to accommodate over five hundred (500) repeated insertions without incurring permanent deformation and it shall pass the reliability test of no more than one (1) contact failure in ten thousand (10,000) connections.
4. Nineteen-inch (19") rack mountable patch panels shall be used. Patch panel installations shall contain a retaining trough between every one hundred (100) pair termination block.
5. The panel shall be able to accommodate 24 AWG cable conductors.
6. The panel shall be Underwriter's Laboratories Inc. (UL) listed.
7. Shall be wired in a TIA/EIA 568B configuration.
8. Separate labeled patch panels shall be installed for each different type of cable installed in each floor rack in all Technology Closets. This refers to all Data Station Cables, Wireless Access Point Cables, and IP Security Camera Cables. Each Panel shall be labeled per current guidelines for the type of cabling terminated on that panel.

2.4 110 COPPER PATCH PANELS TO-T568B JACK (VOICE ONLY)

A. COPPER (Cat6) CABLE

1. The patch panel shall support the Cat6 applications and facilitate cross-connection and inter-connection using patch cords.
2. The patch panels shall be fire-retardant, molded plastic consisting of horizontal index strips for terminating twenty-five (25) or fifty (50) pairs of conductors each. These index strips shall be marked with four (4) colors on the high teeth, separating the tip and ring of each pair, to establish pair location.

3. The patch panels shall be able to accommodate over five hundred (500) repeated insertions without incurring permanent deformation and it shall pass the reliability test of no more than one (1) contact failure in ten thousand (10,000) connections.
4. Shall be wired in a TIA/EIA-568-B configuration. Patch panels shall have six (6) or twelve (12) jacks, as required.
5. The patch panels shall be able to accommodate 24 AWG cable conductors.
6. The patch panels shall be Underwriter's Laboratories (UL) listed.

2.5 FIBER OPTIC DISTRIBUTION ENCLOSURE (FDE) / FIBER OPTIC TERMINATION ENCLOSURE (FTE) / FIBER OPTIC TERMINATION SHELF (RACK MOUNT)

A. Shall provide cross-connect, inter-connect, splicing capabilities, and contain the proper troughs for supporting and routing the fiber cables/jumpers.

B. Shall consist of a modular enclosure with retainer rings in the slack storage section to limit the bend radius of fibers.

C. Shall have a "window" section to insert fiber optic adapter panels for mounting of SC adapters.

D. Connectors shall meet or exceed the following specifications:

1. Operating Temperature: -40 □to 185□F (-40□ to 85□C)
2. Maximum Loss: 3.0 dB

E. Shall provide terminating capability of six (6), twelve (12), twenty-four (24), forty-eight (48), or seventy-two
(72) connectors as indicated on plans or as required for number of fibers.

F. All enclosure housing shall be metal. All terminations shall be enclosed in housing with access door.

G. FDEs SHALL CONTAIN NO PATCH CABLES. Contractor shall use SC FIBER BULK HEAD connectors to achieve the pass-through.

H. No pull out fiber trays are to be used.

2.6 BACKBONE DISTRIBUTION FEEDER CABLE

A. FIBER OPTIC

1. Fiber optic cables shall be Optical Cable Corporation DX-Series Distribution Cables, Riser and Plenum- Rated as required. Equivalent cables from other vendors will be allowed.
2. The Single-mode fiber shall comply with ANSI/TIA/EIA-492CAAA-1998, Detail Specification for Class IVa Dispersion-Unshifted Single-mode optical fibers.
3. Each fiber shall be tight-buffered with color-coded PVC.
4. All fiber must be armored or installed in innerduct.
5. The fiber cable shall meet the NEC requirements for OFN, OFNR or OFNP and comply with Bellcore, FDDI, TIA/EIA-568-B.2 and ICEA standards.
6. All fiber must conform to:
   a. ANSI/TIA/EIA-568-B3
   b. Telcordia GR-20, Telcordia GR-409
   c. ANSI/ICEA S-87-640
   d. ANSI/ICEA S-83-596

7. The fiber must support:
   a. 1000BASE-SX/1000BASE-LX
   b. Fiber channel 1.062/2.125
   c. 10GBASE-SR/SW
   d. 10GBASE-LX4

8. Features of armored fiber must include:
   a. Jacketed armor that remains flexible due to the spiral wrap armoring process.
   b. The armored design allows for an easy one-pull installation into any environment.
   c. Aluminum of steel interlock armor is available.
   d. Aluminum interlock offers ten (10) to thirteen (13) times the impact resistance over all-dielectric optical cable.
   e. Compact outside diameters when compared to plenum inner duct or conduit.
   f. Interlocking armor available without an over jacket.

2.7 MISCELLANEOUS

A. SURFACE AND MULTI-COMPARTMENT RACEWAY

1. Types, sizes and channels as indicated and required for each application, with fittings that match and mate with raceway. Raceway mounting clips to provide concealed mechanical attachment to mounting surface.
2. Surface Metal Raceway: Shall be equal to Wire Mold 700 Series, with fittings that match and mate with raceway.
3. Multi-compartment surface raceway: Shall be equal to Wire Mold 4000 Series, with fittings that match and mate with raceway. Wiring device plates shall overlap raceway cover.

B. POWER/DATA POLES

1. Types, sizes, and channels as required for each application, with fittings that match and mate with pole. Provide dual channel type as required for multi-service applications. Provide pole appropriate for type of ceiling - accessible/inaccessible.

C. PRECAST HAND HOLE STRUCTURES

1. Hand holes shall be equal to Quazite PG2436BA30. Hand holes are twenty-four inches (24”) by thirty- six (36”) by thirty (30”) deep. Provide heavy-duty two (2) bolt cover with “Communications” logo.

D. TERMINATION LABELS

1. Shall conform to ANSI/TIA/EIA-606. Labels will have pressure sensitive, permanent acrylic type adhesive, P-Touch type weather proof or equal, black letters/numbers on white back ground. All TCO labels shall be installed under the clear id window slot cover of face plate.

E. SURGE/TRANSIENT PROTECTOR PANEL

1. Porta PN-1525GT Multi-pair Protector Panels or approved equal for each twenty-five (25) pair cable on both ends where the cable enters the building. Use multiple units for higher pair count cables or multiple cables. The protector units to be provided and installed by the Contractor and the protector units must be with fuses.

F. OPTICAL FIBER RACEWAY

1. Flexible telecommunication raceway (inner duct) designed and listed specifically for use with fiber optic cables. All inner duct installed shall be UL-listed Riser-rated minimum or Plenum-rated. General-rated will NOT be allowed. Use Plenum-rated as required for plenums. UL label must be stamped or printed on product. Use Riser-rated in all other locations. Only fiber optic cable shall be installed in this raceway.
2. Armored fiber may be used as an alternative to inner duct.

G. OPTICAL FIBER RACEWAY FITTINGS

H. Fittings shall be specifically designed to match raceway type and material FOUR (4) POST RACKS: To be furnished and installed by Contractor.

1. Shall be equivalent to Panduit's seven (7) foot 4-post rack system with dual sided horizontal and vertical wire management designed for proposed 4 post rack equivalent to Panduit's "Net Runner" cable manager system. Cable management units shall be installed in between all installed patch panels in floor racks and on the outside of both end floor racks.

I. SWITCH ENCLOSURE (SE) (Mobile Unit Use Only)

1. Enclosure shall be twenty-four inches (24") by twenty-four inches (24") by four inches (4") as per 27 00 00 Guidelines.
2. Enclosure shall be constructed from 16-gauge cold rolled steel. Hinges shall be formed steel type or equivalent and swing from side. Front panels to have louvers mounted horizontally to aid in heat dissipation. Mount enclosure to ensure the louvers run horizontally. Hinge must allow door to open side to side only. Unit shall have thumb latch device. Unit shall have a polyester powder, enamel, or equivalent type finish. Enclosure should be beige in color. Use a Hoffman or equal – wall mounted part number 511-NU.
3. Enclosure shall have one-half inch (½") plywood backboard to mount equipment. Enclosure shall have sealed rubber cable entry grommets where required. Owner to supply and install electronics only. Do not use wing nuts to fasten board to the rear of switch enclosure.
4. Contractor to install a communication circuit assembly in the top right or top left corner of the SE. This unit must be Wiremold Uniduct PN-CM-MMB-293 multi-media box or equivalent. The fibers must be terminated in the enclosure with SC connector adapters. The adapters must be Pass and Seymour Activate PN-2A-2SC (2-strand duplex SC) or equivalent. If an equal is going to be submitted for approval from WCPSS, a sample must accompany the specification submittal process. The Contractor shall ensure that there is at least six feet (6') of repair margin fiber in the enclosure.
5. Enclosure shall be mounted to wall with four (4) one-quarter inch (¼") bolts into wall anchors. Use toggle bolts for hollow partitions. Bolt shall pass through the one-half inch (½") plywood backboard, the enclosure and into the wall anchor.
6. Cable shall be routed to enclosure as follows:
7. New Construction: Two (2) one inch (1") EMT minimum roughed in wall to a single gang box. Enclosure shall have a four inch (4") by four inch (4") diameter opening in back and be mounted directly over outlet box. Conduits to be sized based on number of fiber and copper cables.
8. The cable count cannot exceed twelve (12) copper cables for any single SE. If the cable count exceeds twelve (12), a Re4 Rebox must be installed.

J. REBOX (RE4 Type only)

1. Rebox shall be thirty-two inches (32") high by twenty-four point two inches (24.2") wide by ten inches (10") deep. See 27 00 00 Guidelines. Front door shall have two (2) locks, one (1) set of nineteen inch (19") extension brackets and one (1) set nineteen inch (19") bottom hinge brackets for patch panels. Color should be light gray. Rebox must be a RE4 pre-configured as above or equal.
2. Rebox shall be constructed from sixteen (16) gauge cold rolled steel. Hinges shall be formed steel type or equivalent and swing from side. Front panel shall have louvers mounted horizontally to aid in heat dissipation.
3. Contractor to install a communication circuit assembly in the top right or top left corner of

the Rebox. This unit must be Wiremold Uniduct PN-CM-MMB-293 multi-media box or equivalent. The fibers must be terminated in the enclosure with SC connector adapters. The adapters must be Pass and Seymour Activate PN-2A-2SC (2-strand duplex SC) or equivalent. If an equal is going to be submitted for approval from WCPSS, a sample must accompany the specification submittal process. The Contractor shall ensure that there is at least six feet (6') of repair margin fiber in the enclosure.

4. Rebox shall be mounted to wall with four (4) one-quarter inch (¼") bolts into wall anchors. Use toggle bolts for hollow partitions and lead anchors for solid masonry walls. Bolt shall pass through the one- half inch (½") plywood backboard, the enclosure and into the wall anchor. Rebox shall be mounted approximately thirty six (36") inches AFF to the bottom of the cabinet.
5. Cable shall be routed to Rebox as follows:
   a. New Construction: Two (2) one inch (1") EMT minimum roughed in wall to a single gang box. Rebox shall have a four inch (4") by four inch (4") diameter opening in back and be mounted directly over outlet box. Conduits to be sized based on number of fiber and copper cables.
   b. A maximum of seventy two (72) cables may be terminated in each Rebox. If cable count exceeds this quantity, a second Rebox or floor rack must be installed.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. The contractor shall maintain conductor polarity (tip and ring) identification at the MDF, the Telecommunications sub closets, risers, and station connecting blocks in accordance with industry practices.

B. The Contractor shall provide all cables. All communication cable installed by the Contractor shall be fully tested in accordance with TIA/EIA-568-B.2 (for UTP) and TIA/EIA 526-14-A-B.14 prior to acceptance.

C. The Contractor shall test all fiber optic cable prior to the installation of the cable. The Contractor shall assume all liability for the replacement of the cable should it be found defective at a later date. Fiber test must be bi-directional after installation through all FDEs and show footage in feet.

D. The Contractor shall provide any necessary screws, anchors, clamps, tie wraps, distribution rings, wiring duct (MDF & FDE locations), miscellaneous grounding and support hardware, etc., necessary to facilitate the installation of the system in a neat and orderly fashion as approved by the Architect.

E. It shall be the responsibility of the Contractor to furnish any special installation equipment or tools necessary to properly complete the system. This may include, but is not limited to, tools for terminating cables, testing, and splicing equipment for copper/fiber cables, communication devices, jack stands for cable reels, or cable winches.

F. The Contractor shall be responsible for printed labels for all cables and cords, distribution frames, and outlet locations, according to the specifications. No labels are to be written by hand including numbers on boots. Approval must be obtained from WCPSS for labeling devices used.

G. The Contractor shall not place or attach any telecommunications cabling alongside power lines, or share the same conduit, "J" type hook, channel or sleeve with electrical apparatus or other low voltage system installed cabling.

H. The Contractor shall ensure that the maximum pulling tensions of the specified distribution cables are not exceeded and cable bends maintain the proper radius during the placement of the facilities. Failure to follow the appropriate guidelines will require the Contractor to provide in a timely fashion the additional material and labor necessary to properly rectify the situation. This

shall also apply to any and all damages sustained to the cables by the Contractor during the implementation.

I. The Contractor shall be responsible for providing an approved ground at all newly installed distribution frames and insuring proper bonding to any existing facilities. The Contractor shall also be responsible for ensuring ground continuity by properly bonding all appropriate cabling, enclosures, cabinets, service boxes and framework. All grounds and bonding shall consist of green #6 AWG solid copper wire and shall be supplied from an approved building ground and bonded to the main electrical ground in compliance with J- STD-607 “Commercial Building Ground (Earthing) and Bonding Requirements for Telecommunications, Sections 2.1 and 5.3

J. The Contractor shall furnish a chart (cable schedule) indicating cable termination locations from end to end. This document shall be page-numbered, laminated and attached to each distribution frame (see 27 00 00 attachments 27 00 00 “A through D”). Documents shall also be submitted electronically in .dwg and .pdf file format.

K. The Contractor shall furnish to the Owner all closeout documentation electronically and on some form of media storage device in .dwg and .pdf file format. The documentation (schedules, test results) must be subdivided with tabs indicating cable type and in numerical sequence. See 27 00 00 Guidelines, section 1.3.

L. Any data cable that is not located in the same room as the Rebox, or IDF must have a full label on the cable at both ends.

The Contractor shall install the necessary biscuit jacks for all installed Life Safety System on-site per 27 00 00 Guidelines, 27 00 00 exhibit “E2.05”. The Contractor shall install a home room Cat6 cable from the biscuit jack to the appropriate service equipment. If the service equipment is located in a separate building from the DEMARC room, this cable will then have to pass through an IDF. This cable shall have to be lightning protected. The Owner will install the patch cord to the phone service. The Contractor is to install the Cat6 cable in the biscuit jacks only. Each separate biscuit jack shall be labeled as to the Life Safety System it corresponds to.

M. The contractor shall provide the correct colored (Blue for Data Station and WAP cables and Green for Security Camera cables) patch cords for all cables terminated in any installed Rebox. Patch Cords shall be three feet (3’) in length.

3.2 INSTALLATION, GENERAL

A. Telephone Service: Comply with telephone utility organization requirements as to details of the telephone service.

B. Distribution System: Complete installation required. The system will be fully operational when instruments and electronic equipment are connected.

C. Raceway: Install service and distribution raceway for all cabling as indicated.

D. Existing telecommunication outlets and wiring are to remain fully operational until the new system has been tested and accepted.

E. Conduit sleeves for Computer Network Infrastructure shall be installed not more than four inches (4") from wall and shall be stubbed at a maximum of four inches (4") above or below finished floor. Plastic bushings and pull wires shall be provided. All installed conduits to a location not contained within the main building complex must have a minimum of two (2) separate pathways provided for WCPSS use. One (1) pathway will be for current use and one (1) pathway will be for future use. This can be achieved with multiple conduit runs, internally installed corrugated plastic innerduct, or a “max-cell” type innerduct material.

F. Where the protector panels are installed in a room with a plywood backboard, mount directly on backboard. Where the protector panels are installed on the exterior of the building, mount in a NEMA 3R enclosure (Hoffman Screw Cover Type 3R Enclosures - Bulletin A-3 or equal). Where the protector panels are installed indoors in a room without a backboard, mount in a NEMA 1 enclosure (Hoffman Small Type I Enclosures Bulletin A-2). Size as required to accommodate all devices and wiring with adequate clearance. Contractor will provide protector units.

G. The Contractor shall remove accessible abandoned communications cable per the current edition of the National Electric Code, Section 800.52(B) or Current Release Available.

3.3 HORIZONTAL CABLE INSTALLATION

A. Obtain approval of all raceway system installation from engineer prior to installing any cable. Install cable without damaging conductors or jacket. Do not bend cable to a smaller radius than minimum recommended by manufacturer. Do not exceed manufacturers recommended pulling tensions. Pull cables simultaneously where more than one is being installed in the same raceway or at the same location. Use pulling compound or lubricant where necessary. Compound used must not damage conductor or insulation. Use pulling methods that will not damage cable or raceway, including fish tape, cable, rope, and wire-cable grips.

B. Wiring Method

1. New Construction: Install outlet boxes with jack assemblies at outlets. Install cable in raceway in wall. Terminate raceway with a bushing in ceiling space above outlet except as otherwise indicated. Run cable concealed in accessible ceiling space except as otherwise indicated.
2. Fiber optic cable shall be installed in raceway from Rebox to MDF. All fiber optic cable shall be installed in optical fiber raceway (inner duct) minimum one inch (1”) in diameter or other raceway (i.e., conduit). There shall be no exposed conduit or fiber optic cabling. Utilize fittings and boxes specifically designed for use with the associated raceway. Each end of the fiber shall contain a slack storage box with approximately 6 feet (6’) of cable slack. Provide pull boxes for inner duct at a maximum of one hundred feet (100’). Armored fiber may be used in lieu of inner duct. No splicing of fiber cable is acceptable.
3. Provide bushings on all conduit stubbed to ceiling void.
4. Copper Cable above finished ceilings: Install parallel or perpendicular to surfaces or exposed structural members and follow surface contours where possible. Install cables in approved supports on walls, not diagonally across ceiling void. All cables shall be routed and supported around the exterior walls of the room in a consistent pattern, with all break-outs being 90-degree angled turns without any corners being cut.

    a. Cable Support: Secure cable to independent supports at intervals as required by current industry standards, that prevents sagging between supports. Use metallic supports with corrosion-resistant finish. Please provide separate cable pathways for all Technology related cabling and all other low voltage cabling.
    b. Splices: Do not splice any cable between the normal terminations of runs.
    c. No Dropped Ceiling: Route in conduit along structure.
    d. Attach cable to building structure only as per NEC-800 Refer to Current Release Available.
    e. Technology related cables installed in cable tray shall be separated from all other low voltage cabling by dividing the tray into two distinct sections.
    f. Technology related cabling installed in “J” type hooks” shall be separated from all other installed low voltage cabling. This means a separate installed “J” type hook pathway should be provided for all non-technology related low voltage cabling.

5. In suspended ceiling and raised floor areas where walker duct, cable trays or conduit are not available, the Contractor shall bundle horizontal Cat6 wiring with wire ties at appropriate distances. The cable bundling shall be supported via Cat6 "J" type hooks or Cat6 bridle

rings with saddles attached to the existing building structure and framework. Adhering to industry standards concerning cable fill capacity for cable type being utilized. Use of Velcro straps is prohibited.

C. The 4-pair UTP cables shall be installed using a star topology format from the administration subsystem on each floor to every individual TCO.

D. The length of any horizontal Cat6 cable shall not exceed two hundred ninety-five feet (295') (90 m).

E. In the event the Contractor is required to remove ceiling tiles, such work shall not break or disturb grid and must be coordinated with the construction site superintendent. Any damaged tiles after the ceiling is installed shall be replaced under this contract by the contractor that damaged said tiles.

F. Conduit installed by the Contractor should not exceed one hundred feet (100') or contain more than two (2) ninety degree (90°) degree bends without utilizing appropriately sized pull boxes.

G. No Condulets may be used.

H. Cabling in Telecommunications Sub closets and Cabinets: Install conductors parallel to and at right angles to walls. Bundle, lace and train the conductors to terminal points with no excess. Use wire distribution spools at points where cables are fanned, or conductors turned. Connect conductors that are terminated, spliced, or interrupted to terminal blocks.

I. Conductor Terminations: Terminate conductors of cables on terminal block using tools recommended by terminal block manufacturer.

3.4 TELECOMMUNICATION OUTLET (TCO)

A. Unless otherwise noted on the floor plans, the TCO shall be flush mounted.

B. Outlet jacks shall be color keyed blue for data.

C. Wireless Access Point and Camera drops shall be installed in the center of the room at a maximum height of ten (10') feet AFF with a minimum twenty (20') service loop in ceiling areas containing acoustical ceiling tiles and terminated on an RJ45 keystone style jack enclosed in a surface mount style box installed in and extended to the patch panel in the nearest designated IDF closet. Each biscuit jack installed shall be labeled with the complete label designation for that individual cable drop on the outside cover of biscuit jack and on adjacent ceiling grid.

3.5 FEEDER CABLE

A. Contractor shall obtain approval of all raceway systems installation from the engineer prior to installing any cable.

B. Contractor shall install the feeder cables in a star topology, terminated in the MDF at one end and in the IDF in a Telecommunications sub closet at the other end.

C. All fibers shall be installed in raceway (inner duct or armored fiber) and terminated with approved pre- polished, crimp-on SC-style connectors or hot melts at termination or distribution enclosures or at termination shelves equipped with sufficient panels, adapters, and jumper storage to terminate and secure all fibers.

D. The fiber cable shall be protected by optical fiber raceway or appropriate apparatus at all times. Each end of the fiber cable shall contain a slack storage box with approximately six feet (6') of cable slack.

3.6 OUTSIDE CABLE

A. All buried cable shall be contained in a raceway system. When using PVC, a metallic locating tape shall be installed twelve inches (12") below grade.

B. Contractor shall obtain approval of all raceway system installation from the engineer prior to installing any cable.

C. Provide hand holes on all underground inner building (between buildings) conduit runs that change direction.

D. Contractor shall provide electrical lightning/surge protection panels and protector units on copper cables that will prevent electrical surges on the cable from entering buildings.

E. It shall be the responsibility of the Contractor to stake all areas along the cable route forty-eight (48) hours prior to any trenching or digging.

F. The Contractor shall be responsible for restoring any disturbed earth to its original condition. A reasonable effort shall include any landscaping, seeding, or replacement of shrubbery that may be required to properly restore the excavated area. If settling should occur, the installation Contractor shall be responsible for any secondary restoration.

G. All aerial cabling shall be installed with an environment suitable guide wire and supported by a CAB product #1070 (3 inch diameter Galvanized Standard Style with 3/8" lock) cable ring or equivalent product.

3.7 GROUNDING

A. Communications Systems - In compliance with NEC Refer to Current Release Available, Article 800, J-STD-607-A-2.1, J-STD-607-A-5.1, J-STD-607-Annex B

1. Install a #6 AWG green insulated solid copper ground wire from the main building service entrance grounding system to the MDF Telecommunications Main Grounding Busbar (TMGB).
2. Install a #6 AWG green insulated solid copper ground wire from the TMGB to each Telecommunications cabinet in the MDF.
3. DO NOT GROUND OR BOND TO THE BUILDING STRUCTURE

B. Contractor shall install a copper busbar for grounding of communication systems.

3.8 IDENTIFICATION

A. Provide identification in accordance with the recommendations of ANSI/TIA/EIA-606, "Administration Standard for Telecommunications Infrastructure." Refer to labeling descriptions below.

B. New labeling shall be a fully integrated extension of the existing network labeling system. No duplication of the existing network number may be used in the new labeling system or existing system.

3.9 TELECOMMUNICATIONS LABELING LEGEND

A. Copper Telecommunications Outlet (TCO) - *"X-RMNNN-BNN":*

1. Where *"X"* equals "MDF" (Main Distribution Frame), "IDF" (Intermediate Distribution Facility), or "RB" (Rebox) indicating where the cable is terminated at the other end.

2. Where *"NNN"* equals the room number where the MDF, IDF, SE, or RB is located.
3. Where *"B"* equals the outlet, designation symbolized by "D" for data, "F" for fiber, "WAP" for wireless access point, or "CAM" for camera.
4. Where *"NN"* equals the unique outlet/fiber number. This number shall be consecutive for each MDF, IDF, or RB and shall be numbered 01, 02, 03, etc.

B. Wireless Access Points and Camera drops – "X-RMNNN-BNN" :

1. Where *"X"* equals "MDF" (Main Distribution Frame), "IDF" (Intermediate Distribution Facility), or "RB" (Rebox) indicating where the cable is terminated at the other end.
2. Where *"NNN"* equals the room number where the MDF, IDF, or RB is located.
3. Where *"B"* equals the cable type designation symbolized by "D" for data, "F" for fiber, "WAP" for wireless access point, or "CAM" for camera.
4. Where *"NN"* equals the unique outlet/fiber number. This number shall be consecutive for each MDF, IDF, or RB and shall be numbered 01, 02, 03, etc.
5. A complete cable id label is to be applied to the biscuit jack attached to each individual cable and to the ceiling grid in general area where any WAP or Camera drop is located. A round 3/4" orange sticker should also be applied in same spot as label for all WAP drops. A round 3/4" green sticker should also be applied in same spot as label for all Camera drops.

C. Copper Patch Panels - Label each outlet at the MDF, IDF, or RB patch panels with a corresponding outlet number. Numbering shall be from left to right, top to bottom and with consecutive numbers. *Note: All labels shall be uniform in size using the same font size on letters and numbers (block style) throughout. The schedule sheet and labels on patch panels must match. The patch panel cable numbers should only reflect the cables that are terminated.

D. If the data cables are all contained within the same room, the data labels may read D1, D2, D3, etc. if not, they must have a full label at both ends.

E. Fiber Station Cables and Fiber Distribution Enclosure (FDE) - label as follows:

1. Fiber Station Cables - *"X-RMNNN-B-NN":*
   a. Where *"X"* equals "MDF" or "FDE" (located in an IDF) indicating where the cable is terminated at the other end.
      i. Where *"NNN"* is the room number where the MDF or FDE is located.
      ii. Where *"B"* equals the outlet designation symbolized by "F" for fiber
      iii. Where *"NN"* is the fiber outlet number. This number shall be consecutive for each outlet. The numbers shall be unique for each outlet throughout the entire campus.
      iv. Label each fiber connector in the fiber patch panels at the MDF or FDE with consecutive numbers reading left to right, top to bottom. The numbering system should start at the MDF and work outward.
      v. *Note - Label the Rebox on the inside and outside of the door and on multi-media outlet box.

F. Labeling for the backbone distribution fiber cable - At the MDF label all fiber connectors sequentially from left to right, top to bottom. This number should carry all the way to the Rebox. These numbers shall match at all FDEs. Tag cables at all connections. Format of label is *"*Fiber Feeder Cable to X-RMNNN FNNN- FNNN":

1. Where *"X"* equals "MDF" or "FDE".
2. Where *"NNN"* is the room number where the MDF or FDE is located.
3. Where *"NNN-NNN"* equals the beginning and ending numbers for that feeder cable.

G. Every fiber strand should be labeled with its unique fiber number with an approved labeling tape just behind the boot. Also every six (6) strands of fiber should be labeled with an F1, F6, F7, F12, F13, etc. label on the front side of every six (6) pack or twelve (12) pack insert.

3.10 FIELD QUALITY CONTROL

A. Test Notice: Provide at least ten (10) days' notice in writing when the system is ready for final acceptance testing.

B. Acceptance Tests: Include the following for each pair or conductor of each cable run.

1. One hundred (100) percent of the horizontal and riser wiring pairs shall be tested for opens, shorts, polarity reversals, transposition, and presence of AC voltage.
2. Data horizontal wiring pairs shall be tested from the TCO to the patch panel or block, the basic link test.

C. Data cables shall be tested for conformance to the specifications of TIA/EIA -568-B.2 for Cat6 copper cable.

1. Wire Mapping shall be done to ensure proper wiring and connectivity. Test for:

a. Continuity, end-to-end.
b. Shorts between any two or more conductors.
c. Crossed pairs
d. Reversed pairs
e. Split pairs
f. Other mis-wirings
g. Document as Pass/Fail

2. Length shall be measured. Indicate the length of the cable as the pair with the shortest length and record it
3. Attenuation shall be tested with a remote signal injector and a reading made at the local end. Evaluate the worst pair attenuation and record result on test report.
4. Bi-Directional NEXT. Near-end crosstalk (NEXT) shall be tested on all six pair combinations in each four pair cable. Tests for NEXT shall be performed from both the work area outlet location and link origination point.
5. Fiber optic cables shall be tested in accordance with the requirements of TIA/EIA-526-14-A-B.1.4 Annex B (Bi-directional Testing). Maximum dB loss shall be 3.0. Show footage on test reports. Notify WCPSS Technology Department of exceptions by cable ID number and give reasons for the exceptions.
6. Computer generated test results must be submitted to the WCPSS Technology Department.

D. Re-testing: Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify that the total system meets the Specifications and complies with applicable standards.

E. Report of Tests and Inspections: Prepare a written record of inspections, tests, and detailed test results in the form of a test log and format the log in cable ID number order.

3.11 Entrance Facilities:

A. An entrance raceway (conduit) meeting the following specifications shall be provided by the Contractor for the use of the local telephone service provider.

B. General - (Conduit)

1. Contractor shall install a quantity of two (2) four inch (4") conduits from the Owners' property line, as specified by the local telephone service provider, to the main telecommunications room.
2. Conduits to be intermediate metal, rigid metal or rigid non-metallic conduit installed in accordance with Articles 345, 346, or 347, respectively, of the National Electric Code Refer to Current Release Available.

3. Contractor shall bury conduit to a depth between twenty-four inches (24”) and thirty-six inches (36”) below final grade.
4. Contractor shall equip conduit with no more than the equivalent of two (2) quarter bends (a total of 180 degrees) between cable pulling points.
5. All conduit bends shall have a minimum radius of ten (10) times the inside diameter of the conduit. LBs will not be acceptable.
6. Contractor shall equip conduits with mule tape with footage on tape.

C. Field Side - (Conduit at Right of Way)

1. Contractor shall cap conduit to prevent debris and water from entering before cable placement.
2. Contractor shall install conduits to a hand hole thirty inches (30”) by forty-eight inches (48”) by thirty-six inches (36”) and the hand hole in locations designated by the Owner.

D. Building side - (At Main Telecommunications Room)

1. The responsibility to seal entrance conduits to protect against water damage is left entirely with the Contractor.
2. All fire rated structures that are penetrated during conduit or cable placement must be fire-stopped by the Contractor.

E. The telephone service provider shall terminate its entrance cables inside the building in the Main Telecommunications Distribution Room. This area will be provided by the Contractor with the following requirements met:

1. Contractor shall equip area with an eight foot (8’) wide x four foot (4’) high x three quarter inch (¾”) fire retardant non-painted plywood backboard, with visible fire rating, and securely fastened to the wall. The plywood should be installed on all walls.
2. Contractor shall equip backboard with a standard duplex convenience outlet.
3. Contractor shall maintain clear path to this area and a three foot (3’) maintenance area directly in front of terminal area.
4. Contractor shall equip area with direct lighting sufficient for a uniform light intensity of 30-foot candles measured at floor level.

F. Grounding and Bonding

1. Refer to 27 00 01 guidelines, section 3.7. (See exhibits 27 00 00 “E2.05” and “E2.06”).

END OF SECTION 270001

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SECTION 270010 - SUPPLEMENTAL REQUIREMENTS FOR COMMUNICATIONS

PART 1 - GENERAL

1.1 RELATED REQUIREMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

1.2 SUMMARY

A. Division 27 – Communications governs the structured cabling infrastructure for the low-voltage information transport systems, which can include but are not limited to voice, data, cable TV (CATV), audio/video, intercommunication systems, distributed antenna systems, and their pathways.

B. The installed structured cabling infrastructure should be able to support interconnections to active telecommunications equipment for IP telephony, desktop computers, IP surveillance cameras, and other technologies in a multi-vendor, multi-product environment. The structured cabling infrastructure shall adhere to applicable standards as listed below with respect to performance, pathways, distribution, administration, and grounding of the system. The structured cabling system shall be installed in accordance with local codes and regulations.

C. Contractor is solely responsible for all parts, labor, testing, documentation and all other processes and physical apparatus necessary to turn over the completed cabling system and associated infrastructure fully warranted and operational for acceptance by Owner.

D. This specification includes structured cabling design considerations, product specifications, and installation and testing requirements for low-voltage network systems and associated infrastructure including, but not limited to:

1. Horizontal Cabling and Terminations
2. Backbone Cabling and Terminations
3. Telecommunications Pathways
4. Communications Equipment Room Fittings
5. Communications Grounding and Bonding Systems
6. Cable Labeling and Administration
7. Patch cables and Equipment cords

E. The following equipment is to be owner-furnished; contractor installed.

1. Wireless Access Points
2. Network Switches

F. The following equipment is to be owner-furnished, owner-installed. This does not alleviate the contractor from fully coordinating with the owner to ensure compatibility of the contractor’s systems with the owner’s systems and equipment:

1. Client Workstations, PCs, monitors, printers, faxes

1.3 ABBREVIATIONS

A. AHJ: Authority Having Jurisdiction

B. EMI: Electromagnetic interference.

C. IDC: Insulation displacement connector.

D. IDF: Intermediate Distribution Frame (Telecom Room)

E. LAN: Local area network.

F. MDF: Main Distribution Frame (Main Telecomm Room)

G. RCDD: Registered Communications Distribution Designer

H. UTP: Unscreened (unshielded) twisted pair

1.4 DEFINITIONS

A. Consolidation Point: A location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways.

B. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

C. Communications Jack: A fixed connecting device designed for insertion of a communications cable plug.

D. Communications Outlet: One or more communications jacks, or cables and plugs, mounted in a box or ring, with a suitable protective cover.

E. Communication Plug: Also commonly called a "connector," it is the removable, male telecommunications connector.

F. Junction Box: A box with a blank cover that joins different runs of raceway or cable and provides space for connection and branching of the enclosed conductors.

G. Outlet Box: A box that provides access to a wiring system having pryout openings, knockouts, threaded entries, or hubs in either the sides or the back, or both, for the entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting an outlet box cover, but without provisions for mounting a wiring device directly to the box.

H. Plenum: A compartment or chamber to which one or more air ducts are connected and that forms part of the air distribution system.

I. Pull Box: A box with a blank cover that joins different runs of raceway and provides access for pulling or replacing the enclosed cables or conductors.

1.5 REFERENCE STANDARDS

A. Contractor is responsible for knowledge and application of current versions of all applicable standards and codes. In cases where listed standards and codes have been updated, adhere to the most recent revisions, including all relevant changes or addenda at the time of installation.

B. This document does not replace any code, either partially or wholly. Conform to local codes and regulations that apply to this project

C. If there is a conflict between applicable documents, then the more stringent requirement shall apply.

D. Telecommunications Industry Association (TIA):
1. ANSI/TIA-568.0-E, “Generic Telecommunications Cabling for Customer Premises”
2. ANSI/TIA-568.1-E, “Commercial Building Telecommunications Cabling Standards - Part 1 General Requirements”
3. ANSI/TIA-568.2-D, “Balanced Twisted Pair Telecommunications Cabling and Components”
4. ANSI/TIA-568.3-D, “Optical Fiber Cabling Components”
5. ANSI/TIA-568.4-D, “Broadband Coaxial Cabling and Components”
6. ANSI/TIA-569-E, “Commercial Building Standard for Telecommunications Pathways and Spaces”
7. ANSI/TIA-598-D, “Optical Fiber Cable Color Coding”
8. ANSI/TIA-606-C, “Administration Standard for Telecommunications Infrastructure”
9. ANSI-TIA-607-D, “Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises”
10. ANSI/TIA-758-B, “Customer-Owned Outside Plant Telecommunications Infrastructure Standard”
11. ANSI/TIA-1152-A, “Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling”
12. ANSI/TIA-4966, “Telecommunications Infrastructure Standard for Educational Facilities”

E. Building Industry Consulting Service International (BICSI)
1. BICSI TDMM “Telecommunications Distribution Design Manual”
2. BICSI ITSIM “Information Technology Systems Installation Manual”
3. ANSI/BICSI N1, “Installation Practices for Telecommunications and ICT Cabling and Related Cabling Infrastructure”
4. ANSI/BICSI N3, “Planning and Installation Methods for the Bonding and Grounding of Telecommunication and ICT Systems and Infrastructure”
5. NECA/BICSI 607 “Standard for Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings”
6. ANSI/BICSI 001 " Information and Communication Technology Systems Design and Implementation Best Practices for Educational Institutions and Facilities"

1.6 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate layout and installation of communications equipment with Owner's telecommunications and LAN equipment and service suppliers. Coordinate service entrance configuration with service provider.
2. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.
3. Coordinate telecommunications outlet/connector locations with location of power receptacles at each work area.

B. Pre-installation Meetings

1. Organize pre-installation meeting with telecommunications and LAN equipment suppliers, Engineer, Owner, and service providers to exchange information and agree on details of equipment arrangements and installation interfaces.
2. Record agreements reached in meetings and distributed them to project team.

3. Adjust arrangements and locations of racks, sleeves, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of utility demarcation, and telecommunications and LAN equipment.
4. Adjust configurations and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in equipment room.

1.7 SUBMITTALS

A. Prior to the start of work the contractor shall submit the following. Work shall not proceed without the Engineer's and Owner's completed review of the submitted items.

B. For Product Data, Equipment Shop Drawings, and Product Schedules: Comply with 260010 "General Requirements for Electrical Systems".

C. Coordination Drawings: drawings reviewed and stamped by RCDD with floor plans, sections, riser diagrams, and installation details of telecommunications equipment, to show location and layout of telecommunications equipment, including the following:

   a. Telecommunications room plans and rack elevations including workspace requirements and access for cable connections.
   b. Telecommunications cable tray and pathway layout with relationships to other building elements.
   c. Telecommunications system access points.
   d. Telecommunications grounding system.
   e. Cross Connects
   f. Patch Panels
   g. Telecommunications conductor drop locations.
   h. Typical telecommunications details.
   i. Mechanical, electrical, and plumbing systems.
   j. Firestopping

D. Qualification Data for Manufacturer, Contractor, Project RCDD, Project Manager, Lead Technician, and Installers along with project roster of personnel assigned to the project.

E. Sample System Warranties

F. Closeout Submittals
   1. As-Built Drawings: Plans showing as-built locations that fully represent actual installed conditions and that incorporate modifications made during the course of construction.
   2. Operation and Maintenance Data:
      a. In addition to items specified in Section 017823 "Operation and Maintenance Data" and Section 260010 "General Requirements for Electrical Systems" include the following:
         1) Cable test results.
         2) Manufacturer's recommended maintenance
   3. Product and System Warranty Documentation from both manufacturer and contractor.
   4. Labeling and Administrative printouts and digital copies on USB media.
      a. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables served from that particular room along with their designations, origins, and destinations. Protect with rigid frame and clear plastic cover.
      b. Cabling Administration Drawings: Install in a prominent location in each equipment room and wiring closet. Show building floor plans that identify the location and labelling of Communications devices served out of each telecom room. Protect with rigid frame and clear plastic cover. Identify labeling convention and show labels for telecommunications

closets, terminal hardware and positions, backbone and horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.

5. Final test result printouts and backup on USB media.

1.8 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Five continuous years, minimum, design and manufacture of the materials and equipment specified herein.
2. Manufacturer(s) of products and equipment specified herein shall demonstrate that they have a quality assurance program in place to assure that the specifications are met. Including at a minimum:
   a. Incoming inspection of raw materials
   b. In-process inspection and final inspection of the cable product
   c. Calibration procedures of test equipment to be used in the qualifications of the product
   d. Recall procedures in the event that out of calibration equipment is identified.
3. Conform to government standards on quality assurance for applications within these specifications.

B. Contractor Qualifications: Provide documentation of the following qualifications:

1. Be in business a minimum of 5 continuous years.
2. Provide a minimum of three reference accounts at which similar work, both in scope and complexity, have been completed by The Contractor within the last three years.
3. Demonstrate satisfaction of sound financial condition and can be adequately bonded and insured.
4. Possess licenses/permits required to perform telecommunications installations in the specified jurisdiction.
5. Employ personnel knowledgeable in local, state, province and national codes, and regulations. Comply with the latest revision of the codes or regulations. When conflict exists between local or national codes or regulations, the most stringent codes or regulations shall be followed.
6. Possess current liability insurance certificates.
7. Registered with BICSI and have at least one active RCDD on staff who shall be responsible for the implementation of the project.
8. Employ personnel fluent in the use of Computer Aided Design and possess and operate digital design software.
9. The Contractor shall be a certified installer in good standing with the approved manufacturer.

C. Contractor Training: Provide documentation of the following qualifications:

1. Personnel trained and certified in the design and installation of the approved manufacturer's products.
2. Personnel trained and certified in fiber optic cabling, fusion splicing, termination, and testing techniques. Personnel must have successfully attended an appropriate training program, which includes testing with an OLTS and OTDR, and have obtained a certificate as proof thereof.
3. Personnel trained in the installation of pathways and support for housing horizontal and backbone cabling.

D. Project Personnel Requirements: Contractor must have the following personnel certified by BICSI on staff and assigned to the project.

1. Project RCDD: Preparation of Shop Drawings, cabling administration Drawings, and field-testing program development by an RCDD who a full-time employee of the installing contractor shall be, shall be familiar with the project, and conduct weekly inspections.
2. Project Manager: Minimum BICSI certified Registered Telecommunications Project Manager (RTPM) who shall attend all project meetings and oversee/coordinate all work at the project site.
3. Lead Technician: Minimum BICSI certified Technician who shall provide direct supervision of Installers and be present at all times when work of this Section is performed at the project site.
4. Installers: Personnel installing any part of the structured cabling system shall be a minimum BICSI certified Level 1 Installer or shall have equivalent training and certification from the approved manufacturer.

E. References: The Owner may, with full cooperation of The Contractor, visit client installations to observe equipment operations and consult with references. Specified visits and discussion shall be arranged through The Contractor; however, The Contractor personnel shall not be present during discussions with references.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Environmental Limitations: Do not deliver or install equipment, cables, and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

B. Visually inspect cables upon receipt at Project site. If damage is suspected, test cables to verify and validate the manufacturer’s factory testing certifications.

1. Test optical fiber cable to determine the continuity of the strand end to end. Use optical fiber flashlight or optical loss test set.
2. Test each pair of UTP cable for open and short circuits.
3. Test each coaxial cable on reel for continuity.

C. Comply with manufacturer's storage and handling requirements for each product.

D. Maintain factory wrapping or provide a heavy canvas/plastic cover to protect units from dirt, water, construction debris, and traffic.

E. Do not install damaged materials and equipment.

F. Return visibly damaged products to the supplier and replace at no additional cost to the Owner.

1.10 GENERAL PRODUCT WARRANTY

A. General Requirements: Comply with additional requirements in contract general requirements and extended warranties required in other specification sections. Refer to all other Division 27 sections for specific additional warranty requirements that exceed or are in addition to those of this section.

B. Provide all services, materials, and equipment necessary for successful operation of entire telecommunications system including but not limited to structured cabling system, pathways, grounding, and bonding system, and firestopping for a period of one year after system acceptance. Scope of warranty includes all equipment, devices, wiring, accessories, software, hardware, installation, programming, and configuration required to maintain a complete and operable system. Provide manufacturer’s published recommended preventative maintenance procedures during warranty period. This shall apply to all items except those specifically excluded, or items wherein a longer period of service and warranty is specified

or indicated. All warranties shall be effective for one year, minimum, from date Certificate of Final Acceptance is issued. Use of systems provided under this section for temporary services and facilities shall not constitute final acceptance of work nor beneficial use by Owner and shall not institute warranty period. The warranty shall cover repair or replacement of defective materials, equipment, workmanship, and installation that may be incurred during this period. Warranty work is to be done promptly and to Owner's satisfaction. In addition, warranty shall cover correction of damage caused in making necessary repairs and replacements under warranty. Additional warranty responsibilities are:

1. Obtain written equipment and material warranties offered in manufacturer's published data without exclusion or limitation, in Owner's designated name. Replace material and equipment that require excessive service during guarantee period as determined by Owner.
2. Provide 2-business day service beginning on date of Substantial Completion and lasting until termination of warranty period. Service shall be at no cost to Owner. Service can be provided by installing contractor or by a separate service organization. Choice of service organization shall be subject to Owner's approval. Submit name and a phone number that will be answered on a 24-hour basis each day of week, for duration of service.
3. Submit copies of equipment and material warranties to Owner before final acceptance.
4. At end of warranty period, transfer manufacturers' equipment and material warranties still in force to Owner, at no additional costs to the Owner.
5. If warranty work problems cannot be corrected immediately to Owner's satisfaction, advise Owner in writing, describing efforts to correct situation, and provide analysis of cause for problem. If necessary to resolve problem, provide at no cost services of manufacturer's engineering and technical staff at site in a timely manner to analyze warranty issues, and develop recommendations for correction, for review and approval by Owner.

1.11 ADVANCED SYSTEM WARRANTY

A. The structured cabling system shall be covered by a two-part system performance and extended product warranty guaranteed for a minimum of 25 years. The advanced system warranty shall ensure installation and system performance for the duration of the warranty period.

B. The first part is an assurance program, which guarantees the end-to-end link transmission performance conforms to the applicable performance standards specified herein and will support the applications for which it is designed for the duration of the warranty period.

C. The second portion of the certification is an extended product warranty provided by the manufacturer and the contractor on all structured cabling products within the system (cords, telecommunications outlet/connectors, cables, cross-connects, patch panels, fiber panels, etc.).

D. The contractor shall have the sole responsibility for following the manufacturer's conditions and terms for the installation to qualify for the advanced system warranty. Requirements may include but are not limited to:
   1. Layout and Installation by a manufacturer approved installer with BICSI certification.
   2. Submission of warranty pre-approval, final application, test reports, and bill of materials in a timely manner.
   3. Certification testing of all links to appropriate standards.
   4. Use of manufacturer approved and calibrated test equipment.
   5. Coordination of pre-construction conference.
   6. Coordination of Manufacturer Pre/Post Installation Inspection.

PART 2 - PRODUCTS

2.1 GENERAL

A. Electrical Components, Devices, and Accessories: Provide listing and labels as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Materials used shall present no environmental or toxicological hazards as defined by current industry standards and shall comply with OSHA and EPA standards, other applicable federal, state, and local laws.

C. Product numbers are subject to change by the manufacturer without notification. In the event a product number is invalid or conflicts with the written description, notify the Engineer in writing prior to ordering the material and performing installation work.

2.2 SUBSTITUTIONS

A. Conform to the substitutions requirements and procedures outlined in Division 01 and Section 260010 “General Requirements for Electrical Systems”.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify existing conditions, stated under other sections, are acceptable for installation in accordance with manufacturer's instructions.

3.2 DEMOLITION

A. In addition to demolition requirements in Division 01 and Division 26, disconnect and remove abandoned communications cabling back to its source. This includes sources that are outside of the boundaries of the project area.

B. For abandoned cabling deemed unfeasible to remove by the Engineer, tag, and label at both ends as Abandoned.

C. The owner shall have first right of refusal for any components of the telecommunications system removed during demolition.

3.3 INSTALLATION

A. Comply with NECA 1

B. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both communications’ equipment and other nearby installations. Connect in such a way as to facilitate future maintenance with minimum interference from other items in the vicinity.

C. Under no condition shall the Contractor install any equipment or component that will void Manufacturer warranty or create such conditions that will reduce equipment performance, longevity, and life.

3.4 FIELD QUALITY CONTROL

A. Tests: Conduct tests of equipment and systems to demonstrate compliance with requirements specified. Reference individual Specification Sections for required tests. Document tests and include in Operation and Maintenance Manuals.

3.5 CLEANING

A. In addition to cleaning requirements in Division 01 and Division 26, thoroughly clean exposed portions of equipment upon completion of installation. Remove temporary labels and traces of foreign substances. Remove construction debris and surplus materials accumulated during work.

B. Leave finished work and adjacent surfaces in neat, clean condition with no evidence of damage.

C. Repair or replace damaged installed products.

3.6 SYSTEM ACCEPTANCE

A. System cannot be considered for final acceptance until work is completed and demonstrated to Engineer that installation is in strict compliance with Specifications, Drawings, and manufacturer's installation instructions, particularly in reference to following:

1. Testing Reports
2. Cleaning
3. Operation and Maintenance Manuals
4. Training of Operating Personnel
5. Record Drawings
6. Warranty Certificates, including extended manufacturer's warranties.

END OF SECTION 270010

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SECTION 270526 - GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, Section 260010 “General Requirements for Electrical”, and 270010 “Supplemental Requirements for Communications” apply to this Section.

1.2 SUMMARY

A. Description: The telecommunications bonding and grounding system and its interconnections to the electrical system provide an electrically continuous, low impedance path for all connected telecommunications equipment and pathways.

B. Section Includes:

1. Bonding conductors.
2. Bonding connectors.
3. Bonding busbars.

C. Related Requirements:
1. Refer to Section 260526 “Grounding and Bonding for Electrical Systems” for requirements associated with Electrical System Grounding, Equipment Grounding System, and Grounding Electrode System.

1.3 REFERENCES

A. Abbreviations

1. TBC: Telecommunications Bonding Conductor.
2. SBB: Secondary Bonding Busbar (Formerly TGB).
3. PBB: Primary Bonding Busbar (Formerly TMGB).
4. RBB: Rack Bonding Busbar
5. TBB: Telecommunications Bonding Backbone
6. BBC: Backbone Bonding Conductor
7. TEBC: Telecommunications Equipment Bonding Conductor
8. RBC: Rack Bonding Conductor

B. Definitions

1. Service Provider: The operator of a service that provides telecommunications transmission delivered over access provider facilities.
2. Grounding: Establishing a direct or indirect connection to Earth or some conducting body that serves in place of Earth.
3. Bonding: Method by which all non-energized conductive materials are effectively interconnected to create a low impedance path.

C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.

1. Building Industry Consulting Service International (BICSI)

a. ANSI/BICSI N3-20 “Planning and Installation Methods for the Bonding and Grounding of Telecommunication and ICT Systems and Infrastructure”

1.4 SUBMITTALS

A. Product Data: For each type of product.

B. Field Quality Control Reports: Provide test reports for each test specified in the field quality control section. Include certificate of current equipment calibration.

C. Closeout Submittals:

1. Operation and Maintenance Data: In addition to the items specified in Division 01 and Section 260010 “General Requirements for Electrical” include the following:

a. Results of the ground-resistance and bonding resistance tests.
b. Include recommended testing intervals.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency acceptable to authorities having jurisdiction and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

C. Comply with TIA-607-D.

2.2 CONDUCTORS

A. Insulated Copper Conductors: Comply with Section 260519 “Low-Voltage Electrical Power Conductors and Cables”.

1. Ground wire for custom-length equipment bonding jumpers: minimum No. 6 AWG.

2.3 CONNECTORS

A. Comply with requirements in 260526 “Grounding and Bonding for Electrical Systems”.

2.4 TELECOM BONDING BUSBARS

A. Manufacturers: Subject to compliance with requirements, provide products from one of the following or approved equal:

1. Harger Lightning and Grounding
2. Panduit Corp.
3. Erico
4. Chatsworth CPI
5. Ortronics
6. Eaton

B. General Requirements:

1. Predrilled BICSI/TIA-607 style hole pattern for use with lugs specified in this Section.
2. Mounting Hardware: Stand-off brackets that provide a minimum of 4-inch clearance to access the rear of the busbar. Provide stainless steel brackets and bolts.
3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.
4. Busbar length: Size to accommodate initial conductors plus a 50% growth factor.

C. Primary Bonding Busbar (PBB): Predrilled, wall-mounted, rectangular bars of electro-tin plated copper, 1/4 by 4 inches in cross section, minimum 24 inches in length or as indicated on Drawings. NRTL listed for use as PBB, complying with UL 467 and TIA-607-D.

D. Secondary Bonding Busbar (SBB): Predrilled, wall-mounted rectangular bars of electro-tin plated copper, 1/4 by 2 inches in cross section, minimum 12 inches in length or as indicated on Drawings. NRTL listed for use as a SBB, complying with UL 467 and TIA-607-D.

E. Rack Bonding Busbar (RBB): Comply with requirements for rack busbars in Section 271100 “Communications Equipment Room Fittings”.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the ac grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of the electrical system.

B. Inspect the test results of the ac grounding system measured at the point of TBC connection.

C. Prepare written report, endorsed by Installer, listing any conditions detrimental to performance of the Work.

D. Proceed with connection of the TBC only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Bonding shall include the ac utility power service entrance, the communications cable entrance, and the grounding electrode system. The bonding of these elements shall form a loop so that each element is connected to at least two others.

B. Comply with NECA 1.

C. Comply with TIA-607-D.

3.3 APPLICATION

A. Conductors: Install solid conductor for No. 8 AWG and smaller and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

1. The bonding conductors between the PBB/SBB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.

B. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

C. Conductor Support:

1. Secure grounding and bonding conductors at intervals of not less than 36 inches.

D. Grounding and Bonding Conductors:

1. Install in the straightest and shortest route between the origination and termination point, and no longer than required. The bend radius shall not be smaller than ten times the diameter of the conductor. No one bend may exceed 90 degrees.
2. Install without splices.
3. Support at not more than 36-inch intervals.
4. Install grounding and bonding conductors in minimum 1-inch Schedule 80 PVC conduit where exposed to physical damage or where routed through building walls or footings. Provide EMT conduit for the grounding and bonding conductor pathway where installed in a plenum.

    a. If a grounding and bonding conductor is installed in ferrous metallic conduit bond the conductor to the conduit at both ends using a grounding bushing that complies with requirements in Section 270528 - Pathways for Communications Systems.

3.4 GROUNDING ELECTRODE SYSTEM

A. Provide a Telecommunications Bonding Conductor (TBC) between the PBB and the Electrical service equipment ground busbar no smaller than No. 1/0 AWG and no smaller than the Telecommunications Bonding Backbone (TBB).

B. Where external equipment ground busbar is not available, provide intersystem bonding termination (IBT) device for connecting telecommunications bonding conductor (TBC) with service busbar.

C. Comply with requirements in article 250.94 of the National Electric Code (NEC)

3.5 TELECOM BONDING BUSBARS

A. Provide PBB in main telecommunications equipment room and locate to minimize length of TBC.

B. Provide SBB in each telecom room.

C. Install PBB/SBB horizontally, on insulated spacers 4 inches minimum from wall, 48 inches above finished floor unless otherwise indicated.

D. Install RBB on rack or cabinet using stand-off block insulators to provide a minimum of 0.75 inches of separation for dissimilar metals and to facilitate conductor attachment to RBB. The RBB may be directly mounted/bonded to the rack or cabinet only if doing so allows adequate space for attaching grounding conductors and does not create a dissimilar metals reaction.

3.6 CONNECTIONS

A. Bond all metallic equipment and pathways in each telecommunications room to the bonding busbar in that room, using insulated grounding conductors not smaller than No. 6 AWG.

B. Stacking of conductors under a single bolt is not permitted when connecting to busbars.

C. Assemble the wire connector to the conductor, complying with manufacturer's written instructions and as follows:

1. Use crimping tool and the die specific to the connector.
2. Pretwist the conductor.

D. Clean and apply an antioxidant compound to all bolted and compression connections.

E. Building Entrance Protectors: Bond to the PBB/SBB with insulated bonding conductor.

F. Busbar Interconnections: Interconnect all SBBs with the PBB using a continuous telecommunication bonding backbone (TBB). If more than one TBB is installed, interconnect TBBs using the backbone bonding conductor (BBC) conductor at the top floor and at every third floor in between. The telecommunications bonding backbone and backbone bonding conductor size shall not be less than 2 kcmils/linear foot of conductor length, up to a maximum size of 750 kcmil unless otherwise indicated.

G. Telecommunications Enclosures and Equipment Racks/Cabinets: Bond metallic components of enclosures to the telecommunications bonding and grounding system. Connect the Telecommunications Equipment Bonding Conductor (TEBC) to the Rack Bonding Busbar (RBB) and to the rack/cabinet using a Rack Bonding Conductor (RBC) and listed compression two hole lugs.

H. Structural Steel: Where the structural steel of a steel frame building is readily accessible within the room or space, bond each SBB and PBB to the vertical steel of the building frame.

I. Electrical Power Panelboards: Where an electrical panelboard for telecommunications equipment is located in the same room or space, bond each PBB/SBB to the equipment ground bar of the panelboard.

J. Shielded Cable: Bond the shield of shielded cable to the PBB/SBB in communications rooms and spaces. Comply with TIA-568.1-D and TIA-568-.2-D when grounding shielded balanced twisted-pair cables.

K. Rack- and Cabinet-Mounted Equipment: Bond powered equipment chassis to the rack bonding busbar (RBB) using unit bonding conductors (UBC). Power connection shall comply with NFPA 70; the equipment grounding conductor in the power cord of cord- and plug-connected equipment shall be considered as a supplement to bonding requirements in this Section.

L. Ladder Rack and Cable Tray: Bond ladder rack/cable tray system to the PBB/SBB using manufacturer approved ground lugs and bonding conductors. Remove paint from the ladder rack/cable tray to ensure ground lugs contact bare metal.

M. Metallic Conduits: In telecommunications rooms, bond metallic conduits longer than 24-inches to the PBB/SBB using insulated ground bushing sized for the conduit and ground conductor to be attached.

3.7 IDENTIFICATION

A. Comply with requirements in Section 270553 - Identification for Communications Systems.

3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
2. Bond Resistance Test: Test the bonding connections of the system using a certified micro-ohmmeter, taking two-point bonding measurements in each telecommunications equipment room containing a PBB/SBB and using the process recommended by BICSI TDMM. Conduct tests with the facility in operation.

    a. Measure the resistance between the following:
        1) Each PBB/SBB to the nearest electrical equipment ground.
        2) Each PBB/SBB to the structural steel.
        3) PBB to each SBB.
        4) Structural steel to the electrical ground.

    b. The maximum acceptable value of this bonding resistance is 100 milliohms.

3. Test for ground loop leakage currents using a certified digital clamp-on earth ground tester, with a full-scale of not more than 10 A, displaying current in increments of 0.01 A at an accuracy of plus/minus 2.0 percent.

    a. With the grounding infrastructure completed and the communications system electronics operating, measure the current in every conductor connected to the PBB and in each SBB. Maximum acceptable ac current level is 1 A.

B. Excessive Ground Resistance: If resistance to ground at the TBC exceeds 5 ohms, notify Engineer promptly and include recommendations to reduce ground resistance.

C. Grounding system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 270526

SECTION 270528 - PATHWAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, Section 260010 “General Requirements for Electrical”, and 270010 “Supplemental Requirements for Communications” apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Conduits and fittings.
2. Metallic surface pathways.
3. J-Hooks.
4. Boxes, enclosures, and cabinets.

1.3 REFERENCES

A. Abbreviations

B. Definitions

C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.

1. Building Industry Consulting Service International (BICSI)
   a. ANSI/BICSI N1 “Installation Practices for Telecommunications and ICT Cabling and Related Cabling Infrastructure.”

1.4 SUBMITTALS

A. Product Data: For each product type indicated.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency acceptable to authorities having jurisdiction and marked for intended location and application.

2.2 CONDUITS AND FITTINGS

A. Comply with 260533 “Raceways and Boxes for Electrical Systems”.

B. Conduit Bodies

1. Telecommunications style with standards based internal bend radius control.

2.3 SURFACE METAL PATHWAYS

A. Comply with 260533 “Raceways and Boxes for Electrical Systems”.

B. Boxes and Fittings: Comply with TIA-569 to maintain minimum cable bend radius.

2.4 J-HOOKS

A. Description: Comply with UL 2239, single and multi-tiered prefabricated sheet metal wide base cable supports with integral bend radius support for telecommunications cable.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal:

1. Panduit
2. Legrand
3. Eaton B-Line
4. nVent Caddy
5. Thomas & Betts

C. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

D. Material: Galvanized steel.

E. J shape.

F. UL 2043 and CAN/ULC S102.2 listed and suitable for use in air handling spaces.

G. Pre-riveted assembly allowing for attachment to walls, ceilings, beams, threaded rods, drop wires and underfloor supports to meet requirements of application indicated.

2.5 BOXES, ENCLOSURES, AND CABINETS

A. Comply with 260533 “Raceways and Boxes for Electrical Systems”.

B. General Requirements for Boxes, Enclosures, and Cabinets used for communications:

1. Device Box Dimensions:

a. Minimum 4 inches square by 3-1/2 inches for 1-inch pathways.
b. Minimum 4-11/16 inches square by 3-1/2-inch deep box for pathways 1-1/4 inches and larger.

2. Gangable boxes are prohibited.

PART 3 - EXECUTION

3.1 PATHWAY APPLICATION

A. Comply with requirements in Section 260533 - Raceways and Boxes for Electrical Systems for pathway application except as noted below.

B. Minimum Pathway Size: 1-inch trade size.

1. For Cat6A cable applications: minimum 1-1/4-inch trade size.

C. Install surface pathways only where indicated on Drawings or where approved by Engineer.

D. Use of flexible conduit is prohibited.

3.2 INSTALLATION

A. Comply with the following standards for installation requirements except where requirements indicated on Drawings or in this Section are more stringent:

1. NECA 1.
2. ANSI/BICSI N1.
3. TIA-569.
4. NECA 101.
5. NECA 111.

B. Comply with requirements in Section 260500 – Common Work Results for Electrical Systems for hangers, supports, and sleeves.

C. Comply with requirements in Section 260533 - Raceways and Fittings for Electrical Systems for installation of raceways and fittings except as noted below:

D. Install no more than the equivalent of two 90-degree bends in any pathway run. Support within 12 inches of changes in direction.

E. Utilize manufactured sweeps and long radius elbows for all optical-fiber cables.

F. Raceways for Optical-Fiber and Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:

1. 1-Inch Trade Size and Larger: Install pathways in maximum continuous lengths of 100-feet.
2. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
3. Minimum Bend Radius
   a. For trade size conduits 2-inch or less, provide inside bend radius at least 6 times the internal diameter of the raceway.
   b. For trade size conduits greater than 2-inch, provide inside bend radius at least 10 times the internal diameter.
4. Pull boxes should be readily accessible and should be installed in straight sections of conduit and not used in place of a bend.
5. Provide a conduit stub-up for each outlet box unless noted otherwise.

G. J-Hooks:

1. Size to allow a minimum of 25 percent future capacity without exceeding design capacity limits.
2. Provide dedicated support wires, threaded rod, beam clamps, or strut. Do not use ceiling grid support wire or support rods.
3. Install at spacing intervals to allow no more than 6-inches of slack and to provide a minimum of 6-inches of clearance from the lowest point of the cables to ceilings, mechanical ductwork and fittings, luminaires, power conduits, power, and telecommunications outlets, and other electrical and communications equipment.
4. Maximum Spacing: 4-feet on center.
   a. For Cat6A installations: 3-foot on center.
5. Provide a hook at each change in direction.
6. Do not exceed load ratings specified by manufacturer.
7. Do not install J-hooks that cannot be maintained without removal of another system.
8. Provide additional tiers where required to meet fill capacity and load rating requirements or to separate low voltage systems with varying voltage and power limitations.

3.3 PROTECTION

A. Protect installed cables in open cabling systems:

1. Install temporary protection for cables in open pathways to safeguard exposed cables against paint overspray, falling objects or debris during construction.
2. Replace any cable exposed to paint overspray or other foreign substance that voids the cable warranty, at no cost to the owner.
3. Temporary physical protection for cables and J-hooks can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.

END OF SECTION 270528

SECTION 270536 - CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, Section 260010 “General Requirements for Electrical”, and 270010 “Supplemental Requirements for Communications” apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Wire-mesh cable tray.
2. Cable tray accessories.

1.3 REFERENCES

A. Abbreviations

B. Definitions

1. Grounding: Establishing a direct or indirect connection to Earth or some conducting body that serves in place of Earth.
2. Bonding: Method by which all non-energized conductive materials are effectively interconnected to create a low impedance path.

C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest date as of the date of the Contract Documents, unless otherwise specified.

1. National Electrical Manufacturer’s Association (NEMA)
   a. NEMA VE 1 “Metal Cable Tray Systems”
   b. NEMA VE 2 “Cable Tray Installation Guidelines”

1.4 SUBMITTALS

A. Product Data: For each product type indicated.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR CABLE TRAYS

A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.

B. Source Limitations: Obtain cable trays, components, and accessories from single manufacturer.

C. Sizes and Configurations: Refer to Drawings for specific requirements for types, materials, sizes, and configurations.

2.2 WIRE-MESH CABLE TRAY

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton B-Line
2. Cablofil
3. Chatsworth
4. MP Husky
5. Siemon
6. Snake Tray
7. nVent WBT Tray

B. Description:

1. Configuration: steel wire mesh, complying with NEMA VE 1.
2. Minimum Width: 12 inches unless otherwise indicated on Drawings.
3. Minimum Usable Load Depth: 4 inches unless otherwise indicated on Drawings.
4. Straight Section Lengths: 10 feet, except where shorter lengths are required to facilitate tray assembly.
5. Structural Performance: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb concentrated load, when tested according to NEMA VE 1.
6. Splicing Assemblies: UL classified bolted type, using serrated flange locknuts.
7. Splice-Plate Capacity: UL Classified splices located within support span shall not diminish rated loading capacity of cable tray.

C. Materials and Finishes:

1. Steel:
   a. ASTM A 1011/A 1011M for 14 gage and thicker; ASTM A 1008/A 1008M for 16 gage and thinner.
   b. Straight Sections and Fittings: Comply with the minimum mechanical properties of ASTM A 1011/A 1011M, SS, Grade 33.
   c. Steel Tray Splice Plates: ASTM A 1011/A 1011M, HSLAS, Grade 50, Class 1.
   d. Fasteners: Comply with the minimum mechanical properties of ASTM A 510/A 510M, Grade 1008.
   e. Finish: Hot dip galvanized after fabrication, complying with ASTM A123/A123 M, Class B2 for use in indoor/outdoor locations.
      1) Hardware: Galvanized, ASTM B 633

2.3 CABLE TRAY ACCESSORIES

A. Fittings: Tees, crosses, risers, elbows, and other fittings indicated, of same materials and finish as cable tray.

B. Barrier Strips: Same materials and finishes as for cable tray.

C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.4 SOURCE QUALITY CONTROL

A. Testing: Test and inspect cable trays according to NEMA VE 1.

PART 3 - EXECUTION

3.1 CABLE TRAY INSTALLATION

A. Install cable trays according to NEMA VE 2.

B. Install cable trays as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.

C. Install cable trays to provide a minimum of 12-inch clear space above the top of the cable tray for cable installation.

D. Install cable trays with enough horizontal workspace to permit access for installing cables.

E. Install cable trays so all splices are accessible for inspection and adjustment.

F. Install cable trays to provide a minimum of 3-inch (6-inch recommended) clear space above ceiling tile and grid.

G. Remove burrs and sharp edges from cable trays.

H. Fasten cable tray supports to building structure.

I. Design fasteners and supports to carry cable tray, number of cables at full capacity, and a concentrated load of 200 lb. Comply with requirements in Section 260500 – Common Work Results for Electrical Systems.

J. Place supports so spans do not exceed maximum spans and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.

K. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.

L. Support assembly to prevent twisting from eccentric loading.

M. Locate and install supports according to NEMA VE 2. Do not install more than one cable tray splice point between supports.

N. Support wire-basket cable trays with trapeze hangers, or wall brackets.

O. Support trapeze hangers for wire-basket trays with minimum 1/4-inch diameter rods.

P. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.

Q. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed dimensions recommended in NEMA VE 2. Space connectors and set gaps according to applicable standard.

R. Make changes in direction and elevation using manufacturer's recommended fittings and integral bend radius control.

S. Make cable tray connections using manufacturer's recommended fittings.

T. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.

U. Install barriers to separate cables of different systems or of different insulation levels.

V. Where indicated, install permanent covers, after installing cable. Install cover clamps according to NEMA VE 2. Clamp covers on cable trays installed outdoors with heavy-duty clamps.

3.2 CABLE TRAY GROUNDING

A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 270526 - Grounding and Bonding for Communications Systems.

B. Cable trays shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.

C. When using epoxy- or powder-coat painted cable trays as a grounding conductor, completely remove coating at all splice contact points or ground connector attachment. After completing splice-to-grounding bolt attachment, repair the coated surfaces with coating materials recommended by cable tray manufacturer.

3.3 CABLE INSTALLATION

A. Install cables after each cable tray run has been completed and inspected.

B. Initial fill ratio shall not exceed 25%.

C. Initial cable fill shall not exceed 50% of the manufacturer’s listed load rating.

D. Fasten cables on vertical runs with cable clamps or cable ties every 18-inches according to NEMA VE 2. Fasten cables on horizontal runs where required to maintain a neat and workmanlike installation.

E. Tighten clamps and ties only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device and trim excess to prevent further tightening.

F. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure shall be no more than 72 inches.

G. Provide radius drop-outs wherever multiple cables are existing the cable tray.

H. In existing construction, remove inactive or dead cables from cable trays.

3.4 CONNECTIONS

A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.

B. Connect pathways to cable trays according to requirements in NEMA VE 2.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections.

1. After installing cable trays, provide visual survey for compliance with requirements.
2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
3. Verify that communications cabling is separated from power circuits by barriers or are installed in separate cable trays.
4. Verify there are no intruding items such as pipes, hangers, or other equipment in the cable tray.
5. Remove dust deposits, trash of any description, and any blockage of tray ventilation.
6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
7. Check for improperly sized or installed bonding jumpers.
8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.

B. Prepare test and inspection reports.

3.6 PROTECTION

A. Protect installed cable trays and cables.

1. Install temporary protection for cables in open trays to safeguard exposed cables against paint overspray, falling objects, or debris during construction.
2. Replace any cable exposed to paint overspray or other foreign substance that voids the cable warranty, at no cost to the owner.
3. Temporary physical protection for cables and cable tray can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.
4. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
5. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

END OF SECTION 270536

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SECTION 270553 - IDENTIFICATION FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, Section 260010 “General Requirements for Electrical”, and 270010 “Supplemental Requirements for Communications” apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Color and legend requirements for labels and signs.
2. Labels.
3. Signs.
4. Cable ties.

B. Related Requirements

1. Refer to Section 260553, “Identification for Electrical Systems” for additional requirements related to labeling of electrical equipment and cabling.

1.3 REFERENCES

A. Definitions

1. Identifier: An item of information that links a specific element of the telecommunications infrastructure with its corresponding record.

B. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.

1. Underwriters Laboratories Inc (UL)

a. UL 969, “Marking and Labeling Systems”

1.4 SUBMITTALS

A. Product Data: For each product type.

B. Identification Schedule: System Labeling Schedules with proposed designations for cables, outlets, terminations, and equipment.

1.5 COORDINATION

A. All identifications shall be consistent with the owner's standard practices, especially within existing facilities, unless otherwise require by codes. Where the requirements herein are in conflict, the contractor shall notify the engineer in writing prior to ordering any material.

B. All room names and/or numbers for labeling or programming shall use the Owner's approved room name and numbering scheme, not names and numbers indicated on floor plans. All reprogramming shall be included as required to accommodate construction phasing.

C. Coordinate with Owner for approval of all labelling codes and schemes prior to creation and installation of labeling system.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Comply with NFPA 70 and TIA 606 for a Class 2 system.

B. Comply with UL 969 for Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

C. Labels shall be designed to remain permanently affixed and shall not fade under typical environmental conditions for the life of the product identified.

D. Thermal Movements: Allow for thermal movements from ambient temperatures up to 120-deg F and surface temperatures up to 180-deg F.

E. Provide mechanically printed black letters on a white field unless noted otherwise.

F. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Brady
2. Brother
3. Dymo
4. HellermanTyton
5. Panduit

2.2 LABELS AND TAGS

A. Heat Shrink Tubes: Flame-retardant shrinkable polyolefin tube with thermal transfer-printed identification label. Sized to suit diameter of cable and shrinks to fit firmly around cable it identifies. Full shrink recovery at a maximum of 200 deg F.

B. Self-Adhesive Labels: Thermal transfer-printed, minimum 3-mil- thick, flexible labels with acrylic pressure-sensitive adhesive.
1. Wraparound Vinyl or Nylon Cloth Type: Repositionable for wrapping and flagging flexible cables.
2. Self-Laminating Vinyl Type: Clear wrap around tail shield laminates the entire printed legend for abrasion, UV-, weather- and chemical-resistance on flexible cables.
3. General Purpose Polyester Type: for component labelling on flat surfaces.

C. Marker Plate Tags: Thermal transfer printed, UV, weather, and chemical resistant polyolefin suitable for large cables or bundles. Pre-punched holes for attachment with cable ties.

2.3 SIGNS AND NAMEPLATES

A. Engraved Plastic Signs and Nameplates:

1. 3-layer melamine plastic laminate
2. Weather and UV-resistant for Wet and Damp Locations.
3. Thickness:

    a. For signs up to 20 sq. in., minimum 1/16 inch thick.
    b. For signs larger than 20 sq. in. or 8 inches in length, 1/8 inch thick.
    c. Engraved designation with black letters on white face
    d. Punched or drilled for mechanical fasteners with 1/4-inch grommets in corners for mounting. Exception for locations where specifically approved contact type permanent adhesive may be used where screws cannot or should not penetrate substrate.
    e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.4 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in Division 09 painting Sections for paint materials and application requirements. Select paint system suitable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs:
1. Self-tapping, stainless-steel screws, or stainless-steel machine screws with nuts and flat and lock washers.
2. Pop-Rivets.
3. Two-Part Epoxy Adhesive

C. Cable Ties: Self-extinguishing, one-piece, self-locking, UV-stabilized or plenum rated where required by installed environmental conditions. 3/16-inch minimum width.

PART 3 - EXECUTION

3.1 CABLING ADMINISTRATIVE DRAWINGS

A. Provide professionally produced, scaled drawings using Computer Aided Design software identifying the location and labelling of Communications devices served out of each telecom room.

B. Print on Arch D or E1 size paper and install in a prominent location in each equipment room and wiring closet so as not to interfere with future equipment installation.

C. Provide rigid frame and 1/8-inch clear plastic protective overlay.

D. Supply separate drawings for each Communications Room.

3.2 INSTALLATION

A. Mechanically produce all labels. Write-on labels are not permitted.

B. Install identifying devices before installing acoustical ceilings or similar concealment.

C. Verify identity of each item before installing identification products.

D. Self-Adhesive Identification Products: Before applying communications identification products, clean substrates of substances that could impair bond using materials and methods recommended by manufacturer of identification product and manufacturer of substrate to retain product warranties.

E. For surfaces that require a finish, apply identification devices to surfaces after completing finish work.

F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of communications systems and connected items.

G. Install all labels in a neat manner, plumb and parallel to equipment lines.

H. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

I. Provide labels within 12-inches from cable termination points and secure tight to surface at a location with high visibility and accessibility for ease of identification after termination.

3.3 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

B. Equipment Room Racks, Cabinets, and Frames:

1. Identify top and bottom, front and rear of each with self-adhesive engraved laminated plastic nameplate containing rack or cabinet identifier (xy).
2. Label Size: minimum 2-inches in height with letters no less than 1-1/2-inches tall.

C. Rack Patch Panels and Fiber Enclosures:

1. Label each fiber enclosure and patch panel with a letter (-r) designating the order of the panel from the top of the cabinet or frame.
2. Label each fiber enclosure adapter panel with self-adhesive label indicating range of port numbers.
3. Label fiber enclosure cover with self-adhesive labels indicating each backbone cable link identifier including:

    a. Near end port numbers
    b. Far end building identifier (b) for inter building cable.
    c. Far end Telecomm space identifier (fs)
    d. Far end rack identifier (xy)
    e. Panel identifier (-r)
    f. Panel port numbers (: p)

4. Label each patch panel port or group of ports with a self-adhesive label or manufacturer provided insert indicating the following:

    a. Room number of outlet being served.
    b. Faceplate number.
    c. Patch panel port number

5. Use manufacturer provided labels and mounting surfaces wherever possible.

D. Wall Punchdown Blocks
1. Label each cable termination position with a sequential number designator.
2. Where insert type labels are used, install clear plastic cover over mechanically produced labels.
3. Use manufacturer provided labels and mounting surfaces wherever possible.

E. Backbone Cables:
1. Label each cable with a thermal transfer marker tag indicating the backbone cable link identifier including the following:

a. Strand/pair count and cable type
b. Near end identifier and far end identifier including:

1) Building identifier (b) for inter building cable
2) Telecomm space identifier (fs)
3) Rack identifier (xy)
4) Panel identifier (-r)
5) Port grouping(:p)

2. Label Backbone cables at termination points and entrance/exit point of telecom space.
3. Outside plant pathways: In addition to labels at termination points, label each backbone cable at all manholes, handholes, and pull points where cable enters and exits pathway.

F. Horizontal Cables:
1. Label each cable with a vinyl self-laminating label indicating the horizontal cabling link identifier including:

a. Room and faceplate number.
b. Telecomm Space identifier (fs)
c. Rack identifier (xy)
d. Patch Panel identifier (-r)
e. Patch Panel port number (: p)

2. Outside plant pathways: In addition to labels at termination points, label each cable at manholes, handholes, and pull points where cable enters and exits pathway.

G. Faceplates:

1. Label individual faceplates with self-adhesive labels or manufacturer provide insert. Place label at top of faceplate. Each faceplate shall be labeled with its individual, sequential designation, numbered clockwise when entering room from primary egress, indicating the following:

a. Room number of outlets
b. Faceplate number.

2. Label each individual jack within the same faceplate with its horizontal link identifier.

H. Telecommunications Bonding Busbars and Conductors

1. Label each Busbar with a self-adhesive label indicating the following:

a. Telecomm space identifier (fs)
b. Busbar identifier

2. Label each bonding conductor with a vinyl self-laminating label indicating the far end busbar or object identifier
3. Label each bonding conductor at its attachment point with a thermal transfer marker tag with the following.

    a. WARNING: IF CABLE OR CONNECTOR IS LOOSE OR MUST BE REMOVED, PLEASE CONTACT TELECOMMUNICATIONS MANAGER.

4. Warning labels: yellow marker plate type with black print.

I. Underground duct and raceway

1. Label both ends of each underground duct and raceway with self-adhesive label indicating the following:
    a. Pathway Identifier and sequence number
    b. Far End Building Identifier (b)
    c. Far End Telecomm Space Identifier (fs)
    d. Far End Outdoor Space Identifier (T)

END OF SECTION 270553

SECTION 271100 - COMMUNICATIONS EQUIPMENT ROOM FITTINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, Section 260010 “General Requirements for Electrical”, and 270010 “Supplemental Requirements for Communications” apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Backboards
2. 19-inch equipment racks.
3. 19-inch freestanding equipment cabinets.
4. 19-inch wall-mounted equipment cabinets.
5. Cable Management.
6. Ladder Rack/Cable Runway.
7. Rack Power Distribution.
8. Rack Bonding Busbars.
9. Building Entrance Protection.

B. Related Requirements:

1. Section 270536 "Cable Trays for Communications Systems" for cable trays and accessories.
2. Section 271300 "Communications Backbone Cabling" for copper, optical fiber, and coaxial data cabling and termination devices.
3. Section 271500 "Communications Horizontal Cabling" for copper and coaxial data cabling and termination devices.

1.3 REFERENCES

A. Abbreviations

1. RCDD: Registered communications distribution designer.
2. SBB: Secondary Bonding Busbar (Formerly TGB).
3. PBB: Primary Bonding Busbar (Formerly TMGB).
4. RBB: Rack/Cabinet Bonding Busbar.

B. Definitions

1. Access Provider: An operator that provides a circuit path or facility between the service provider and user. An access provider can also be a service provider.
2. Ladder Rack: A specialized cable tray with side stringers and cross members, resembling a ladder, which supports cable either vertically or horizontally within an equipment room.
3. Service Provider: The operator of a telecommunications transmission service delivered through access provider facilities.

C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.

1. Building Industry Consulting Service International (BICSI)

a. ANSI/BICSI N1 “Installation Practices for Telecommunications and ICT Cabling and Related Cabling Infrastructure”

1.4 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For custom equipment racks and cabinets.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. UL Listed.

B. RoHS compliant.

2.2 BACKBOARDS

A. Backboards: AC grade plywood, fire-retardant treated, 3/4 by 48 by 96 inches.

B. Backboard Paint: Light-colored fire-retardant paint.

2.3 19-INCH EQUIPMENT RACKS

A. Description: Two- and four- post racks with threaded rails designed for mounting telecommunications equipment. Width is compatible with EIA/ECIA 310-E, 19-inch equipment mounting with an opening of 17.72 inches between rails.

B. Manufacturers: Subject to compliance with requirements, provide product indicated on drawings or approved equal by one of the following:

1. Belden
2. Chatsworth CPI
3. Great Lakes
4. Ortronics
5. Middle Atlantic
6. Panduit
7. Siemon

C. General Requirements:

1. Frames: Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
2. Material: Extruded aluminum.

3. Finish: Manufacturer's standard, baked-polyester powder coat.
4. Color: Black.

D. Floor-Mounted Racks:

1. Overall Height: 84 inches or as indicated on Drawings.
2. Overall Depth: 20 inches.
3. Upright Depth: 3 inches.
4. Two-Post Load Rating: 1000 lb minimum.
5. Four-Post Load Rating: 2000 lb minimum.
6. Number of Rack Units per Rack: 45U or as indicated on Drawings.

    a. Numbering: Every rack unit, on interior of rack.

7. Threads: #12-24 universal hole pattern.
8. Provisions for attaching vertical and horizontal cable management channels, top and bottom cable troughs, and grounding lug.
9. Base shall have a minimum of four mounting holes for permanent attachment to floor.
10. Top shall have provisions for attaching to cable tray or ceiling.
11. Self-leveling.
12. Four post rack shall be adjustable in depth in 1” increments.
13. Horizontal RBB for two post racks, Vertical RBB for four post racks.

E. Wall-Mounted Racks:

1. Height: 40” minimum or as indicated on Drawings.
2. Depth: 29 inches minimum.
3. Load Rating: 150 lb minimum.
4. Number of Rack Units per Rack: 19U minimum or as indicated on Drawings.
5. Threads: #12-24 universal hole pattern.
6. Wall Attachment: Four mounting holes.
7. Equipment Access: Integral swing.
8. Horizontal RBB.

2.4 19-INCH EQUIPMENT CABINETS

A. Description: Manufacturer-assembled four-post frame enclosed by side and top panels and front and rear doors, designed for mounting telecommunications equipment. Width is compatible with EIA/ECIA 310-E, 19-inch equipment mounting with an opening of 17.72 inches between rails.

B. Manufacturers: Subject to compliance with requirements, provide product indicated on drawings or approved equal by one of the following:

1. Belden
2. Chatsworth CPI
3. Great Lakes
4. Ortronics
5. Middle Atlantic
6. Panduit
7. Siemon

C. General Cabinet Requirements:

1. Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
2. Material: Steel.
3. Finish: Manufacturer's standard, baked-polyester powder coat.
4. Color: Black.

D. Modular Freestanding Cabinets:

1. Overall Height: 84 inches or as indicated on Drawings.
2. Overall Depth: minimum 36-inches.
3. Load Rating: 2500 lb. minimum.
4. Number of Rack Units: 45 or as indicated on Drawings.
    a. Numbering: Every rack unit, on interior of rack.
5. Threads: #12-24 universal hole pattern.
6. Removable and lockable side and top panels.
7. Perforated, hinged, and lockable front and rear doors.
8. Adjustable feet for leveling.
9. Cable ports with sealed grommets in top panel.
10. Integral lashing brackets and vertical cable management.
11. Vertical RBB.
12. Rack-mounted, minimum 550-cfm fan with filter.
13. Power strip.
14. All cabinets keyed alike.
15. Bonding wires for all panels.

E. Modular Wall Cabinets:

1. Height: 36 inches or as indicated on Drawings.
2. Depth: 30 inch minimum.
3. Load Rating: 200 lb. minimum.
4. Number of Rack Units: 18U or as indicated on Drawings.
5. Threads: #12-24 universal hole pattern.
6. Dual Hinged swing out body
7. Lockable front and rear doors.
8. Louvered side panels.
9. Knockouts for conduit or cable entry grommets in top and bottom rear.
10. Integral lashing brackets and vertical cable management.
11. Grounding lugs.
12. Horizontal RBB.
13. Side-mounted, minimum 100-cfm fan.
14. All cabinets keyed alike.
15. Bonding wires for all panels.

2.5 CABLE MANAGEMENT

A. Description: accommodates the support and orderly routing of cabling inside equipment racks and/or cabinets within the communications rooms. Managers shall protect network equipment by controlling cable bend radius and providing cable strain relief.

B. Source Limitations: Obtain rack/cabinet cable management from same manufacturer or alliance partner as the rack/cabinet.

C. Vertical Cable Management for Racks and Cabinets

1. Double sided, front, and rear
2. Mounts to side of rack/cabinet
3. Material: Steel panels and Plastic fingers
4. Cable fingers with rounded edges at 1U intervals
5. Height to match rack/cabinet
6. Width: 6” or as indicated on drawings
7. Cable distribution spools
8. Color: Black
9. Hinged front and rear doors

D. Horizontal Cable Management for Racks and Cabinets

1. Double sided, front, and rear
2. Cable finger with rounded edges along top and bottom surfaces
3. Hinged front and rear cover
4. Height: 2U or as indicated on drawings
5. Color: Black

E. Cable Support Rings: NTRL labeled. Designed to prevent degradation of cable performance and pinch points that could damage cable.

1. D-shaped wall mount loop designed for cable management
2. Continuous loop for pull through cable installation or open slot insertion type cable installation
3. Size: various pre-manufactured sizes
4. Mounting holes for attachment with screws
5. Material: Rigid nylon or zinc covered steel

2.6 LADDER RACK/CABLE RUNWAY

A. Description: Accommodates the support and orderly routing of cabling within the communications rooms from the cable pathway to the equipment racks and/or cabinets.

B. Manufacturers: Subject to compliance with requirements, provide product indicated on drawings or approved equal by one of the following:

1. Chatsworth CPI
2. Eaton B-Line
3. Ortronics
4. Panduit
5. Snake Tray

C. General Requirements

1. 1-1/2 inch high by 3/8 inch wide tubular steel
2. Rung spacing: minimum 12-inches on center.
3. Color: Black powder coat
4. Width: 12-inches or as indicated on Drawings

5. Minimum linear cable bearing surface of 1-1/2 inches per linear foot.

D. Fittings and Accessories:

1. Install all fittings, supports, splices, etc. for the ladder rack system to provide a complete assembly- including fasteners, hardware, and other items required to complete the installation as indicated on the drawings.
2. Fittings shall be pre-manufactured, and match rung size and spacing, material, and finish of ladder rack.
3. Mechanically connect ladder rack sections and turns together with splices and jumpers to form an electrically continuous pathway.

2.7 RACK POWER DISTRIBTUTION

A. Manufacturers: Subject to compliance with requirements, provide product indicated on drawings or approved equal by one of the following:

1. Tripp Lite
2. Panduit
3. Leviton
4. Chatsworth CPI
5. Middle Atlantic
6. Geist
7. Siemon

B. Power Distribution Unit: Comply with UL 1363.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Rack mounting.
3. Height: 1 RU.
4. Housing: Metal
5. Minimum Two front-facing 15-A, 120-V ac, NEMA WD 6, Configuration 5-15R and Ten rear facing 20-A, 120-V ac, NEMA WD 6, Configuration 5-20R receptacles.
6. LED indicator lights for power and protection status.
7. LED indicator lights for reverse polarity and open outlet ground.
8. Circuit Breaker and Thermal Fusing: When protection is lost, circuit opens and cannot be reset.
9. Cord connected with 10-foot line cord.
10. Rocker-type on-off switch illuminated when in on position.
11. Surge Protection: UL 1449, Type 3.
    a. Maximum Surge Current, Line to Neutral: 96 kA and neutral to ground.
    b. UL 1449 Voltage Protection Rating for line to neutral and line to ground shall not be more than 330 V.
    c. EMI/RFI noise filtering: 40-80dB.
    d. AC Suppression Joule Rating: 3800 J minimum.

2.8 RACK BONDING BUSBAR

A. Comply with requirements in Section 270526 - Grounding and Bonding for Communications Systems for bonding conductors and connectors.

B. Source Limitations: Obtain rack/cabinet grounding hardware from same manufacturer or alliance partner as rack/cabinet.

C. Rack and Cabinet Bonding Busbars (RBB): Rectangular bars of electro-plated copper, accepting conductors ranging from No. 14 to No. 2/0 AWG, NRTL listed as complying with UL 467, and complying with TIA-606-C. Predrilling shall be with holes for use with lugs specified in this Section.

1. Rack-Mounted Horizontal RBB: Designed for mounting in 19-inch equipment racks. Include stainless-steel or copper-plated hardware and insulator blocks for attachment to the rack.
2. Rack-Mounted Vertical RBB: 72 inches long, with stainless-steel or copper-plated hardware and insulator blocks for attachment to rack.

D. Stand-Off Brackets: Non-conductive nylon “L” brackets mounted to back channel of rack/cabinet, providing tie-down point for grounding and bonding cable runs.

2.9 BUILDING ENTRANCE PROTECTION

A. Description: The building entrance protection terminals safeguard communication equipment from damaging electrical surges on outside plant cables.

B. Manufacturers: Subject to compliance with requirements, provide product indicated on drawings or approved equal by one of the following:

1. Circa Telecom
2. Tii Technologies
3. Vertiv

C. Terminals: Comply with UL497 for primary and secondary protection.

1. Accept UL listed industry standard 5-pin protection modules.
2. Built in splice chamber for input cable
3. 66 block style quick clip connectors for input and output terminals
4. Available in 25, 50, and 100 pair counts
5. Stackable to accommodate future growth
6. Internal 26AWG fuse link.

D. Protection Modules
1. Solid State protector module with self-resetting current limiters.
2. Minimum 5 ns transient surge response time

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

A. Contact telecommunications service provider and arrange for installation of demarcation point, protected entrance terminals, and a housing when so directed by service provider.

B. Comply with requirements in Section 270528 - Pathways for Communications Systems and Section 260543 - Underground Pathways and Structures for Electrical Systems for materials and installation requirements for raceways.

3.2 INSTALLATION

A. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

B. Backboards:

1. Install from 6-inches to 8-feet, 6-inches above finished floor on all walls of communications space with A side exposed to the interior. Ensure that fire-rating stamp is visible after installation.
2. Paint all sides of backboard with two coats of fire-retardant paint, leaving fire rating stamp visible.

C. Racks and Cabinets

1. Provide racks and cabinets with a minimum 36-inches of clear, unobstructed space from the front and rear of the rack/cabinet.
2. Securely fasten floor mounted racks and cabinets to the structural floor using manufacturers recommended anchors or as required by local codes.
3. Install wall mounted racks and cabinets with hinged enclosures or frames so that it can be accessed fully without obstruction by other building, storage, or architectural components. Follow the manufacturer's installation instructions for securing the rack/cabinet to the wall and backboard.
4. Install and adjust to position all rack/cabinet accessories including cable management, power distribution, mounting rails, thermal management, and grounding prior to installing any equipment into the rack/cabinet.

D. Cable Management

1. Attach vertical cable managers to the side of the rack/cabinet using the manufacturer’s installation instructions and included hardware.
2. When a single vertical cable manager is used between two racks/frames, attach the vertical cable manager to both racks/frames.
3. Locate horizontal managers so that the number of ports (cables) that each manager supports does not exceed each cable manager’s cable fill capacity. Provide a minimum of one horizontal cable manager above each patch panel.
4. The color of the rack(s)/cabinets(s) and cable manager(s) must match.
5. Securely attach covers to the cable manager(s) after cabling is complete.
6. Space rings at maximum intervals of 12 inches along the path of the cables served.
7. Provide rings of sufficient size and quantity so that no ring is utilizing more than 25% of the rated capacity.

3.3 LADDER RACK/CABLE RUNWAY

A. Secure to the structural ceiling, building truss system, wall, or floor and to the tops of equipment racks and/or cabinets using the manufacturer’s recommended supports and appropriate installation hardware.

B. Ladder rack splices will be made in mid-span, not over a support, with the manufacturer’s recommended splice hardware.

C. Support ladder rack in accordance with TIA-569-E and the following:
1. A minimum of every 5-feet for straight runs.
2. Within 2-feet of every splice.
3. Within 2-feet on all sides of every intersection.
4. Within 2-feet on both sides of every change in elevation.
5. Every 2-feet when attached vertically to a wall.

D. Leave a minimum of 12-inches in between ladder rack and ceiling/building truss structure. Install multiple tiers of ladder rack with a minimum clearance of 12-inches in between each tier of ladder rack.

E. Provide an elevation kit to maintain a minimum of 6-inches in between ladder rack and the tops of equipment racks and/or cabinets.

F. Provide vertical ladder rack and supports where vertical distance between sleeves/pathways and horizontal ladder rack exceeds 5-feet.

G. Within each telecommunications room, bond ladder rack together with manufacturer's recommended ground straps, and bond to the PBB/SBB, unless otherwise noted in the specifications and contract documents.
1. Bond ladder rack and turns across each splice with a bonding kit.
2. Bond ladder rack to the PBB/SBB using an approved ground lug on the ladder rack and a minimum #6 grounding wire or as recommended by the AHJ.
3. Remove paint from the ladder rack where bonding/ground lugs contact the ladder rack so that the lug will contact bare metal.
4. Use antioxidant joint compound in between the bare metal on the ladder rack and ground lug and in between the bus bar and the ground lug.
5. Verify continuity through the bonds at splices, intersections between individual ladder rack sections and turns, and through the bond to the PBB/SBB.

H. Use a radius drop to guide cables wherever cable exits overhead ladder rack to access a rack, cabinet, or termination field. Provide a moveable cross member to attach and align the radius drop in between the welded cross members of a ladder rack.

I. Cover the exposed ends of the ladder rack that do not terminate against a wall, the floor, or the ceiling with end caps made from a rubberized material or an end closing kit.

J. Provide touch-up paint color-matched to the finish on the ladder rack and correct any minor cosmetic damage (chips, small scratches, etc.) resulting from normal handling during the installation process prior to delivery to the owner.

K. Initial cable fill shall not exceed 2-inches in height and shall not exceed 25% of the interior area of the ladder rack. The interior area of ladder rack will be considered to be the width of the ladder rack multiplied by a height of 2-inches. Provide cable retaining posts where initial cable fill is exceeded.

L. Do not exceed load ratings specified by manufacturer.

3.4 GROUNDING

A. Provide bonding conductors and connectors in accordance with requirements in Section 270526 - Grounding and Bonding for Communications Systems.

B. Clean the rack bonding busbar (RBB) and apply a compatible antioxidant prior to fastening connectors to the busbar.

C. Install RBB on rack or cabinet using block insulators to provide a minimum of 0.75 inches of separation.

D. Connect RBB to either the Rack Bonding Conductor (RBC) or Telecommunications Equipment Bonding Conductor (TEBC) and to the rack using listed compression two-hole lugs.

3.5 IDENTIFICATION

A. Provide component labelling in accordance with requirements in Section 270553 - Identification for Electrical Systems.

END OF SECTION 271100

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SECTION 271300 - COMMUNICATIONS BACKBONE CABLING

PART 1 - GENERAL

1.1 RELATED DOCUEMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, Section 260010 “General Requirements for Electrical”, and 270010 “Supplemental Requirements for Communications” apply to this Section.

1.2 SUMMARY

A. Backbone Cabling Description:

1. The backbone cabling system shall provide intra- and/or inter-building connections between communications equipment rooms, main terminal space, and entrance facilities in an multi room telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.

B. Section Includes:

1. Multimode, optical fiber cable.
2. Single-mode, optical fiber cable.
3. Optical fiber cable hardware.

1.3 REFERENCES

A. Abbreviations

1. OTDR: Optical Time Domain Reflectometer
2. OSP: Outside Plant

B. Definitions

1. Backbone Cable: Cable and connecting hardware that provide interconnections between telecommunications rooms, equipment rooms, and entrance facilities.

C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.

1. Building Industry Consulting Service International (BICSI)

a. ANSI/BICSI N1, “Installation Practices for Telecommunications and ICT Cabling and Related Cabling Infrastructure”

2. National Electrical Contractors Association (NECA)

a. NECA 301, “Installing and Testing Fiber Optics”

1.4 SUBMITTALS

A. Product Data: For each type of product.

B. Product Schedule: For each type of cable, identify intended location and use.

C. Optical Fiber, Twisted Pair Cable Testing Plans:
1. Sample test report sheet for each type of test required
2. Description of the cable testing procedures to be used including equipment to be used and testing standards equipment will test to.

D. Closeout Submittal
1. Operation and Maintenance Data: In addition to the items specified in Division 01 and Section 260010 “General Requirements for Electrical” include the following:
a. Cable Test Results

PART 2 - PRODUCTS

2.1 GENERAL CABLE CHARACTERISTICS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

1. Plenum Applications: Type OFNP, OFCP, or CMP complying with NFPA 262
2. Non-plenum applications: Type OFNR, OFCR, or CMR complying with UL 1666
3. Wet Location or Outdoor Applications: OSP.

B. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

2.2 OPTICAL FIBER PERFORMANCE REQUIREMENTS

A. General Performance: Optical Fiber Backbone cabling system shall comply with minimum performance values below as well as transmission standards in TIA-568.1 and TIA-568.3, when tested according to test procedures in TIA-568.

B. Manufacturers: Subject to compliance with requirements, provide product indicated or approved equal by one of the following:

1. Belden
2. Berk-tek
3. Commscope Systimax
4. Corning
5. General Cable
6. Panduit
7. Siemon
8. Superior Essex

C. Jacket Identification

1. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches
2. Provide cable cordage jacket, fiber, unit, and group color in accordance with TIA-598.
3. Color:
   a. OM4: Orange
   b. OS2: Yellow
   c. OSP: Black

D. 50 Micrometer cabling and connectivity products shall use bend insensitive fiber.

E. 850nm Laser Optimized 50/125 Micrometer, Multimode, Optical Fiber (OM4)

1. Comply with TIA-492AAAD for detailed specifications
2. Maximum Attenuation Coefficient: 3.0 dB/km at 850 nm; 1.0 dB/km at 1300 nm.
3. Minimum Over-Filled Launch Bandwidth: 3500 MHz-km at 850 nm; 500 MHz-km at 1300 nm.
4. Minimum Effective Modal Bandwidth-length Product: 4700 MHz-km at 850 nm.

F. 9/125 Micrometer, Single-Mode, Optical Fiber (OS2)

1. Comply with TIA-492CAAB for detailed specifications.
2. Maximum Attenuation Coefficient: 0.4 dB/km at 1310 nm; 0.4dB/km at 1550 nm.

2.3 INDOOR OPTICAL FIBER CABLE

A. Description: Tight Buffer, armored distribution optical fiber cable suitable for use in indoor applications.

B. Comply with ICEA S-83-596 for mechanical properties.

C. Tight Buffer Cable Construction

1. 900 µm thermoplastic buffered fibers
2. Lightweight aramid yarn overall strength member.
3. Ripcord to facilitate jacket removal.
4. Multiple subunits with central dielectric strength member for cables with greater than 24 fibers.
5. Flame retardant jacket.

D. Armor

1. Aluminum Interlocking Armor with additional outer jacket

2.4 INDOOR/OUTDOOR OPTICAL FIBER CABLE

A. Description: Tight Buffer, armored distribution optical fiber cable suitable for use in indoor or outdoor applications.

B. Comply with ICEA S-104-696 for mechanical properties.

C. Tight Buffer Cable Construction

1. 900 µm thermoplastic buffered fibers
2. Water blocking aramid yarn overall strength member.
3. Ripcord to facilitate jacket removal.
4. Multiple subunits with central dielectric strength member for cables with greater than 24 fibers.
5. UV-, Moisture-resistant, Flame retardant jacket.

D. Armor

1. Aluminum Interlocking Armor with additional outer jacket

2.5 OUTDOOR OPTICAL FIBER CABLE

A. Description: Loose Tube, armored distribution optical fiber cable suitable for use in outdoor applications.

B. Comply with ICEA S-87-640 for mechanical properties.

C. Loose-Tube Cable Construction

1. Gel-Free Loose Buffer Tubes with dry water blocking material
2. Aramid yarn overall strength member.
3. Ripcord to facilitate jacket removal.
4. Color coded buffer tubes stranded around central dielectric strength member
5. Water Blocking tape.
6. Single UV-, Moisture-resistant jacket.

D. Armor

1. Aluminum Interlocking Armor with additional outer jacket

2.6 OPTICAL FIBER CABLE HARDWARE

A. Source Limitations: Obtain optical fiber cable hardware from same manufacturer or alliance partner as optical fiber cable.

B. Standards:

1. Comply with Fiber Optic Connector Intermateability Standard (FOCIS) specifications of the TIA-604 series.
2. Comply with TIA-568.3.

C. Modular Patch Panels:

1. Rack mount, metal patch panel with numbered units that accept adapter panels or individual adapter modules.

D. Fiber Enclosures

1. Steel Enclosure used to protect and manage fiber optic terminations and splices.
2. Provide integral bend radius control and cable management for fiber patch cords.
3. Include grommets, cable ties, spools, and brackets to provide strain relief for cable routing.
4. Rack Mount
   a. Enclosure with slide-out, tilt down tray suitable for installation in standard EIA 19" rack rails
   b. Front and rear access with latching hinged doors.
5. Wall Mount
   a. Compact enclosure segmented into service and user sides with latching door for each segment.

E. Fiber Adapter Panels

1. Snap-in installation into fiber enclosures and fiber patch panels

2. Contains compatible simplex or duplex fiber optic adapter modules and meets or exceeds TIA-568.3 requirements.

F. Adapter Modules:

1. Female; simplex and duplex; ceramic sleeve, modular adapter designed for mating two fiber optic connectors.
2. Follow the TIA-568.3 suggested color identification scheme
3. Designed to snap into an adapter panel or faceplate.

G. Connectors:

1. Pre-polished, factory terminated, Fusion splice-on connectors with integral strain relief boot for termination of 900 µm buffered fibers.
2. Type: Type LC complying with TIA-604-10-B connectors.
3. Maximum Insertion loss: 0.4 dB for multi-mode or single-mode connectors.

H. Pigtail Assemblies:

1. Multi-leg, factory terminated, fiber connector assembly for termination of tight buffered or loose tube cables.
2. Maximum Insertion loss: 0.4 dB for multi-mode or single-mode connectors.

I. Buffer Tube Fan-Out Kits:

1. 900 µm fan out assembly for use when terminating 250 µm coated fibers in loose buffer tubes.
2. Color coded to match fiber color scheme.
3. Rated for installed environment.

J. Patch Cords: Factory-made, push-pull type, dual-fiber cables in varying lengths.

K. Splices

1. Type: Fusion
2. Maximum Insertion loss: 0.3 dB for multi-mode or single-mode splices.
3. Provide heat shrinkable sleeve to secure and protect splice while maintaining individual access.

L. Splice Trays

1. Metal enclosure with integral strain relief, cable management, and fiber spooling for protection of splices.
2. For use with both loose-tube and tight buffered fiber optic cable in indoor fiber enclosures or outdoor splice enclosures

M. Outdoor Splice Closures

1. Non-metallic housing with hinged case, re-usable seal, and locking clips for easy access.
2. Provide re-enterable sealing components to prevent water penetration into the closure. Injected encapsulate is not permitted.
3. Suitable for aerial, underground, or direct buried applications.
4. Size to accommodate the number of fiber splices indicated plus 25% spare capacity.
5. Accommodate splice trays suitable for single fiber, heat shrink, mechanical, or fusion splices.
6. The cable clamping and sealing hardware used to terminate the optical fiber cable shall not cause an attenuation change greater than ± 0.05 dB per fiber.
7. Provide appropriate hardware and installation procedures to facilitate the bonding and grounding of metal components in the closure and any armored cable sheath.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

A. Coordinate service backbone cabling with the protectors and demarcation point equipment provided by communications service provider.

3.2 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for pathways specified in Section 270528 "Pathways for Communications Systems."
3. Unenclosed wiring methods may be used in accessible ceiling spaces.

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools. Install conductors parallel with or at right angles to sides and back of enclosure.

3.3 GENERAL REQUIREMENTS FOR BACKBONE CABLING INSTALLATION

A. Comply with NECA 1, NECA 301, and NECA/BICSI 568.

B. Terminate all cables; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.

C. Cables may not be spliced unless noted otherwise.

D. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.

E. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.

F. Bundle, lace, and train cable to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.

G. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.

H. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.

I. In each telecommunications space, securely fasten all backbone cables and provide a 30-foot- long service.

J. Backbone cables shall be installed separately from horizontal cables:

1. Where backbone cables and horizontal cables are installed in a cable tray or wireway, backbone cables shall be installed first and segregated from the horizontal cables.
2. Where cables are routed using conduits or j-hooks, the backbone and horizontal cables shall be installed in separate conduits/j-hooks.

K. Open Cable Installation

1. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
2. Cable and support hardware shall not obstruct access to panels, equipment, valves, boxes, or other control devices.

L. Support vertical runs of cable with a wire mesh grip, messenger strand, cable ladder, or other method to provide proper support for the weight of the cables.

M. Provide inner duct for installation of new cabling in conduit with existing cables. Do not install new cabling in same conduit or innerduct with existing cables.

N. Under no circumstances shall the cable or patch cords be painted, treated, or covered with other material unless approved by the manufacturer, Owner, and Engineer.

3.4 INSTALLATION OF OPTICAL FIBER BACKBONE CABLES

A. Strip each fiber cable upon entering the splice tray and route the individual fibers in the splice tray.

B. Provide 20-inch slack loop and neatly coil fiber within the fiber splice tray or enclosure. Unprotected fiber shall not be allowed external to the fiber enclosure.

C. Attach each individual cable to the respective fiber enclosure by mechanical means. The cables strength member shall be securely attached the cable strain relief bracket in the enclosure.

D. A maximum of 12 strands shall be spliced in each tray.

E. All spare strands shall be installed into spare splice trays or adapter panels.

F. Provide blank adapter panels for all un-used spaces in fiber enclosures.

G. After system testing and acceptance, seal outdoor splice closures and flash test with a maximum of 10 PSI to ensure water-proof seal.

3.5 IDENTIFICATION

A. Provide identification of cabling and devices in accordance with Section 270533 “Identification for Communications Systems”.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections on all new and modified cabling and termination hardware.

B. Tests and Inspections:

1. Visually inspect optical fiber and twisted pair jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding and inspect cabling connections for compliance with TIA-568.
2. Visually confirm Category marking of outlets, cover plates, outlet/connectors, and patch panels.
3. Visually inspect cable placement, cable termination, cable bend radius, grounding and bonding, equipment, and patch cords, and labeling of all components.
4. Field-test instruments shall be approved by the cable manufacturer, be within the calibration period recommended by the instrument manufacturer and meet a minimum Level III accuracy in accordance with TIA-1152-A. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
5. Optical Fiber Performance Tests:
    a. Optical Fiber Cable Tests shall be performed on all fiber strands.
    b. Fiber end faces shall be inspected using a video scope and recorded in the memory of the test instrument for subsequent reporting.
    c. Link Tier 1 Attenuation Tests:
        1) Testing shall be performed on each cabling segment (connector to connector) individually as its installed and on each end to end cabling channel (equipment to equipment) for final acceptance.
        2) Multimode backbone link measurements: Test at 850 and 1300 nm in both directions according to TIA-526-14-B, Method B, one-cord reference method, with an Encircled Flux compliant launch.
        3) Singlemode backbone link measurements: Test at 1310 and 1550 nm in both directions according to TIA-526-7, Method A.1, one-cord reference method.
        4) Attenuation test results shall be less than those calculated according to equation in TIA-568 with a maximum allowable connector loss of 0.4dB and maximum allowable splice loss of 0.3dB.
    d. For all OSP cable, backbone cable with splices, or fiber strands that exceed specified maximum power loss, perform Tier 2 testing utilizing an OTDR bi-directional tester at the wavelengths specified above to ensure uniformity of cable attenuation, connector insertion loss and reflectance. Overall, the OTDR test results shall be made up of the wavelength of the conducted test, the link length, attenuation, cable identification, the locations of the near end, the far end and each splice point or points of discontinuity.
    e. Paired duplex fibers in multi-fiber cables shall be tested to verify polarity in accordance with Clause E.5.3 of TIA-568. The polarity of the paired duplex fibers shall be verified using an OLTS.
6. Final Verification Tests: Perform verification tests for optical fiber and twisted pair systems after the complete communication cabling and workstation outlet/connectors are installed.
    a. Voice Tests: After dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.
    b. Data Tests: After Owner's Information Technology Staff has a network installed and is available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.

C. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report or shall be transferred from the instrument to the computer, printed, and submitted unaltered.

D. End-to-end cabling will be considered defective if it does not pass tests and inspections. Marginal passes are not acceptable.

E. Remove, replace, and re-test cabling and terminations where test results indicate that it does not comply with specified requirements.

F. Prepare test and inspection reports.

G. The Engineer may request that a 10% random field re-test be conducted on the cabling system, at no additional cost, to verify documented findings. Tests shall conform to the requirements listed above. If findings contradict the documentation submitted by the contractor, additional testing can be requested to the extent deemed necessary by the Engineer, including a 100% re-test. Any re-testing shall be at no additional cost to the Owner.

END OF SECTION 271300

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SECTION 271500 - COMMUNICATIONS HORIZONTAL CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, Section 260010 “General Requirements for Electrical”, and 270010 “Supplemental Requirements for Communications” apply to this Section.

1.2 SUMMARY

A. Horizontal Cabling Description

1. Horizontal cable and its connecting hardware provide means of transporting signals between a telecommunications outlet/connector and the horizontal cross connect located in a telecommunications room. The cabling system consists of horizontal cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for horizontal-to-horizontal cross-connection. This cabling and its connecting hardware are called a “permanent link,” a term that is used in the testing protocols.
2. A work area is approximately 100 sq. ft. and includes the components that extend from the equipment outlets to the station equipment.
3. The maximum allowable horizontal cable length is 295 feet. This maximum allowable length does not include an allowance for the length of 16 feet to the workstation equipment or in the horizontal cross-connect.

B. Section Includes:

1. Twisted Pair Cabling
2. Twisted pair cable connecting hardware, including patch panels and cross connects
3. Telecommunications outlets/connectors, including plugs and jacks.
4. Grounding provisions for twisted pair cable.
5. Source quality control requirements for twisted pair cable.

1.3 REFERENCES

A. Abbreviations

1. EMI: Electromagnetic Interference
2. IDC: Insulation Displacement Contact
3. UTP: Unshielded Twisted Pair

B. Definitions

1. Horizontal Cabling: Distribution media that connects the telecommunications outlet/connector at the work area and the horizontal cross-connect in the telecommunications room or enclosure.
2. Telecommunications Outlet: An assembly consisting of a faceplate, backbox, or supporting bracket, and one or more receptacles or jacks of a telecommunication connector. Also known as a work area outlet.

C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.

1. Building Industry Consulting Service International (BICSI)

a. ANSI/BICSI N1, “Installation Practices for Telecommunications and ICT Cabling and Related Cabling Infrastructure”

1.4 SUBMITTALS

A. Product Data: For each type of product.

B. Twisted Pair Cable Testing Plans:
1. Sample test report sheet for each type of test required
2. Description of the cable testing procedures to be used including equipment to be used and testing standards equipment will test to.

C. Closeout Submittal
1. Operation and Maintenance Data: In addition to the items specified in Division 01 and Section 260010 “General Requirements for Electrical” include the following:
a. Cable Test Results

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance: Horizontal cabling system shall comply with minimum performance values listed herein and transmission standards in TIA-568.1, when tested according to test procedures of this standard.

2.2 GENERAL CABLE CHARACTERISTICS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard, UL 444, and NFPA 70 for the following types:

1. Plenum Applications: Type CMP complying with NFPA 262.
2. Non-plenum applications: Type CMR complying with UL 1666.
3. Wet Location and Outdoor Applications: OSP.

B. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

C. RoHS compliant.

2.3 ENHANCED SMALL DIAMETER CATEGORY 6a TWISTED PAIR CABLE

A. Description: Four-pair, small diameter, balanced-twisted pair cable, with internal separator, certified to meet transmission characteristics of Category 6a cable at frequencies up to 500MHz and minimum +4 dB margin for alien crosstalk parameters.

B. Manufacturers: Subject to compliance with requirements, provide product indicated or approved equal by one of the following

1. Berk-Tek LANmark XTP
2. General Cable GenSPEED 10 MTP
3. Belden 10GXS
4. Siemon Category 6a GT
5. Superior Essex 10GainXP

C. Standard: Comply with TIA-568.2 for Category 6a cables.

D. Conductors: 100-ohm, 23 AWG solid copper.

E. Shielding/Screening: Unshielded twisted pairs (UTP) with overall discontinuous shield.

F. Jacket: Blue, plenum rated thermoplastic unless noted otherwise.

2.4 TWISTED PAIR CABLE HARDWARE

A. Description: Hardware designed to connect, splice, and terminate twisted pair copper communications cable.

B. General Requirements for Twisted Pair Cable Hardware:

1. Comply with the performance requirements of the twisted pair cabling.
2. Comply with TIA-568.2, IDC type, with modules designed for punch-down caps or tools.
3. Cables shall be terminated with connecting hardware of same category or higher.

C. Source Limitations: Obtain twisted pair cable hardware from same manufacturer or alliance partner as twisted pair cable.

D. Expansion Criteria: Unless otherwise noted, provide spare positions in cross connects and patch panels to accommodate 20% future growth.

E. Connecting Blocks:

1. 110-style IDC
2. 50, 100, and 300 pair footprint.
3. Supports termination of 22-24 AWG solid conductors.
4. Provide blocks for the number of cables terminated on the block, plus 25 percent spare, integral with connector bodies, including plugs and jacks where indicated.

F. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between horizontal and backbone cables.

1. Number of Terminals per Field: One for each conductor in assigned cables.
2. Management rings shall be provided between vertical columns of blocks to provide management of cross connect wire.

G. Modular Patch Panel: Metal patch panel with numbered jack units that accept modular type connectors at each jack location for permanent termination of pair groups of installed cables.

1. Features:

a. Universal T568A and T568B wiring labels.
b. Labeling areas adjacent to conductors.
c. Replaceable connectors.
d. 24 or 48 ports.
e. Strain Relief Bar

2. Construction: 16-gauge steel and mountable on 19-inch equipment racks.
3. Number of Jacks per Field: One for each four-pair cable indicated, plus spares and blank positions adequate to suit specified expansion criteria.

H. Patch Cords: Factory-made, four-pair cables in various lengths; terminated with an eight-position modular plug at each end.

1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure performance. Patch cords shall have latch guards to protect against snagging.
2. Patch cords shall have color-coded boots for circuit identification.
3. Patch cords shall match performance rating of horizontal link.

I. Plugs and Plug Assemblies:

1. Male; eight position; color-coded modular telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable, rated to match performance of horizontal link.
2. Standard: Comply with TIA-568.2.
3. Marked to indicate transmission performance.

J. Modular Jacks and Jack Assemblies:

1. Female; eight position; modular; fixed telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable, rated to match performance of horizontal link.
2. Designed to snap-in to a patch panel or faceplate.
3. Standard: Comply with TIA-568.2.
4. Marked to indicate transmission performance.

K. Faceplate:

1. Four port, vertical single gang faceplates designed to mount to single gang wall boxes.
2. Plastic Faceplate: High-impact plastic. Coordinate color with Section 262726 "Wiring Devices."
3. Metal Faceplate: Stainless steel, complying with requirements in Section 262726 "Wiring Devices."
4. For use with snap-in modular jacks accommodating any combination of twisted pair, optical fiber, and coaxial work area cords.

L. Surface Mount Box

1. Two port, low profile, surface mount housing, with removeable cover.
2. Plastic housing suitable for installation in plenum air handling spaces. Coordinate color with Section 262726 "Wiring Devices."
3. For use with snap-in modular jacks accommodating any combination of twisted pair, optical fiber, and coaxial work area cords.

M. Legend:

1. Machine printed, in the field, using adhesive-tape label.

PART 3 - EXECUTION

3.1 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays, except within consoles, cabinets, desks, and counters. Conceal raceway and cables, except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for raceways and boxes specified in Section 270528 "Pathways for Communications Systems."
3. Unenclosed wiring methods may be used in accessible ceiling spaces.

B. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools. Install conductors parallel with or at right angles to sides and back of enclosure.

3.2 INSTALLATION OF TWISTED-PAIR HORIZONTAL CABLES

A. General Requirements for Cabling:

1. Provide a minimum of two equipment jacks for each work area outlet unless noted otherwise.
2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications equipment outlet.
3. Bridged taps and splices shall not be installed in the horizontal cabling.
4. Do not untwist twisted pair cables more than 1/2 inch from the point of termination to maintain cable geometry.
5. Maintain the cable jacket to within 1-inch of the termination point.
6. Provide horizontal cabling with the following minimum bending radius:
    a. Twisted Pair Cable: 4 times the outside diameter of the cable.
    b. Coax Cable: 10 times the outside diameter of the cable.
7. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
8. Coordinate with owner requirements for use of T568A or T568B standard for terminations.
9. Coil cables in the outlet boxes if adequate space is present to house the cable coil without exceeding the cable bend radius.
10. Store no more than 12-inches of twisted pair and 36-inches of fiber optic cable in an outlet box or modular furniture raceway after termination. Loosely store excess slack in the ceiling above each drop location.
11. In the telecommunications room, provide minimum 10-foot of slack for all horizontal cables and dress/store on ladder rack system without exceeding the cable bend radius.
12. Store cable slack in a Figure 8, “U” or “S” pattern.
13. MUTOAs shall not be used as a cross-connect point.
14. Provide consolidation point and cabling listed for wet locations at floor boxes in slab-on grade construction.:
    a. Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.

b. Locate consolidation points for twisted-pair cables at least 49 feet from communications equipment room.

15. The same orientation and positioning of jacks and connectors shall be utilized throughout the installation.
16. Provide blank filler inserts for all unused work area faceplate ports.
17. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
18. Cables shall be neatly bundled and dressed into groups of no more than 48 cables and routed from the point of entrance into the telecommunications space to their respective patch panel or connecting block.
19. Each patch panel or connecting block shall be fed by individual bundles separated and dressed with hook and loop straps.
20. Install lacing bars and distribution spools to restrain cables, prevent straining connections, and maintain minimum bending radii.
21. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
22. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used for heating.
23. Pulling Cable: Comply with BICSI Information Technology Systems Installation Methods Manual (ITSIMM), "Copper Structured Cabling Systems," "Pulling and Installing Cable" Section. Monitor cable pull tensions.
24. Under no circumstances shall the cable or patch cords be painted, treated, or covered with other material unless approved by the manufacturer, Owner, and Engineer.

B. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable management in telecommunications spaces with terminating hardware and interconnection equipment.
2. Cable shall not be run through structural members, attached to ceiling grid/luminaire supports, or in contact with pipes, ducts, or other potentially damaging items.
3. Cable and support hardware shall not obstruct access to panels, equipment, valves, boxes, or other control devices.

C. Group connecting hardware for cables into separate logical fields.

D. Separation from EMI Sources:

1. Comply with recommendations from BICSI's "Telecommunications Distribution Methods Manual" and TIA-569 for separating unshielded copper communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.

4. Separation between communications cables in grounded metallic raceways, power lines, and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.3 IDENTIFICATION

A. Provide identification of cabling and devices in accordance with Section 270533 “Identification for Communications Systems”.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections on all new and modified cabling and termination hardware.

B. Tests and Inspections:

1. Visually inspect jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments and inspect cabling connections for compliance with TIA-568.1.
2. Visually confirm Category marking of outlets, cover plates, outlet/connectors, and patch panels.
3. Visually inspect cable placement, cable termination, grounding and bonding, equipment, and patch cords, and labeling of all components.
4. Field-test instruments shall be approved by the cable manufacturer, be within the calibration period recommended by the instrument manufacturer and meet a minimum Level IV accuracy in accordance with TIA-1152. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
5. Twisted Pair Continuity Tests:

    a. Test twisted pair cabling for shorts, opens, intermittent faults, polarity, and pair reversals, crossed pairs, and split pairs. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.

6. Twisted Pair Performance Tests:

    a. Test each cable link to the performance requirements outlined in this specification and manufacturer’s warranty requirements. Perform the following tests according to TIA-568.1, TIA-568.2, and TIA-1152:

        1) Wire Map
        2) Length (physical vs. electrical, and length requirements).
        3) DC resistance.
        4) DC resistance unbalance.
        5) Insertion loss.
        6) Near-end crosstalk (NEXT) loss.
        7) Power sum near-end crosstalk (PSNEXT) loss.
        8) Equal-level far-end crosstalk (ELFEXT).
        9) Power sum equal-level far-end crosstalk (PSELFEXT).
        10) Return loss.

11) Propagation delay.
12) Delay skew.

7. Final Verification Tests: Perform verification tests for UTP systems after the complete communication cabling and workstation outlet/connectors are installed.

   a. Voice Tests: After dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.
   b. Data Tests: After Owner's Information Technology Staff has a network installed and is available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.

C. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similarly to Table 10.1 in BICSI's "Telecommunications Distribution Methods Manual," or shall be transferred from the instrument to the computer, printed, and submitted unaltered.

D. End-to-end cabling will be considered defective if it does not pass tests and inspections. Marginal passes are not acceptable.

E. Remove, replace, and re-test cabling and terminations where test results indicate that they do not comply with specified requirements.

F. Prepare test and inspection reports.

G. The Engineer may request that a 10% random field re-test be conducted on the cabling system, at no additional cost, to verify documented findings. Tests shall conform to the requirements listed above. If findings contradict the documentation submitted by the contractor, additional testing can be requested to the extent deemed necessary by the Engineer, including a 100% re-test. Any re-testing shall be at no additional cost to the Owner.

END OF SECTION 271500

SECTION 274110 – ELEMENTARY SCHOOL SOUND SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

1.2 SUMMARY

A. Description: A complete and fully functional sound reinforcement system that is durable, intuitive, easy to operate, compatible with any future components, and suitable for the following applications:

1. Elementary multi-purpose room and platform.

B. Section Includes:

1. Loudspeakers
2. Amplifiers
3. Digital Signal Processor
4. Media Players
5. Microphones
6. Cabling and Connectors
7. Power and Surge Suppression
8. Assistive Listening System

C. Related Requirements:

1. Refer to other Division 27 sections for telecommunication requirements related to data LAN connections and building horizontal cable.

1.3 REFERENCES

A. Abbreviations and Acronyms

1. DSP: Digital Signal Processing
2. NC: Noise Criterion
3. SPL: Sound Pressure Level
4. STI: Speech Transmission Index
5. THD: Total Harmonic Distortion

B. Definitions

1. Channels: Separate parallel signal paths, from sources to loudspeakers or loudspeaker zones, with separate amplification and switching that permit selection between paths for speaker alternative program signals.
2. Reverberation Time: The time that would be required for the reverberantly decaying sound pressure level in the enclosure to decrease by 60 decibels.
3. Zone: A group of loudspeakers and associated supply wiring that may be arranged for selective switching between different channels.

C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.

1. Audiovisual and Integrated Experience Association (AVIXA)

a. ANSI/AVIXA D401.01, “Standard Guide for Audiovisual Systems Design and Coordination Processes”
b. AVIXA F501.01, “Cable Labeling for Audiovisual Systems”
c. AVIXA F502.01, “Rack Building for Audiovisual Systems”
d. AVIXA F502.02, “Rack Design for Audiovisual Systems”
e. AVIXA 10, “Audiovisual Systems Performance Verification”
f. AVIXA A102.01, “Audio Coverage Uniformity in Listener Areas”

1.4 COORDINATION

A. Coordinate system scope and layout requirements, attachment methods, and penetrations with other disciplines.

B. For devices located in finished spaces, coordinate all finishes with Architect and Engineer. Paint grilles and enclosures as direct.

1.5 PRE-INSTALLATION MEETINGS

A. Schedule preconstruction conference with Architect, Owner’s Representative, and all affected trades. Agenda topics should include, but are not limited to, the following:

1. System installation schedule and sequencing.
2. Site readiness requirements.
3. Review of all device locations, conductor routing, and pathway coordination.
4. Equipment delivery and site security.
5. System programming and owner’s user group requirements.
6. Interface requirements for connection to other building systems.

1.6 SUBMITTALS

A. Product Data: Submit for each type of product specified.

B. Shop Drawings: For sound system and related equipment.

1. Include floor plans drawn to scale which show locations of all devices and equipment. Indicate electrical power connections, approximate location and size of conduit/wiring runs, and other information required to clearly describe the proposed system.
2. Include identification numbers and wiring connections for all equipment and devices in entire system. Identify loudspeaker mounting height and vertical/horizontal aiming.
3. Include enlarged plans, drawn to scale, for all equipment rooms with dimensioned equipment layouts.
4. Include scaled elevations to describe equipment arrangements for racks and cabinets.
5. Functional Block and Wiring Diagrams: Detail all equipment with wire and connections for power, signal, and control. Clearly differentiate between factory installed wiring and field installed wiring. Identify terminal numbers and wiring color codes to facilitate installation, operation, and maintenance.
6. Include wiring schedules showing source, destination, and cable types. Identify terminal numbers and wiring color codes to facilitate installation, operation, and maintenance.

7. Include details of all connector plates.
8. Installation details and load capacity for loudspeaker support structures and mounting brackets.

C. Delegated-Design Submittal: For loudspeaker supports

D. Qualification Data: For qualified installer.

E. Test and Inspection Reports

1. Test procedures and equipment used.
2. Graphical or numerical test results that show conformance with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

F. Closeout Submittals

1. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:

a. Operating instructions and block diagrams laminated and mounted to the inside of the equipment cabinet. Detail the theory of operation, narrative descriptions, and pictorial illustrations.

1.7 QUALITY ASSURANCE

A. Manufacturer Qualifications:
1. Five continuous years, minimum, design and manufacture of the materials and equipment specified.
2. Manufacturing facilities certified to ISO 9001 International Quality Standard with third-party certification verifying quality assurance in design/development, production, installation, and service.
3. Maintain, within 100 miles of Project site, a service center capable of providing training, parts, maintenance, emergency repairs to equipment, and response times less than eight hours.
4. Employ trained staff that are available 24/7 to provide scheduling support and assist with reporting needs.

B. Installer Qualifications:

1. Manufacturer’s authorized representative who is trained and certified by the manufacturer for installation of the specified product.
2. Minimum of five years successful installation experience with Projects of similar size and complexity.
3. Upon request, be able to provide a minimum of three reference accounts at which similar work, both in scope and complexity, have been completed by The Contractor within the last three years.
4. Project Personnel Requirements: Installer must have the following certified full-time employees on staff and assigned to the project:
5. All personnel must be trained and certified by the manufacturer for installation of units required for this Project.
   a. System Designer: Preparation of shop drawings, cabling administration drawings, and field-testing program development by a CTS-D certified technician (or equivalent NICET certification) trained and certified in audio visual system design by the approved manufacturers within the last 36 months.
   b. Lead Technician: Provide a CTS-I certified technician who shall supervise installation of all devices, connections, and programming for the sound system. Technician shall be certified by the approved manufacturer within the last 36 months. The lead technician shall be present at all times when work of this Section is performed at the project site.

c. Technicians: Personnel installing any part of the work related to this section shall be trained and certified by the approved equipment manufacturer within the last 24 months.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Storage and Handling Requirements: Comply with manufacturer instructions for storage of electrical equipment to prevent damage from condensation or other environmental factors.

1.9 WARRANTIES

A. Manufacturer Warranty: Manufacturer agrees to repair or replace components of sound system and all associated components that fail in materials or workmanship within 1 year of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency acceptable to authorities having jurisdiction and marked for intended use.

B. Provide equipment and components that have been commercially available for at least one year prior to bid, unless approved by Engineer.

C. Technologies or equipment with announced /published End-of-Life or End-of-Sale dates scheduled within three years of project completion will not be installed.

D. Equipment identified by part number and manufacturer are to establish acceptable quality and performance desired for this system.
1. For items identified by part number and manufacturer, performance specifications published in the most recent manufacturer's data sheets available at the time of bidding this contract shall apply to the work as specified.
2. For those items that are not identified by part number and manufacturer, select items that conform to the functional and technical specifications required to support the performance of the system.

2.2 SYSTEM PERFORMANCE REQUIREMENTS

A. Signal to Noise Ratio: Capable of an acoustic output SPL of at least 25dB above ambient noise level in each octave band. For spaces with high ambient noise conditions (above 35 dB), 15 dB S/N ratio is recommended.

B. System Frequency Response: 20-Hz to 20-kHz, plus or minus 0.5 dB.

C. THD: 1-percent maximum from 20-Hz to 20-kHz measured at the output of any speaker.

D. Headroom: Plus or minus 20 dB above nominal SPL, without increase in hum, noise, THD, or frequency response.

E. Hum and Noise: 80 dB below nominal SPL.

F. Power Capacity: 50-percent greater than power output at nominal SPL.

G. Crosstalk

H. Speech Transmission Index (STI): minimum 0.58 in listener areas.

2.3 LOUDSPEAKERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   1. Front Stage Speakers – Connect to CH-1 on amp.
      a. Apogee AFI4 or approved equal.
   2. Fill In Speakers
      a. JBL Control 26CT or approved equal.
   3. Monitor Speaker – Connect to CH-2 on amp
      a. Apogee AFI – Point 5

B. General Characteristics

   1. Enclosure: Cabinet
   2. Input Connections: Screw terminal blocks.
   3. Enclosure: Suitable for installed operating environment.
   4. Integral rigging points suitable for use with manufacturers standard mounting brackets.

2.4 RIGGING AND SUPPORT STRUCTURES

A. Delegated Design: Engage a qualified professional engineer, to design attachments, rigging, and support structures.

   1. Minimum safety factor for structural support members: 5:1.
   2. Minimum safety factor for hardware, attachments, and safety wire: 8:1.

2.5 EQUIPMENT

A. Stereo Power Amplifier
   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Main Stereo Amplifier: Apogee CA-2000 or approved equal
      b. Fill In Speaker Amplifier: Bogen C-60

   2. General Characteristics
      a. Class D
      b. Rack mountable
      c. 2-channel minimum
      d. 4, 8-ohm bridge
      e. Gain selection switches
      f. Input: 3 pin XLR and 1/4-inch TRS
      g. Output: Binding post and NL4
      h. Built in Digital Signal Processing

B. Rackmount Mixer (Quantity of 2)
   1. Basis of Design Product: Bogen VMIX, with RPK87 rack mount kit.
   2. Inputs: 8 balanced line level
   3. Frequency Response: 15Hz to 55 kHz, plus or minus 3db.

C. Equalizer
1. Basis of Design Product: Shure DFR22

D. Digital Media Player
1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
a. Tascam model CD-RW900MKII
2. General Characteristics
a. Capable of playing digital media files from the following
1) DVD and Blu-Ray discs.
2) CD discs using WAV/MP3/AAC file formats.
3) Portable devices connected to a USB host port.
4) Portable devices connected to a 3.5mm AUX input.
5) Bluetooth paired device.
b. Balanced XLR and unbalanced RCA audio outputs.
c. HDMI audio/visual outputs.
d. RS-232c control capable.
e. Wireless remote

2.6 MICROPHONES

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Shure
2. Electro-Voice
3. Audio-Technica

B. Wired Handheld Microphones: (2) SHURE SM-58
1. Type: Dynamic
2. Frequency Response: 50 to 15,000 Hz
3. Polar Pattern: Cardioid
4. Connector: 3-pin male XLR
5. On/Off Switch

C. Wireless Handheld Microphones: (4) Shure SLX24, (2) SM-58 handhelds and (2) WL185 lapels.
1. Working Range: 300 feet
2. 470MHz to 680 MHz transmitter frequency range
3. 100 mW (nominal) RF transmitter power source
4. Power: Rechargeable Lithium-Ion battery
5. Charging Station
6. On/Off Switch
7. Antenna
8. Receiver

2.7 ASSITIVE LISTENING SYSTEM

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Drake ALT-1000 with Drake MR306 Receivers

B. Description: Provide a complete code compliant system including transmitter, antennas, receivers, ear speakers, batteries, neck loops, and carrying cases, with accessory materials required for fully functional

system. Provide quantities determined by capacity calculations performed in accordance with ADA/ABA and accessibility requirements of authorities having jurisdiction, and per NCBC Section 1108.

2.8 CABLING AND CONNECTORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   1. Belden
   2. Switchcraft
   3. West Penn.

B. Faceplates: Stainless Steel
   1. Jacks: Interlocking with microphone cable

C. Cable
   1. Microphone: XLR- type, 25ft minimum
   2. Speaker

2.9 CABINETS

A. Description: Manufacturer-assembled four-post frame enclosed by side and top panels and front and rear doors, designed for mounting telecommunications equipment. Width is compatible with EIA/ECIA 310-E, 19-inch equipment mounting with an opening of 17.72 inches between rails.

B. Manufacturers: Subject to compliance with requirements, provide product indicated or approved equal by one of the following:

   1. Lowell LFR Series
   2. Chatsworth CPI
   3. Great Lakes
   4. Ortronics
   5. Middle Atlantic
   6. Panduit
   7. Siemon

C. General Cabinet Requirements:

   1. Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
   2. Material: Steel.
   3. Finish: Manufacturer's standard, baked-polyester powder coat.
   4. Color: Black.

D. Modular Wall Mounted Cabinets:

   1. Height: 36 inches or as indicated on Drawings.
   2. Depth: 30 inch minimum.
   3. Load Rating: 200 lb minimum.
   4. Number of Rack Units: 18U or as indicated on Drawings.
   5. Threads: #12-24 universal hole pattern.
   6. Dual Hinged swing out body
   7. Lockable front and rear doors.
   8. Louvered side panels.
   9. Knockouts for conduit or cable entry grommets in top and bottom rear.

10. Integral lashing brackets and vertical cable management.
11. Grounding lugs.
12. Horizontal RBB.
13. Side-mounted, minimum 100-cfm fan.
14. All cabinets keyed alike.
15. Bonding wires for all panels.

E. Rack and Cabinet Bonding Busbars (RBB): Rectangular bars of electro-plated copper, accepting conductors ranging from No. 14 to No. 2/0 AWG, NRTL listed as complying with UL 467, and complying with TIA-606-C. Predrilling shall be with holes for use with lugs specified.

2.10 POWER AND SURGE SUPRESSION

A. Manufacturers: Subject to compliance with requirements, provide product indicated or approved equal by one of the following:

1. Tripp Lite
2. Panduit
3. Leviton
4. Chatsworth CPI
5. Middle Atlantic
6. Geist
7. Siemon

B. Power Distribution Unit: Comply with UL 1363.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Rack mounting.
3. Height: 1 RU.
4. Housing: Metal
5. Minimum Two front-facing 15-A, 120-V ac, NEMA WD 6, Configuration 5-15R and Ten rear facing 20-A, 120-V ac, NEMA WD 6, Configuration 5-20R receptacles.
6. LED indicator lights for power and protection status.
7. LED indicator lights for reverse polarity and open outlet ground.
8. Circuit Breaker and Thermal Fusing: When protection is lost, circuit opens and cannot be reset.
9. Cord connected with 10-foot line cord.
10. Rocker-type on-off switch illuminated when in on position.
11. Surge Protection: UL 1449, Type 3.
    a. Maximum Surge Current, Line to Neutral: 96 kA and neutral to ground.
    b. UL 1449 Voltage Protection Rating for line to neutral and line to ground shall not be more than 330 V.
    c. EMI/RFI noise filtering: 40-80dB.
    d. AC Suppression Joule Rating: 3800 J minimum.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine raceway rough-in and electrical connections to verify actual locations of connections before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CABLING AND CONDUCTOR APPLICATION

A. Provide protection for exposed cables where subject to damage.

B. Use suitable cable fittings and connectors.

C. Provide cable listed for wet locations where routed outdoors or in/under concrete slabs on grade.

3.3 INSTALLATION

A. Wiring Methods: Install all cabling in raceway, minimum 3/4-inch, in accordance with Section 260533, “Raceways and Boxes for Electrical Systems” and manufacturer’s recommendations. Conceal raceway, except in unfinished spaces.

1. Provide dedicated pathways and conduits for the following.
   a. Microphone level circuits (up to -20 dBm).
   b. Line level circuits (up to +30 dBm).
   c. Loudspeaker circuits (above +30 dBm).
   d. Power circuits.

B. Wiring and Cabling Installation
1. Install wiring and cable in a continuous manner, do not splice cable between termination, tap, or junction points.
2. At device outlets, provide 12-inches of excess cable and coil cables in the outlet boxes without exceeding the cable bend radius.
3. At equipment enclosures, provide 6-feet of excess cable and dress/store with cable management without exceeding cable bend radius.
4. Install cable management to restrain cables, prevent straining connections, and maintain minimum bending radius.
5. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
6. Within enclosures, bundle cables by the following signal types. Do not mix circuits in the same bundle. Where not in enclosures, provide separate raceways for signal types.
   a. Microphone level signal circuits.
   b. Line level audio signal circuits.
   c. Loudspeaker signal circuits.
   d. Control, data, and communication signal circuits
   e. Power circuits.
7. Separate pathways for power circuits at least 12-inches from other signal circuits to avoid EMI.

C. Follow manufacturer’s instructions for installing, operating, configuring, and programming equipment.

D. Mount racks, cabinets, and equipment plumb, level, and square without physical distortion.

E. Install and arrange system cabinets in accordance with AVIXA F502.01, F502.02, and manufacturer's instructions to ensure adequate ventilation and service access.

1. Provide ventilation where required to maintain equipment within the manufacturer's specified temperature limits. Select and locate fans to minimize noise impact in the area.
2. Arrange amplifiers per manufacturer instructions with appropriate spacing and ventilation above and below.
3. Allow a minimum 20 percent open rack space.
4. Provide rear support for rack mounted equipment greater than 15" deep.
5. Fill all empty spaces with blank panels, sizing as required, painted to match housing.
6. Locate operator useable equipment and patch panels at an appropriate operating height.
7. Key all door locks for each housing type (front, rear) alike

F. Loudspeaker Installation

1. Mount or suspend loudspeakers at the appropriate position in a safe, secure, and permanent manner in accordance with the stamped delegated design drawings.
2. Install mounting system to enable adjustment of aiming direction in plus or minus 5 degree increments.
3. Install safety cable to secure loudspeaker to the building structure.

G. Leave 12-inches of cable at each termination for microphone, volume controls, speaker, and other system outlets.

H. Leave 6-feet of excess cable at each termination at system cabinet.

I. Speaker lines in Gyms, Auditoriums, and Cafeterias shall be paralleled at the Amplifier and NOT at the speakers.

J. Speaker lines on Football Fields, Softball Fields, and Stadiums shall be paralleled at the bottom of the pole in waterproof junction boxes and NOT on the top of the pole at the speakers.

K. Provide surge protection devices on all stadium public address system cables that enter or leave the press box.

L. Provide surge protection device on 120-volt power circuit serving the stadium public address consol.

M. Emergency and Paging System Interface
1. Provide priority control device to interface public address and/or emergency systems with system mute control ports.
2. Mute program audio when system detects audio signal in public address or life safety system for duration of announcement.

3.4 GROUNDING AND BONDING

A. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" and Section 270526 "Grounding and Bonding for Telecommunications Systems".

1. Ground audio cable shields only at the power amplifier inputs. Terminate shields at the "floating" end with insulating collars or heat shrink tubing. Preserve continuity of shields at connecting points. Connect all audio grounds in this system to a common point at a rack bonding busbar.
2. Connect rack bonding busbar to the telecommunication bonding system and to the rack using listed compression two-hole lugs.

3.5 IDENTIFICATION

A. Comply with requirements in Section 270553, “Identification for Communication Systems”, AVIXA F501.01, and as noted below.
   1. Identify all system components, wiring, cabling, and terminals. Identify all wiring at terminations and junction locations.
   2. Provide front and rear mounted lamicoid labeling for all rack-mounted equipment.
   3. Identify all connector plates with consistent input and output designations corresponding to shop drawings.
   4. Label relevant inputs and outputs on switchers, matrices, and mixers. This includes digital/virtual labelling of audio channels and video inputs and outputs.
   5. Provide engraving only after approval by Engineer and Owner’s Representative.

3.6 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative. Comply with AVIXA 10 test and measurement procedures.

B. Provide written 7-day advance notice of any testing to allow The Engineer and Owner’s Representative the option to witness the tests.

C. Visual and Mechanical Inspection

   1. Examine equipment and confirm proper identification and labelling.
   2. Inspect the physical, electrical, and mechanical condition of the equipment and all components in accordance with the manufacturers’ instructions.
   3. Visually inspect cable placement, cable bend radius, cable terminations, grounding and bonding, and labeling of all components. Ensure all connectors are fully seated and lock screws are fully tightened.
   4. Visually inspect equipment enclosure anchorage, alignment, and grounding.
   5. Confirm individual components are installed and performing under provisions of each manufacturer's published specifications.
   6. After running performance testing, verify the temperatures in the equipment enclosures are within tolerances defined by the manufacturer’s guidelines.

D. Electrical Tests:

   1. Test each rack/cabinet AC power outlet for proper connections to current carrying conductors, grounded conductors, and grounding conductors.
   2. Measure and record the DC resistance between the following using a two-point bonding test. Resistance should be 0.15 ohms or less.
      a. Each rack or cabinet bonding busbar to the nearest electrical equipment ground.
   3. Cable Testing: Using a cable tester, test each cable path for positive continuity, cross wiring, loose contacts, open circuits, leakage between wires, and short between wires or to ground.

E. Audio System Performance Tests and Inspections:

   1. Loudspeaker Testing:
      a. Impedance: Use an impedance meter to test each loudspeaker cable at the amplifier and verify the measurements are not below the predicated impedance.
      b. Zoning: Pass audio test signal or program audio material through each line individually to verify loudspeakers are zoned correctly.
      c. Physical Alignment: Check each loudspeaker to verify proper mounting location, mounting height, and vertical and horizontal aiming.
      d. Polarity: Test each audio path with an impulse tone to verify all loudspeakers have proper polarity.

2. Microphone Testing: Connect microphones and setup in room where it will normally be used.
   a. Feedback: Using a pink noise source, playback audio in the listening area at a level equal to the microphone dB level. Mute the pink noise and verify feedback or ringing is detected. Unmute the noise source and raise the level at 3-dB increments, muting each time to determine if feedback is present.
   b. Level Alignment: Verify calibration of microphone inputs so that the difference between any input signal level after the first common gain adjustment is no more than plus or minus 1 dB.
   c. Wireless Microphones: Confirm transmitter/receiver frequencies, channels, and range are in conformance with manufacturer's requirements.
3. Program Source Audio Alignment: Align all audio program source levels at the first common gain adjustment to establish unity gain and ensure there is no hiss, hum, or distortion on the audio system. Verify the common signal level at the output complies with system performance requirements.
4. System Noise: Verify there is no audible noise on the system by performing the following tests on each loudspeaker individually:
   a. Rattle: Use a continuous sweep signal operating at 3dB below onset of distortion and verify there is no undesired acoustically induced noise, such as equipment vibration.
   b. Buzz: With all equipment on and audio level set to 3dB below onset of distortion, verify there is no audible noise within the system from conditions such as unbalanced input pick-ups or stray EMI signals.
5. System Sound Pressure Level and Ambient Noise:
   a. Ambient Noise: With HVAC and other building systems operating under normal conditions, use a SPL spectrum analyzer to measure background noise levels throughout the space. Record measurements at each test position. Notify Architect and Engineer if A-weighted SPL level exceeds 35 dB.
   b. Using the same test positions, measure the sound system SPL. Verify the system SPL exceeds the ambient noise level as defined by the performance requirements.
6. Frequency Response and System Equalization: Use a pink noise generator or sine wave sweep generator connected to a system input and a sound analyzer to measure the following:
   a. Compare system input and output signals for proper frequency response curve conforming with performance requirements. Any input or output signal processing should be bypassed to achieve accurate results.
   b. Measure loudspeaker output with a measurement microphone to ensure the system can accurately reproduce the audio source frequency response to within +/- 3dB at a distance of 3.3-feet on axis. Analyze a minimum of four different microphone locations.
7. Total Harmonic Distortion: Use an audio test generator to produce a 1 kHz sine wave at the system input and perform a spectral analysis on the output to provide the level of each harmonic and a root mean square (RMS) summation to calculate the THD.
8. DSP Programming: Verify all DSP components have been programmed as required to achieve performance criteria and system functionality.

F. Functional Acceptance Testing

1. Operational Test: Perform tests that include originating program and speech messages at microphone outlets, preamplifier program inputs, and all other inputs. Verify proper routing and volume levels and that system is free of noise and distortion.
2. Test all system control functions to verify each input and function activates the proper system response.
3. Activate paging and emergency systems to ensure audio system is muted for duration of announcement or duration of emergency system operation.
4. Assistive Listening System: Verify functionality of assisted listening system in accordance with manufacturer's instructions.

G. Products will be considered defective if they do not pass tests and inspections. Remove and replace malfunctioning units and retest as specified above.

H. Test and Inspection Reports: Prepare a written report to certify compliance with test parameters and record the following:

1. Test procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
4. Record adjustable settings and measured insulation resistances, time delays, and other values and observations.

3.7 ADJUSTING

A. Engage a factory-authorized service representative to provide on-site assistance in adjusting sound levels, resetting transformer taps, and adjusting controls to meet occupancy conditions.
1. Arrange with Owner's representative for period of complete quiet for testing and adjustments to the sound system. These periods may occur at night.
2. Perform adjustments, equalization, time delay and balancing to prepare the sound system for Owner's use.

B. Post-Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's personnel to adjust, operate, and maintain sound systems.

END OF SECTION 274110

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SECTION 275123.50 - EDUCATIONAL INTERCOMMUNICATIONS AND PROGRAM SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes network-based intercommunications and program systems with the following components:

1. Network Administrative console.
2. Graphical User Interface.
3. SIP Interface.
4. Network Talk Back Speaker.
5. Network amplifier.
6. Power Amplifier.
7. Loudspeakers/speaker microphones.
8. IP Clocks
9. Conductors and cables.
10. Raceways.

B. Related Requirements:

1. Section 271513 "Communications Horizontal Cabling" for cabling used for voice and data circuits.

1.3 DEFINITIONS

A. DHCP: Dynamic Host Configuration Protocol.

B. FXO: Foreign exchange Office.

C. H.323: Audio and Video Protocol.

D. SIP: Session Initiation Protocol.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For educational intercommunications and program systems.

1. Include plans, elevations, sections, and mounting details.

2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

3. Include scaled drawings for arrangement of built-in equipment.

4. Include diagrams for power, signal, and control wiring.

a. Identify terminals to facilitate installation, operation, and maintenance.

b. Single-line diagram showing interconnection of components.

c. Cabling diagram showing cable routing.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Reflected ceiling plans, drawn to scale, on which ceiling-mounted items including luminaires, diffusers, grilles, speakers, sprinklers, access panels, and special moldings are shown and coordinated with each other, using input from installers of the items involved.

2. Elevation drawings, drawn to scale, on which wall-mounted items including luminaires, intercommunications components, windows, doors, access panels, wall finishes, trims, piping, and conduit are shown and coordinated with each other, using input from Installers of the items involved.

B. Qualification Data: For Installer.

C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For educational intercommunications and program systems to include in operation and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. A record of final matching transformer-tap settings and signal ground-resistance measurement certified by Installer.

2. A record of Owner's equipment-programming option decisions.

3. Plans, drawn to scale, indicating location, designation, and connection of intercommunications system components.

4. Operating instructions laminated and mounted adjacent to operating console location.

5. Training plan.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.

2. Program Software Backup: On USB media or compact disk, complete with data files.

3. Device address list.

4. Printout of software application and graphic screens.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer for the installation of units required for this Project.

1. Show satisfactory evidence, upon request, that Installer maintains a fully equipped factory approved and authorized service organization with minimum five-year record of successful installations and of furnishing adequate inspection and service to the system, including replacement parts.

2. Indicate capability of providing warranty and service work within four hours of notification of such requirements.

3. Upon request, able to offer a service contract for the maintenance of the system following expiration of the warranty period.

1.8 COORDINATION

A. Coordinate layout and installation of ceiling-mounted speaker microphones and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements provide Telecor E-series network-based intercom/clock system.

2.2 SYSTEM DESCRIPTION

A. Supply and install a complete supervised network-based intercom system. Field wiring shall be CAT 5E or CAT 6 cable, all station equipment shall utilize standard RJ-45 modular connections. All remote devices utilizing standard structured cabling shall be capable of PoE (Power over Ethernet) or power supplied within the CAT 5E or CAT 6 cable jacket. Wiring shall be capable of either being installed in conduit or cable trays, where shown on the plans.

B. The system shall be capable of interconnecting with the building LAN (Local Area Network). This connection shall be minimal and utilize only one Ethernet 100 Mbps (or optionally 1 Gb) connection per station to accomplish all intercom operations. Ethernet ports and associated network switches that are required to connect any intercom devices will be provided by the OWNER.

C. Provide a separate circuit for each classroom and administrative office area so each room, speaker, amplifier, and emergency messaging display/clock can be individually addressed.

D. Equipment: Modular type using solid-state components, fully rated for continuous duty unless otherwise indicated. Select equipment for normal operation on input power usually supplied at 110 to 130 V, 60 Hz in a satisfactory manner without the requirement of any external power conditioning equipment. Comply with UL 813.

E. Expansion Capability: Increase number of stations in the future by **25**percent above those indicated without adding any internal or external components or main trunk cable conductors.

F. Integration: Coordinate features and select components to form an integrated system. Match components and interconnections for optimum performance of specified functions.

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for location and application.

H. Weather-Resistant Equipment: Listed and labeled by an NRTL for duty outdoors or in damp locations.

2.3 FUNCTIONAL DESCRIPTION OF IP-BASED INTERCOMMUNICATION SYSTEMS

A. The system specified is based on the Telecor eSeries Supervised Network based Communications System providing at least the features and functions outlined below. It shall be installed and programmed by a local authorized and certified Telecor dealer.

B. The system shall utilize a decentralized network structure not requiring any head-end equipment, central server, or any other control hardware to maintain system operation. Systems utilizing centralized electronics and subject to a single-point-of-failure (power supply, CPU, server, power, etc.) shall not be accepted unless the system has 100% duplication of all centralized operating equipment running concurrently and can automatically take over, including up to the minute programming configuration in the event of a failure of the main system head-end electronics or any required, centralized electronics required to make the system fully operational. Systems that are not based on decentralized structure or systems that do not provide 100% duplication of head-end or systems that operate in a “down-graded” operational mode as the result of a centralized failure are not acceptable.

C. All station devices shall receive power and data through a Power-Over-Ethernet switch. Once plugged into the LAN through a Power-over-Ethernet network switch, all networked devices shall be immediately operational and as applicable shall be able to place or receive calls and pages from Stations as well as page all devices in the network. Consoles, intercom stations, clocks, emergency displays, or speakers connected to the network shall not require any network configuration or administration to function.

D. Speech shall be transmitted in the frequency range from 50 Hz to 7 kHz and shall use a maximum of 128 kbps of bandwidth during a call. In order to assure maximum intelligibility, all system audio shall be HD Audio as defined in Intel (TM) High Definition Audio Specifications, June 17, 2010.

E. Intercom communications between consoles and system devices shall be non-blocking with no channel restrictions or limitations (other than network capacity) to the number of simultaneous conversations at any time between pairs of intercom stations, intercom station to console, console to console, console to speaker or zone of speakers, program source to a speaker or zone of speakers, or bell tones to a speaker or zone of speakers regardless of number of stations or consoles.

F. Any and all devices shall have the ability to have its programming downloaded, individually or simultaneously via the network. Programming shall be downloadable in a series of human readable, industry standard comma-separated values (CSV) files that can be saved and edited using common

spreadsheet applications. Consoles, intercom stations, clocks, displays, and speakers residing on a network shall have the ability to update their programming, simultaneously from a CSV file. Furthermore, all devices shall also have the capability to be configured directly, such that device numbers, names, zones, and call-in destinations can be altered in real time without the uploading or downloading of their programming. System shall be capable of uploading firmware updates to all device classes simultaneously, via the network, without the requirement of tools, by authorized technician or qualified facility technician or representatives. Systems that require a proprietary software as a means to program shall not be acceptable.

G. Audio communications between all devices shall be accomplished with latency values of a maximum of 0.1 seconds and connection times of 0.01s for 1 to 500 speakers.

H. The system shall support a minimum of 50 channels of simultaneous duplex communication paths on the intercom system LAN, plus a minimum of 10 simultaneous duplex channels for PBX integration

2.4 NETWORK ADMINISTRATIVE CONTROL CONSOLE

A. The Console shall be supervised and allow the operator to establish two-way communications with an intercom station, talkback speaker, or another Console using the handset or speakerphone. VOX functioning shall be automatically enabled when the handset is used. The Push-to-Talk button shall toggle the Console between talk and listen mode when the speakerphone is used.

B. Provide a 2-line by 20-character LCD display. The display shall be able to be tilted at different angles for optimum viewing. When there are no active calls, the display shall show the Console name and dial number. If a time server is connected to the network, the display shall also show the time and date.

C. Incoming calls to a Console shall show the originating station dial number and name on the Console display. Calls shall be displayed in the order they are received. The operator shall be able to scroll through the list of calls and answer them out of sequence. Emergency call-ins shall be distinctly annunciated both visually and audibly.

D. The Console shall allow call-ins to be forwarded to another Console, or for calls to be put on hold or transferred to another Console location. Additionally, call-ins or calls shall be forward/transfer-able to PBX telephone extensions via a SIP trunk interface.

E. The Console shall be able to select remote audio sources connected at any location on the local area network and distribute the audio broadcast from the source to all speakers in a facility or to selected areas such as a speaker zone or a selection of speakers. The Console shall be capable of audio source verification by attendant prior to page zone activation. In this manner attendants shall be able to listen to the audio source locally, including listening to pre-recorded announcements, prior to system broadcast.

F. The Console shall be able select a tone or a pre-recorded announcement and broadcast the tone or announcement to all facility speakers or to select areas, such as a speaker zone or a selection of speakers.

G. The Console shall be equipped with digital volume control that shall allow for the separate adjustment of the speaker listen and handset listen volumes. The levels for intercom listen, tones, and program distributions shall be independently adjusted and stored in memory.

H. The system shall allow user programming of alphanumeric architectural room names and numbers. The Console shall be capable of using 1 to 7-digit sequences for dial out and call-in identification, and shall display station numbering, station name, and call-in priority.

I. The end-user shall be allowed to choose and determine the number and location of Consoles. The end-user shall not be limited by pre-set manufacturer limitations of the number of Consoles required by this

project, allowing for unrestricted future expansion. Consoles may be added at any time. Communication between consoles or consoles and intercom stations or rooms shall not be inhibited by channel number restrictions.

J. The Console shall be capable of displaying room statuses such as Privacy and Do Not Disturb and shall have the ability to override any status limiting communication between the Console and a station with Privacy or Do Not Disturb status activated. Temporary override shall not interfere with continued activation of Privacy and Do Not Disturb after communication has been established and electively terminated.

2.5 SUPERVISED GRAPHICAL USER INTERFACE

A. The IGUI shall be supervised and shall utilize an easy-to-use Graphical User Interface for quick and easy graphically aided navigation to access functionality for all intercom stations, paging zones, and program distribution sources. Emergency operations shall be simplified through the IGUI allowing stored audio files and alphanumeric messages for message displays to be activated from the IGUI. The IGUI shall allow common operations such as daily announcements to become simplified into single touch activated icons, removing multi-step console set ups and dial strings.

B. The voice device used to originate voice communication for the IGUI to selected locations shall be a system console, telephone handset, or microphone independent from the computer hosting the IGUI. The voice device shall remain functional and accessible regardless of the operational state of a computer supporting the IGUI.

C. The IGUI shall allow the creation of a custom operating screen(s) based on the floor plans of the facilities. Icons representing intercom stations, zones used for paging, tone distribution, textual Message distribution, and audio program distribution shall be incorporated onto the floor plans. The IGUI software shall provide:

1. Simple routine call processing, including hold, transfer, and forward.

2. Activation of remote station auxiliary relays for applications such as door lock or release

3. Emergency functions

4. Paging

5. Audio program distribution

6. Customizable page elements

7. Customizable operating screen

8. Element library for emergency event icons

9. Initiation of emergency and non-emergency messaging, textual and audible

10. Remote station volume adjustment

11. Remote activation of do not disturb status and/or message waiting status

12. Remote station trouble indication

13. Remote station background music channel selection

14. Dynamic zone management for interactive on-the-fly console specific zones

15. Single touch emergency response (supporting both actual emergencies and drills) including but not limited to all or any combination of the following:

    a. Live voice notification

    b. Pre-recorded audio message

    c. Digital plain text messaging with simultaneous numerically coded message capability

    d. Computer pop-up notification

    e. SMS text messaging

    f. Email

    g. Remote system activation, i.e., access control systems, CCTV systems, door release systems, etc.

D. The IGUI must provide an efficient and reliable method of notifying the occupants within the facility of critical situations. A variety of emergency tone signals that reside within the intercom/paging system shall be activated by clicking on pre-programmed buttons on the IGUI screen, initiating the transmission of tone signals to speakers, and alphanumeric messages to message displays/digital clocks. A "lockdown" icon shall be designed as per Owner direction, with Owner selecting the appropriate tone. Whole building macros for emergency or off-normal response shall be built into the internal communication system as directed by the Owner. Each macro shall be capable of being activated by the console, the IGUI as indicated on plans or as directed by the Owner or AHJ. It shall be possible to activate a WAV file message or Owner selected tone coinciding with multi-language textual messages for distributions to zones as directed by the Owner, all from a single activation icon located on the IGUI. Other single action macros shall be activated in similar fashion via the IGUI and a custom labeled icon. Plain language labeling of all icons on the IGUI shall be user changeable.

2.6 SUPERVISED SIP TRUNK IP/PBX INTERFACE

A. The system Session Internet Protocol (SIP) Interface shall be a VoIP PBX phone interface of the same manufacturer as the supervised network intercom and paging system. Third party gateway devices shall not be accepted.

B. The SIP Interface shall be supervised and shall connected directly to the facilities network and the PBX's network and shall provide the following:

1. Establish a barrier gateway between the intercom and paging network and the PBX and/or common computer network.

2. Transparent audio operation between VoIP PBX phones and any device on the supervised network intercom and paging system. Paging access from any telephone on the facility system VoIP PBX to any intercom speaker, speaker zone, intercom station, console, all speakers, or paging horns and zones throughout the facility.

3. Any call-in from the supervised network intercom and paging system shall be capable of being routed directly to a VoIP PBX phone. Call-in stations can be configured and programmed to automatically dial any number on the publicly switched telephone network, landline, or cellular number through the SIP interface and via the PBX.

4. Ability to escalate a call-in directed to a console to be redirected to a VoIP PBX connected phone via the SIP Interface. Escalation can also include the ability to dial any number on the publicly switched telephone network, landline, or cellular number through the SIP interface via the PBX.

5. Ability to initiate alarm and crisis response protocols from any VoIP PBX connected phone.

6. Ability to require security access code to utilize the intercom or paging system emergency communication features.

7. Minimum of 10 simultaneous telephone channels of access to/from VoIP PBX phone system.

8. Full caller ID support from any supervised network intercom call-in device to a VoIP PBX connected phone identifying the calling station ID/Location.

9. Emergency level call-in to be uniquely identified as emergency on the VoIP PBX phones.

10. Activation of all supervised networked intercom and paging system emergency tones and pre-recorded announcements from any phone connected to the building VoIP PBX phone system.

11. The SIP Interface shall additionally allow for calls to be placed from a console to any phone number on the publicly switched telephone network (landline or cellular). Additionally, intercom calls at a console may be transferred to any number on the publicly switched telephone network to any landline or cellular number through the SIP interface via the PBX.

C. Systems that connect to a building or district phone system and are limited to a SLT or CO connection will not be accepted as a substitute for a fully operational SIP Interface.

2.7 SUPERVISED NETWORK INTERCOM TALK-BACK SPEAKER

A. The Supervised Network Intercom Talk-Back Speaker (subsequently referred to as Network Speaker) shall be supervised and capable of up to 10 watts of audio signal and provide a minimum of 92db @ 1-meter SPL for maximum intelligibility. Speaker spacing shall be as defined by manufacturer to provide maximum intelligibility.

B. The Network Speaker shall provide transmission of HD audio as generated from intercom console and/or associated push-to-talk, intelligent microphone, supervised network amplifier, or program sources connected to the network.

C. The Network Speaker shall provide a dry contact output that can be activated remotely from a station or from a console, such as may be required in a door release application.

D. The Network Speaker shall receive power and data over a RJ45 connect CAT5E/6 cable via a Power-Over-Ethernet switch port. Once plugged into the LAN through a Power over Ethernet network switch, the Network Speaker shall be immediately functional and be able to receive calls and pages from consoles on the network. The Network Speaker shall not require any network configuration or administration to function.

E. The Network Speakers shall support talkback; to optimize intelligibility talkback capabilities shall be supported via a microphone conditioned for low noise, HD audio, and with compression and noise gate capability. Stations that use the speaker instead of a separate microphone for talkback capability shall not be accepted.

F. The Network Speaker shall have a call-in roll-over feature where if it places a call-in to a primary call destination which is not answered after a preset amount of time, the call-in shall be automatically

escalated to a secondary call-in destination. If both the primary and secondary call-in destinations are unavailable, the call-in shall be redirected to a back-up Station, Console, or telephone device.

G. The Network Speaker shall have the capability to be configured as a member of 1 or more paging zones.

H. The Network Speaker shall support the direct connection with RJ45 connectors of two, supervised room notification stations. The stations shall provide the means for: normal calls, emergency calls, privacy mode, and do not disturb mode. Notification stations shall include a call placed assurance status LED to indicate a call has been placed. Notification stations shall be supervised and immediately indicate disconnection or a wiring fault.

I. In addition to the visual call-in assurance status indicators on the notification stations, call-in assurance status indication must also be provided on the associated speaker. Also, in addition to visual call-in assurance, audible call-in assurance shall also be provided in support of persons with visual disabilities.

J. Under blackout conditions the notification station shall be illuminated such that it can be located in the dark.

K. Normal call stations must support the ability to activate emergency call-in signals via multiple button presses and press and hold operations. Emergency call stations shall be separate and clearly labeled with a red button so as to impart obvious operation in the event of an emergency. Systems that only provide a single call station with dual emergency and normal operation shall not be acceptable.

L. The Network Speaker shall provide local, visual indication of operation or failed communication and shall immediately annunciate a loss of communication at the main console location.

M. Network Speaker volume must be capable of individual level settings through the network. Settings must not be adjustable without authorization. Volume controls located in rooms must be centrally lockable via the network. Systems that allow a volume adjustment without authorization shall not be acceptable. Systems that utilize a manually operated transformer or resistive volume control design shall not be acceptable. Volume controls shall be capable of establishing and maintaining levels for intercom, paging, program distribution, and tones, independently for each of the above functions. Emergency announcements shall be sent at a volume/level as required by the AHJ and shall not be affected by the adjustment of other speaker volume/levels for the purposes of paging, intercom, or other lower priority audio events.

2.8 SUPERVISED NETWORK INTERCOM STATIONS

A. The Supervised Network Security Intercom Station (subsequently referred to as Intercom Station) shall be supervised and used to establish communication between specific areas of a facility, providing for two-way communications as well as call-in capabilities.

B. The Station shall be equipped with zero to three tamperproof push-button switches as required for the application. The unit shall be inscribed with simple operating instructions on the stainless-steel faceplate. Stations shall support placement of a call-in (normal or emergency), the annunciation of a call-in, answering of a call-in for intercom, and placement of an all call, emergency, or zone page as required.

C. The Station shall have a station status LED indicator with “Status” inscribed on the faceplate.

D. The Station shall provide a dry contact output that can be activated remotely from another station or from a console, such as may be required in a door release application.

E. The Station shall receive power and data through a Power-Over-Ethernet switch. Once plugged into the LAN through a Power over Ethernet network switch, the Station shall be immediately functional and be

able to receive calls and pages from consoles on the network. The Station shall not require any network configuration or administration to function.

F. The Stations shall have a call-in roll-over feature where if it receives a call-in as a primary call destination which is not answered after a preset amount of time, the call shall be automatically escalated to a secondary call destination. If both the primary and secondary call destinations are unavailable, the call shall be redirected to a back-up station or console.

G. The Station shall have the capability to be configured as a member of 1 or more paging zones.

H. The Station shall be wall-mounted on a 3-gang surface mount backbox with a depth of no less than 2.75". Mounting hardware shall be tamper-proof. The face plate shall be fabricated from 11 gauge stainless steel with a brushed, mar-resistant finish. The Station shall be designed to withstand physical damage and everyday wear-and-tear. The buttons shall be tamper-proof, and the overall assembly shall be designed to be vandal-proof. A G3 weather-seal gasket shall be available as an additional option to weatherproof the Stations.

2.9 CLASSROOM CALL INITIATION HANDSET

A. Mounting: Individual stations shall be surface wall at elevation shown on drawings.

B. Twelve-button touch key selector to originate calls to other stations.

C. Handset for providing two-way communication.

D. Tone annunciator on incoming calls.

E. Overhead speaker disconnects by lifting handset.

F. Tamper-resistant construction.

G. Finish to be coordinated with architect.

H. Standard molded plastic telephone handset with 5' long permanently coiled cord.

2.10 SUPERVISED NETWORK AMPLIFIER

A. The Supervised Network Amplifier (subsequently referred to as Network Amplifier) shall provide a minimum of 25 watts for paging and public address and shall be capable of utilizing analog amplifiers to increase the amount of amplified signal from the network amplifier. The Network Amplifier shall be connected directly to the network switch by an RJ45 connector and shall receive signals directly from the network.

B. The Network Amplifier shall be supervised and, in the event, that network communications is lost, an audible alert shall sound on the Amplifier. The Network Amplifier shall provide a silence feature to mute the audible alert for 24 hours.

C. The Network Amplifier shall also be capable of receiving local input from local devices such as tape decks, iPod docks, CD players, etc. The network amplifier shall be capable of transmitting signals received from the local input to other network locations or locally to directly connected 25/70 volt or 8 ohm analog speakers.

D. Each Network Amplifier shall be capable of providing two audio inputs for local devices and shall be programmable as either a microphone or line-level input.

E. The Network Amplifier shall be controlled remotely such that audio programs, input, tones, textual messages, or announcements may be initiated by other devices connected at different locations on the local area network.

F. The Network Amplifier shall have a minimum of 4 local tone/pre-recorded announcement audio message control lines which when activated will distribute tones/pre-recorded audio messages to intended network amplifiers for re-distribution, network talk-back speakers (or a zone), and/or local 25/70 volt or 8-ohm analog speakers directly connected to amplifier. Each network amplifier shall be capable of storing four (4) pre-recorded announcements in addition to a minimum of 16 tones. Tones and announcements shall be activated locally or from other network devices.

G. The Network Amplifier shall store and transmit companion textual messages for each stored audio announcements. Textual messages shall be automatically broadcasted to the same zones along with the audio messages such that any device programmed for that zone automatically receives both the audio and textual announcement/message and automatically reproduced each or both messages to the extent of the devices' capabilities.

H. The Network Amplifier shall be capable of transmitting HD level audio as defined by Intel (TM) High Definition Audio specifications, at a minimum.

I. The Network Amplifier shall shut down to protect itself should an output short circuit fault or overload occur that jeopardizes the integrity of the Network Amplifier.

2.11 INTERCOMMUNICATION POWER AMPLIFIER

A. Minimum Output Power: 15 W; adequate for all functions.

B. Total Harmonic Distortion: Less than 5 percent at rated output power with load equivalent to one station connected to output terminals.

C. Minimum Signal-to-Noise Ratio: 50 dB, at rated output.

D. Frequency Response: Within plus or minus 3 dB from 70 to 10,000 Hz.

E. Output Regulation: Maintains output level within 2 dB from full to no load.

F. Input Sensitivity: Matched to input circuit and to provide full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on microphones in administrative console, speaker microphones, or handset transmitters.

G. Amplifier Protection: Prevents damage from shorted or open output.

2.12 CONE-TYPE LOUDSPEAKERS

A. Minimum Axial Sensitivity: 91 dB at one meter, with 1-W input.

B. Frequency Response: Within plus or minus 3 dB from 70 to 15,000 Hz.

C. Minimum Dispersion Angle: 100 degrees.

D. Line Transformer: Maximum insertion loss of 0.5 dB, power rating equal to speakers, and at least four level taps.

E. Enclosures: Steel housings or back boxes, acoustically dampened, with front face of at least 0.0478-inch steel and whole assembly rust proofed and factory primed; complete with mounting assembly and suitable for surface ceiling, flush ceiling, pendant or wall mounting; with relief of back pressure.

F. Baffle: For flush speakers, minimum thickness of 0.032-inch aluminum brushed to a satin sheen and lacquered with textured white finish.

G. Vandal-Proof, High-Strength Baffle: For flush or surface-mounted speakers, self-aging cast aluminum with tensile strength of 44,000 psi, 0.025-inch minimum thickness; countersunk heat-treated alloy mounting screws; and textured white epoxy finish.

H. Size: 8 inches with 1-inch voice coil and minimum 5-oz. ceramic magnet.

2.13 HORN-TYPE LOUDSPEAKERS

A. Speakers shall be all-metal, weatherproof construction, complete with universal mounting brackets.

B. Frequency Response: Within plus or minus 3 dB from 275 to 14,000 Hz.

C. Minimum Power Rating of Driver: 15 W, continuous.

D. Minimum Dispersion Angle: 110 degrees.

E. Line Transformer: Maximum insertion loss of 0.5 dB, power rating equal to speakers, and at least four level taps.

2.14 ANALOG STATION TERMINATION UNIT

A. The Termination Unit shall reside on the facilities LAN providing provide two-way intercom communications between Consoles and industry standard 25 Volt speaker stations.

B. The Termination Unit shall distribute program audio to speaker locations and detect call-in annunciation from call switches in room locations. It shall be able to selectively transmit Paging, Audio Programs and Time Tone Signals originating on the eSeries Network Devices, to individual rooms, all rooms, selected rooms, or zones of loudspeakers.

C. The Termination Unit shall be consistent with the ANSI/NEMA SB 40 Standard for Communications Systems for Life Safety in Schools, supporting multiple call-in locations per room. These include the support of call-in devices with LED call assurance and privacy or do-not-disturb indication for each room. Multiple devices at a room location shall be configured to place call-ins with different destinations and priority levels. If the call-in destination of these devices is a Console or an IP-PBX phone extension, the device display shall indicate the calling room location dial number, a textual room name, and the priority level of the call-in. Room locations can be configured with a primary, secondary, and back-up call-in destinations. Emergency priority call-ins placed from a room location shall be configured with a different call-in destination.

D. The Termination Unit shall support a Message Waiting (MW) feature. This feature shall use the LED on call stations to indicate waiting messages to room occupants. If no one is present in a room location to respond to a call or if the room is in Privacy or DND mode, the caller has the option to activate a MW indication. This causes the LED on the call station to pulse. When a call-in is initiated from the room, it shall be directed to the device that activated the MW indication and the MW indication will be deactivated.

E. The Termination Unit shall support the Privacy function on Call Stations that are equipped with a Privacy button. When pressed, the Privacy button shall place the room location in privacy mode. This shall prevent monitoring of audio in the room. In privacy mode, the LED on the Call Station shall illuminate to indicate privacy mode. When a call-in is placed from the room location, privacy mode shall automatically be suspended for the duration of the call and re-enabled afterwards. If a call is placed to the room location while in privacy mode, the caller shall be alerted to the privacy mode and given the option to connect the call, leave a message waiting indication, or to cancel the call.

F. The Termination Unit shall include support for the Do Not Disturb mode. Call Stations equipped with a Do Not Disturb (DND) button shall be able to place the room in DND mode when pressed. In DND mode, the LED on the Call Station shall flash to indicate that the station is in the DND mode. This shall suspend zone pages and normal priority audio distributions from being broadcast into that room. DND mode shall not prevent emergency priority operations from reaching the location. If a call is initiated from a room location that is in the DND state, the DND shall be automatically suspended for the duration of the call and re-enabled afterwards.

G. The Termination Unit shall also provide synchronization and correction of traditional Digital and Analog Clocks, as well as Electronic Message Displays. The digital signaling that provides support for these devices shall originate in the eSeries Network. Analog Clock correction formats supported by Legacy T2 or XL systems, shall also be supported by the Termination Unit.

H. The Termination Unit shall monitor the wiring of all room location call devices for call line failure. It shall analyze the wiring for an open circuit, short circuit, or short to ground conditions. In the event of a fault, the Termination Unit shall detect the fault and provide trouble notification messages to a designated Console. Other system devices equipped with trouble LED and buzzers will also annunciate trouble signals. Trouble messages and notifications shall be temporarily silenced up to 24 hours at the discretion of the Console Operator. After a 24-hour period, the notifications will re-annunciate automatically.

I. The Termination Unit shall be equipped with an integrated 25-watt, dual-purpose intercom/paging amplifier. It shall be used to provide amplification for two-way intercom communications to room stations, as well as amplification for paging, audio programs, and time tone signals to speaker locations. In the event that the audio load is greater than 25 watts, a line level output shall provide for the connection of an external power amplifier.

J. All speakers, when connected to the Termination Unit shall reside on an “Off Bus.” This shall ensure failsafe operation, where even in the event that network connectivity is lost, a redundant audio source can be connected to the “Off Bus” and emergency paging announcements can be transmitted to all speakers connected to the Termination Unit.

K. The Termination Unit shall mount in a standard rack panel measuring 19" W x 1.75" H and shall occupy a single rack unit. It shall be ideally suited for use with the Telecor C5PPL patch panel. Alternatively, two 50-pin, RJ-21 connectors shall provide termination facilities to a pair of TM-2X25 terminal blocks for connecting field devices. The unit shall be powered from an external 24 VDC Power Supply.

2.15 SUPERVISED SPEAKER BREAKOUT MODULE

A. The speaker breakout module shall reside on the network providing two-way intercom communications between consoles, SIP connected VoIP telephones and industry standard 25 Volt speaker stations.

B. The speaker breakout module shall provide connections for a standard 8-ohm, 25V or 70V speaker. It shall provide connection for standard call button and supervised call switches. The module shall provide two-way communications through the speaker and allow normal and emergency call to be placed from an industry standard pushbutton call station.

C. The module shall utilize POE technology and a decentralized network structure to ensure easy wiring and simplified network planning. The module shall not require any network configuration, IP address or DHCP server to operate.

D. The module shall have individually adjustable volume setting for intercom, paging, emergency paging and public music channels. The module shall provide connections for the eCS-4 or eCS-5 digital volume control stations.

E. The module can be used as a single zone paging adaptor enabling paging and Public Channel audio to be broadcast to a group of speakers. The module shall provide 4-watts of power for a small zone of speakers. The module shall provide a line level audio output to feed larger power amplifiers, as required.

F. The module shall be monitored for network connectivity. In the event of a loss of a network connection, the e300 master console will report that station as absent and display the modules dialing number.

G. The module shall be equipped with three relays that can be utilized to operate auxiliary devices such as strobe lights, tone initiating devices and door locks.

2.16 CONDUCTORS AND CABLES

A. Conductors: Jacketed, twisted pair and twisted multipair, untinned solid copper. Sizes as recommended by system manufacturer, but no smaller than No. 22 AWG.

B. Insulation: Thermoplastic, not less than 1/32 inch thick.

C. Shielding: For speaker-microphone leads and elsewhere where recommended by manufacturer; No. 34 AWG, tinned, soft-copper strands formed into a braid or equivalent foil.

1. Minimum Shielding Coverage on Conductors: 60 percent.

D. Plenum Cable: Listed and labeled for plenum installation.

2.17 RACEWAYS

A. Educational Intercommunication and Program System Raceways and Boxes: Comply with requirements in Section 270528 "Pathways for Communications Systems."

PART 3 - EXECUTION

3.1 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters**,** and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.

2. Comply with requirements for raceways and boxes specified in Section 270528 "Pathways for Communications Systems."

B. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.2 INSTALLATION OF RACEWAYS

A. Comply with requirements in Section 270528 "Pathways for Communications Systems" for installation of conduits and wireways.

B. Install manufactured conduit sweeps and long-radius elbows whenever possible.

3.3 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Requirements:

1. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at outlets and terminals.

2. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Cables may not be spliced.

3. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.

4. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

5. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.

6. Cold-Weather Installation: Bring cable to room temperature before derailing. Heat lamps shall not be used.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunication spaces with terminating hardware and interconnection equipment.

2. Suspend cable not in a wireway or pathway a minimum of 8 inches above ceiling by cable supports not more than 60 inches apart.

3. Cable shall not be run through structural members or be in contact with pipes, ducts, or other potentially damaging items.

D. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install in separate raceways or, where exposed or in same enclosure, separate conductors at least 12 inches apart for speaker microphones and adjacent parallel power and telephone wiring. Separate other intercommunication equipment conductors as recommended by equipment manufacturer.

3.4 INSTALLATION

A. General: Install all equipment and wiring in accordance with NFPA 70 and applicable EIA codes and standards, as well as manufacturer’s written instructions and procedures. All devices shall be provided as indicated on approved submittals.

B. Wiring: Wiring shall be routed above suspended, fully accessible, “lay-in” ceilings where possible. Route in cable trays where provided above suspended ceilings. Provide raceways for all exposed runs of wiring. Support all raceway as required by NFPA 70.

C. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

D. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables so they identify media in coordination with system wiring diagrams.

E. Weatherproof Equipment: For units that are mounted outdoors, in damp locations, or where exposed to weather, install consistent with requirements of weatherproof rating.

F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

G. Mounting of Stations: Surface mount at 54 inches above finished floor to center of station unless otherwise indicated.

H. Provide additional expansion capacity and all components necessary, except handsets, for twenty (20) percent additional capacity.

I. All final connections shall be made by factory trained technicians.

3.5 GROUNDING

A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

B. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.

3.6 SYSTEM PROGRAMMING

A. Programming: Fully brief Owner on available programming options. Record Owner's decisions and set up initial system program. Prepare a written record of decisions, implementation methodology, and final results.

3.7 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Perform tests and inspections with the assistance of a factory-authorized service representative:

C. Tests and Inspections:

1. Schedule tests with at least seven days' advance notice of test performance.

2. After installing educational intercommunications and program systems and after electrical circuitry has been energized, test for compliance with requirements.

3. Operational Test: Test originating station-to-station, all-call, and page messages at each intercommunication station. Verify proper routing and volume levels and that system is free of noise and distortion. Test each available message path from each station on system.

4. Frequency Response Test: Determine frequency response of two transmission paths, including all-call and paging**,** by transmitting and recording audio tones. Minimum acceptable performance is within 3 dB from 150 to 2500 Hz.

5. Signal-to-Noise Ratio Test: Measure signal-to-noise ratio of complete system at normal gain settings as follows:

   a. Disconnect speaker microphone and replace it in the circuit with a signal generator using a 1000-Hz signal. Measure signal-to-noise ratio at paging speakers.

   b. Repeat test for three speaker microphones, and one administrative console microphone, and for each separately controlled zone of paging loudspeakers.

   c. Minimum acceptable ratio is 45 dB.

6. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 150, 200, 400, 1000, and 2500 Hz into each intercom**,** paging, and all-call amplifier. For each frequency, measure distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 5 percent total harmonics.

7. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band filters to measure level at five locations in each paging zone. Maximum permissible variation in level is plus or minus 3 dB; in levels between adjacent zones, plus or minus 5 dB.

8. Power Output Test: Measure electrical power output of each paging amplifier at normal gain settings of 150, 1000, and 2500 Hz. Maximum variation in power output at these frequencies is plus or minus 3 dB.

9. Signal Ground Test: Measure and report ground resistance at system signal ground. Comply with testing requirements in Section 270526 "Grounding and Bonding for Communications Systems."

D. Inspection: Verify that units and controls are properly labeled, and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging and independent room speaker-line matching transformers.

E. Educational intercommunications and program systems will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.8 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service and initial system programming.

1. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements.

2. Complete installation and startup check according to manufacturer's written instructions.

3.9 ADJUSTING

A. On-Site Assistance: Engage a factory-authorized service representative to provide on-site assistance in adjusting sound levels, resetting transformer taps, and adjusting controls to meet occupancy conditions.

B. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to four visits to Project during other-than-normal occupancy hours for this purpose.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the educational intercommunications and program systems.

1. Train Owner's maintenance personnel on programming equipment for starting up and shutting down, troubleshooting, servicing, and maintaining the system and equipment.

2. Provide a minimum of eight hours of training to owner’s personnel.

END OF SECTION 275123.50

SECTION 281000 – ACCESS CONTROL SYSTEM

PART 1 - SCOPE

1.1 GENERAL

A. This section details product and execution requirements for the Access Control System for the project.

B. Work includes furnishing all labor, materials, tools and equipment, and documentation required for a complete turnkey working system as specified in this Section. SMS shall consist of but not be limited to Door Controllers, Card Readers, Sensors, Switches, Conduit, Boxes, Power Supplies, Cable, and Wired Devices. Programming and cardholder enrolling are also considered as part of installation as well as coordination with Owner.

C. The Access Control System (ACS) shall function as an electronic physical access and situational control system and shall integrate the alarm monitoring, ID badging, and database management into a single executable application. The ACS shall function as the primary means of controlling all access and situational control needs. A scalable, open architecture and network ready solution shall allow for an assured access and alarm monitoring solution.

D. Communications routing from SMS to door controllers shall be via LAN.

E. The system shall be fully integrated and connected to the Wake County S2 Global ACS system for centralized administration of card holder records.

1.2 RELATED SECTIONS

1. 283100 – Intrusion Detection System
2. 087000 – Door Hardware Specifications
3. 260000 - Electrical Specifications
4. 270000 - Communication Systems

1.3 REFERENCES AND STANDARDS

A. Other applicable standards are as follows:
   1. UL 294 - Access Control System Units.
   2. UL 1076 - Proprietary Burglar Alarm Units and Systems.
   3. FCC Rules and Regulations Part 15, Radio Frequency Devices
   4. NEC Compliance: Comply with applicable requirements of NFPA-70, National Electrical Code (NEC) standards pertaining to door access control systems.
   5. Testing Laboratory Compliance: Comply with provisions of UL safety standards pertaining to door access control systems. Provide products and components which are Listed and Labeled.

B. All work and materials shall conform in every detail to rules and requirements of National Fire Protection Association and North Carolina Electrical Code

C. All materials shall be listed by UL and shall bear UL label. If UL has no published standards for a particular item, then other national independent testing standards shall apply, and such items shall bear those labels. Where UL has, an applicable system listing, and label entire system shall be so labeled.

1.4 DEFINITIONS AND ABBREVIATIONS

A. SMS – Security Management System

B. ACS – Access Control Security

C. BICSI – The Building Industry Consulting Service International, Inc.

D. Unless otherwise noted, contractor refers to access control system integrator and installer.

E. Access Card: A coded employee card, usually the size of a credit card, recognizable to the access control system and read by a reader to allow access. It can be used for photo identification of the cardholder and for other data collection purposes. Card technologies include magnetic strips, wiegand-effect, proximity (active/passive), barium ferrite, smart/intelligent cards, and NFC enabled applications on mobile devices.

F. Access Control System: An interconnected set of controllers, managing the entrance and exit of people through secured areas.

G. Access Level: The door or combination of doors and/or barriers an individual is authorized to pass through and the times they are permitted.

H. Anti-Pass back (Anti-Tailgating): This feature protects against more than one person using the same card or number. It defines each system card reader and card ID number as IN, OUT or other. Once a card is granted access to an IN reader, it must be presented to an OUT reader before another IN-reader access is granted. Cards will continue to have access to all authorized OTHER readers.

I. Alarm: A signal that indicates a problem.

J. Alarm input: A device that is monitored by the access control panel. An alarm signal will be generated if the device is activated.

K. Badge: Badge is a template or a design for creating a card.

L. Bar Code: A method of encoding information using lines and blank spaces of varying size and thickness to represent alphanumeric characters.

M. Biometrics: A general term for the verification of individuals using unique biological characteristics (i.e., fingerprints, hand geometry, voice analysis, the retinal pattern in the eye).

N. Card and Card Holder: A card is an identity proof of a person, and a card holder is a person who holds the card. Multiple cards can be assigned to a single card holder to provide different access.

O. Controller: A microprocessor-based circuit board that manages access to a secured area. The controller receives information that it uses to determine through which doors and at what times cardholders are granted access to secure areas. Based on that information, the controller can lock/unlock doors, sound alarms, and communicate status to a host computer.

P. Card Reader: A device that retrieves information stored on an access card and transmits that information to a controller.

Q. Digital Video Recorder (DVR): A security system device that records the video from the surveillance cameras (IP and Analog) on a hard disk.

R. Door: A generic term for a securable entry way. In many access control applications, a "door" may be a gate, turnstile, elevator door, or similar device.

S. Duress: Forcing a person to provide access to a secure area against that person's wishes.

T. Input: An electronic sensor on a controller that detects a change of state in a device outside the controller.

U. Integrated lockset: An integrated, intelligent locking solution that typically runs on batteries, but can be externally powered, that contains most of the door components, i.e., reader, door contact, and request to exit in a single, mountable unit.

V. Keypad: An alphanumeric grid which allows a user to enter an identification code. A flat device which has buttons that may be pressed in a sequence to send data to a controller, and which differs from a typewriter-like computer keyboard.

W. Output Relay: A device that changes its state upon receiving a signal from a controller. Typically, the state change prompts an action outside of the controller such as activating or deactivating a device. The auxiliary relays found in access control panels or NODES that control external devices.

X. Shunt Time: The length of time a door open alarm is suppressed (shunted) after a valid card access or free egress request. This time should be just enough to allow a card user to open a door or gate, pass through, and then close it.

Y. Time Schedules: Schedules that allow cards to function or not function depending on the time of day. This is used to limit access to the facility. The schedule may include not only time but which days of the week a card is valid.

Z. Video Management System (VMS): An enterprise-class video management and storage solution

1.5 SUBMITTALS

A. Manufacture Product Data: Submit the manufacture’s data sheet indicating systems and components for use.

B. Shop Drawings: Submit complete shop drawings indicating system components, wiring diagrams locations of equipment.

C. Record Drawings: During construction maintain record drawings indicating location of equipment and wiring. Submit an electric version of record drawings for the Security Management System no later than Substantial Completion of the project.

D. Operation and Maintenance Data: Submit manufacture’s operation and maintenance data, customized to the Security Management System installed. Include system and operator manuals.

E. Operation statements for all SMS doors.

F. Certifications from BICSI.

1.6 QUALITY ASSURANCE

A. Security Management System Contractor shall:
1. Have successfully completed two (2) similar system projects in equal magnitude of the building systems specified in following sections.
2. Installer must have a minimum of 1 (one) technician that has successfully completed the access control manufacture’s certification training course that is present on the project site to supervise the installation and system testing.

3. Proper proof of manufacturer credentials and certification will be submitted at time of Bid.
4. Be responsible for complete turnkey system including programing.
5. Comply with all certification requirements set out in Division 27 as it related to the installation of any cabling.
6. Contractor will comply with the requirement of all cabling being installed by BICSI certified installers and installation supervised by a registered, in good standing RCDD and must be a full-time employee of the project contractor.
7. Deliver materials in original packaging. Store and handle in accordance with the manufacture's requirements.
8. Installer Qualifications: The Security Management System shall be provided and installed by a Factory Certified S2 integrator with factory certified technicians.

1.7 GUARANTEE

A. Warranty requirements for Access Control System shall be one (1) year on all parts and labor commencing on Date of Substantial Completion. Those requirements apply to all software and hardware components covered in this section. If manufacture's equipment warranties extend past one (1) year, the term of those warranties extend to the life of this project warranty. Provide warranty information and duration as part of the submittal process.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR ACCESS CONTROL SYSTEM

A. The ACS Wake County Public School System (WCPSS), in order to maintain consistency on access control systems, has identified the following products as the Owner's Security Office preferred standard.

1. Control Panel: S2 Security Corporation. S2 Netbox
2. Door Contacts (DPS / Monitor Points when not included in Door Hardware)
3. Steel Door contacts.

a. Manufacturers: GE Interlogix 1078 Series or approved equal. Provide 1" round recessed door positioning sensor

4. Request to Exit Sensor: Takex PU-PS520W or Honeywell IS-310 or approved equal.
5. Door Access Control Power Supply: IEI – International Electronics Inc. – Model PG-1224-3.
6. Card Readers: S2-900PTNNEK00460-S2SEC

    a. Wall-mount: provide standard width model. Shall cover entire junction box.
    b. Mullion-mount: provide reduced width model for mullion mount applications only.

B. A sufficient number of controllers and sub-controllers will be provided to monitor all credential reader, monitor point, and relay point locations shown on plan.

2.2 SYSTEM REQUIREMENTS

A. The S2 NetBox ® Security Management System shall be deployed. This system includes the Network Controller that contains the operating system, database engine, web server, application software, and configuration data. The solid-state NetBox ® Network Controller shall contain a processor, flash memory, and a network switch. The Network Controller shall be supplied with 12V DC at a minimum of 5 amps. Internal battery backup shall supply sufficient power to provide for an orderly shutdown of the system in case of loss of external power. External battery backup shall be used to provide uninterrupted operation in the event of external power loss. If required, the Network Controller shall be accompanied by a Network

Node. The Network Node shall contain I 2C for communication with the Application blades and a network interface port.

B. The Network Node shall make and manage access control decisions with data provided by the Network Controller, and it shall manage the communication between the Controller and Application blades connected to the system's inputs, outputs, temperature sensors and readers. The Node shall be supplied with 12V DC at a minimum of 5A. Each Network Node shall support up to seven Application blades.

Communications between the node and Network Controller shall be encrypted and authenticated (SHA-1).

Each Network Node shall have the following capabilities:

1. Application blades 7
2. Access control readers 14
3. Access Levels 512
4. Portals 14
5. Portal Groups 64
6. Readers 14
7. Reader Groups 128
8. Supervised Inputs 56
9. Input Groups 64
10. Relay Outputs 56
11. Output Groups 64
12. Temperature Monitor Inputs 56
13. Elevators 14
14. Floors 52
15. Floor Groups 128
16. Credential storage 20,000
17. Activity Log records 27,000

C. The Application blades shall interface with the Network Controller through the Network Node. The Application blades shall be blade-style circuit cards. There shall be four types of Application blades:

1. Access Control blade: shall support 2 readers (input devices such as keypads, RFID devices or Biometric readers), 4 supervised inputs and 4 relay outputs.
2. Supervised Input blade: shall support 8 supervised inputs. Supervised input connectors are 2- pin. The system shall support a wide variety of input supervision types such as: no-resistor, one resistor or two resistors including normally open circuit and normally closed circuits.
3. Output blade: shall support 8 relay outputs. Outputs are form C relay represented by 3-pin connectors. Both normally open circuit and normally closed-circuit output devices are supported. The relay outputs shall support any output devices that operate on the following maximum electrical ratings: 30 V DC or AC, 2.5 Amps inductive or 5.0 Amps non-inductive.
4. Temperature blade: shall support 8 analog temperature sensor inputs. Temperature range shall be 32° to 158° F (0° to 70° C). Temperature precision within that range shall be ±1.0° F (±0.5° C).

D. Additional Features:

1. Multi-User/Network Capabilities: The ACS shall support multiple operator workstations via local area network/wide area network (LAN/WAN). The communications between the workstations and the server computer shall utilize the TCP/IP standard over industry standard IEEE 802.3 (Ethernet). The communications between the server and workstations shall be supervised and shall provide the ability to generate alarm messages when the server is unable to communicate with a workstation.
2. Operating Environment: The ACS shall be a 3-tier client/server, ODBC compliant application based on Microsoft tools and standards. The ACS application shall operate in the following environments: The most recent Windows Enterprise/Professional. Windows Server most recent Version.

3. Multi-level Password Protection: The ACS application shall provide multi-level password protection, with user-defined operator name/password combinations. Name/password log-on shall restrict operators to selected areas of the program. The application shall allow the assignment of operator levels to define the system components that each operator has access to view, operate, change, or delete.
4. Alarm Events: The ACS shall include a feature where alarm events with defined priorities shall be able to pop-up automatically in an Alarm event window for operator attention. The pop-up shall display the following information: description of the event, time, date, point description, if a card event the card number, type of event and cardholder name. An event counter shall also display the number of times the event was reported to the Alarm event monitor prior to Acknowledgement or Clearing the event. Event instructions shall be made available by double clicking on the event. The Alarm shall also display an icon to indicate that a camera is associated to the device. The Alarm event window shall allow the operator to initiate a physical response to the event as well as a written response. Responses shall include but not be limited to acknowledge, clear, open a pre-programmed floor plan, activate, de-activate, pulse, time pulse, add comment, retrieve archived video, and bring up live video, disarm, or arm.
5. Global Device Control: The ACS shall allow manual control of one or more selected inputs, outputs, and doors. Global device control shall include pulse, timed pulse, and energize/de-energize or return to normal options for output points and arm/disarm or return to normal options for input points. For global control of doors, the ACS shall include Disabled, Unlocked, Locked, Facility Code Only, Card Only, PIN Only, Card and PIN, Override Mode, and Cancel Override Mode.
6. Global Edit: The ACS shall support, by way of a multi-select function, a method to globally edit input points, outpoint points, doors, readers, personnel, and cards.
7. Levels of System Operation: The ACS shall include a feature to define the levels of system operation for each individual operator using passwords and profiles. System operation for individual operators shall include, but not be limited to, restricted time periods for login, inactivity notifications, and lockout for failed logon attempts. Operator actions range from no view or control rights to basic monitoring including the ability to block the viewing of card and or personal identification numbers, to full control of the system including programming.
8. Distributed Processing: All the control components of the ACS shall utilize “Distributed-Processing” design. The distributed processing shall include the ability to download operating parameters to any field panel, thus allowing the field panel to provide full operating functions independent of the ACS application server.

D. Video Entry System:

Wake County Public School System (WCPSS), in order to maintain consistency on video entry systems, has identified the following products as the Owner’s Security Office preferred standard.

Master Station: AiPhone IX-MV

IP addressable video master station with a 3.5-inch color LCD monitor. It can be wall or desk mounted (desk stand included). The IX-MV offers handset (duplex) and hands-free (VOX/PTT) communication and call up to 500 other IX units. It connects directly to a network using CAT-6 cable. This station requires an 802.3af compliant Power-over-Ethernet network connection.

Audio Video Door Station-Aiphone IX-DA

Shall provide a means to integrate intercom master and sub-stations into the application. Surface mount unit connects to a PoE network using CAT-5e/6 cable. The IX-DA will call up to 20 IX-MV masters or Instances of the IX MOBILE. The door station features a form C contact for door release, a 600-ohm output for paging or an amplified speaker, call placed/answered indication, and a contact input. Provide necessary back boxes if required.

E. Cabling

1. General

a. Cable shall be:
1) Access Control Composite Cable
2) Plenum Rated.
3) Yellow or white in Color for all Access Control Devices

2. Reader Cable
a. Construction:
1) 18 AWG stranded or as recommended by system manufacturer.
2) Aluminum/Mylar shield with drain wire applied over assembled conductors.

3. Door Lock Power Cable
a. Provide and install as required for door hardware. Refer to Architectural Door Schedule and Door Hardware documents. Provide cable size based on Lock requirements and distance from Power Supply.

4. Door Contact / Signal Cable
a. Door Contact/Signal Cable used for monitoring purposes.
b. Construction:
1) 22 AWG twisted, stranded, or as recommended by system manufacturer.
2) Aluminum/Mylar shield with drain wire applied over assembled conductors.

5. Request-to-Exit Motion Detector Signal Cable
a. Motion Detector Signal Cable used for monitoring purposes.
b. Construction:
1) 20 AWG stranded or as recommended by system manufacturer.
2) Aluminum/Mylar shield with drain wire applied over assembled conductors.

6. Door Prop Alarm Signal Cable
a. Signal Cable used for notification purposes.
1) Cable size per manufactures recommendations.
2) Size for distance

7. Door Controller Cable
a. Provide all LAN patch cables, jacks, and faceplates.

PART 3 - EXECUTION

3.1 PRE-INSTALLATION COORDINATION

A. Coordinate with Electrical Contractor (Division 260000) that:
1. Provided pathways and equipment back boxes are completed and are coordinated with no conflicts for system installation.
2. Provide Adequate power properly located for security system equipment.
3. Code-complying fire alarm relays will be installed for cable termination.
Fire Alarm contractor will provide relay contacts in Com Closet for connection to Access control panels. Contractor is responsible for coordination with Fire Alarm Contractor. Access control Contractor shall provide all parts and pieces including all cabling from Access control panel to Fire Alarm Contact point.
4. Coordinate scheduling of work to make sure there are no conflicts.

B. Coordinate with Door Frame supplier (Division 8):
1. Doors and door frames are properly prepared for electric locking hardware and door position switches are furnished by door type.
2. Locations of all devices prior to installation.
3. Electric door power supply locations and connections requirements.

C. Coordinate with Store Front Aluminum Door supplier and installer.
   1. Location of all devices prior to installation
   2. Schedules for installation of cabling and devices
   3. Electric door power supply locations and connections requirements.

D. Coordinate with ADA Actuator supplier and installer.
   1. For Access Control operation using intelligent logic controller

E. Coordinate with the Communications Contractor (Division 27):
   1. Locations of all LAN-connected devices with no conflicts.
   2. Coordinate scheduling of work.

F. Coordinate with the Intrusion Detection System Contractor
   1. Coordinate termination of DPDT Door Position Switches

G. At a minimum, coordinate the following with Owner:
   1. VLAN/or network partitioning for SMS system.
   2. Owner-provided IP addresses for SMS devices.
   3. Initial database programming.
   4. Planned system downtime.
   5. Programming and training for new system.

H. Coordinate with Construction Team as required providing a fully functioning turnkey Security system.

I. Provide necessary interconnection with door actuator plates for auto operated doors. Contractor will supply any and all associated timer boards or additional parts required for complete operating doors system.

J. Coordination Meetings shall be scheduled and conducted as necessary and in accordance with the Project General Conditions.

3.2 INSTALLATION

A. General
   1. Verify acceptance of each type of specified request-to-exit hardware for each application with local life safety code officials.
   2. Provide tamper proof fasteners for all equipment in public areas. Fastener finish shall match equipment finish.
   3. Maintain minimum three feet of access in front of class 1 electrical equipment.
   4. Ensure Closets are free of dust and debris before installation of access control equipment.
   5. Ensure Closets are properly conditioned with adequate cooling before installation of access control equipment.

B. Delivery, Storage, and Handling
   1. Deliver products to and receive products at site under provisions of General Requirements.
   2. Materials shall be stored according to manufacturer's recommendations at minimum.

C. Equipment
   1. Provide equipment as indicated on Drawings and specified herein. Additional specific installation requirements are as follows:
   2. Enclosures/Power Supplies
      a. Coordinate installation with Design team and owner for installation in Data closet.
      b. If there are multiple enclosures mount vertically to conserve wall space.
      c. Mount enclosures 48” AFF to the bottom at minimum.

d. Ensure that enclosures that house door controllers are equipped with a 2hr battery back up at minimum.

3. Door Controllers
   a. Provide and install Door Controllers in as indicated on drawings.
   b. Coordinate location of Enclosures with the design team.
   c. Provide 120 VAC via hardwire conduit. Coordination with Division 260000.
   d. Separate 24 VDC and 120 VAC, wire, cable, and devices by 12" minimum space.
   e. Enclose wire and cable in wire ways or bundle with wire exiting wire ways to terminal strips or panel mounted devices.
   f. Space controllers according to manufacturer's requirements. Ensure adequate space is allowed for device heat dissipation.
   g. Do not place controller or control devices on enclosure sides.

4. Card Readers
   a. Provide card readers and card reader devices as shown on Drawings.
   b. Wire card reader LEDs to indicate valid and invalid card reads, and door locked and unlocked conditions. All card reader LED indicators shall operate identically throughout Project. LED shall be red in normal, secured state, and shall be green on valid card read and while door is unlocked.

5. Electric Locking Mechanics
   a. Interface with electric locking mechanics as required by the door hardware.
   b. Provide lock control of electrified locking mechanics through output contacts activated by Door Controller.
   c. Ensure power transfer wiring is identified by color on final set of shop drawings.

6. Electrified Panic Devices
   a. Interface with electrified panic devices. Provide all low-voltage wire and connections between SMS power transfer device and electric locking mechanics.
   b. Provide lock control of electrified panic devices through output contacts activated by Door Controller.
   c. Provide all 120VAC if required for Device operation per hardware specifications. Provide connection to Fire Alarm connection points as required by Code. Fire Alarm Contractor to provide relay contacts in Com closets for this purpose. Contractor is responsible for all parts and pieces including cable from Access control panel to the Fire Alarm relay contract. Contractor is responsible for coordination with Fire Alarm contractor.
   d. Ensure power transfer wiring is identified by color on final set of shop drawings.

7. Door Position Switches
   a. Install as shown on drawings and where not integrally provided in door hardware.
   b. Coordinate pathways.
   c. Coordinate terminations with Intrusion Detection System Contractor prior to installing.

8. Request-to-Exit Motion Sensors
   a. Provide as shown on drawings and where not integrally provided in door hardware.
   b. Coordinate pathways.

9. Fire Alarm Interface
   a. Connect (hard wire) door controller to building fire alarm system for fail-safe release upon any fire alarm.
   b. Interface with low voltage / low current normally closed dry contact from fire alarm system provided by fire alarm Contractor (verify exact location in Data Closet for connection with FA). Contact shall open on any fire alarm condition.
   c. Provide all additional UL listed fail-safe relays and power supplies necessary to interface to this contact and unlock all fail-secure doors.

10. Audio/Video Intercom Station
    a. Provide as shown on drawings.
    b. Program operation to release door(s) from Master Intercom Station(s)
    c. Door release triggered by using input on access control system. No cabling or connection directly to electrified door hardware allowed.
    d. Adjust video of each door station as required.

11. Cable Installation
    a. Visually inspect all wire and cable for faulty insulation prior to installation.
    b. Furnish and install all specified wire and cable as required for functioning SMS system.
    c. Neatly lace, dress and support cabling.
    d. Pull cables in accordance with cable manufacturer's recommendations.
        1) Do not exceed manufacturer's recommended pulling tensions.
        2) Do not install bruised, kinked, scored, deformed, or abraded cable.
        3) Do not splice cable between indicated termination, tap, or junction points.
        4) Remove and discard cable where damaged during installation and replace it with new cable.
        5) Pull all cable by hand unless installation conditions require mechanical assistance.
    e. Run all wire and cable continuous from device location to final point of termination. No mid-run cable splices shall be allowed.
    f. Cables shall not be attached to existing cabling, plumbing or steam piping, ductwork, ceiling supports, or electrical or communications conduit.
    g. Cable shall never be laid directly on a ceiling grid or attached in any manner to ceiling grid wires.
    h. Furnish and install all cable such that ample slack is supplied at device terminating end of cable to compensate for any final field modifications at install locations.
        1) Loosely coil slack in “Figure-eight” in a manner that prevents kinking.
        2) Loop radius shall be at least 4X minimum bend radius for cable.
        3) Slack length of cable shall be 4 feet (minimum).
    i. Provide code-compliant fire proofing techniques for all penetrations of fire rated partitions and slabs, where penetrations are made by or used for installation of SMS System.
    j. Coordinate routing of wire and cable requiring isolation from power, radio frequency (RF), electromagnetic interference (EMI), telephone, etc. with other trades.
    k. At no time, shall any cable be subjected to a bend less than manufacturer’s specified minimum radius.
    l. Provide grommets and strain relief material to avoid abrasion of wire and excess tension on Wire and Cable.
    m. Make connections with solder-less devices, mechanically and electrically secured in accordance with manufacturers’ recommendations. Wire nuts shall not be an acceptable means of connecting wire and cable.
    n. Utilize conduit and cable trays and or pathways to route SMS cables from each door or device to Door Controller.
    o. No A/C current-carrying conductors are allowed in same pathway as signal or low-voltage power cables.
    p. Wire and cable within Door Controllers, enclosures and or other security enclosures shall be neatly installed, completely terminated, pulled tight with slack removed and routed in such a way as to allow direct, unimpeded access to equipment within enclosure. All wire and cable shall be bundled and tied. Ties shall be similar to T&B TyRap cable ties.
    q. Use of electrical tape for splices and connections shall not be acceptable.
    r. Make connections with solder less devices, mechanically and electrically secured in accordance with manufacturers’ recommendations. Wire nuts shall not be an acceptable means of connecting wire and cable.
    s. All system cabling within vertical risers (as required) shall be bundled, wrapped, and tied to structure at three-meter intervals in order to isolate it from other wire and cable within riser. Additionally, all wire and cable within shaft shall be supported at least every two floors using

Greenlee Slack Grips (Split Mesh Lace Closing) or approved equal. Provide all personnel and equipment necessary to install and support cable. All equipment shall be UL listed for application.

D. System Programming and Data Entry
1. Collect all data required to make the Security Management System operational. Deliver data to Owner on data entry forms, utilizing data from Contract Documents, Contractor's field surveys and all or pertinent information in Contractor's possession required for complete installation database. Identify and request from Owner any additional data needed to make SMS System fully operational and integrated. Completed forms shall be delivered to Owner for review and approval at least 30 days prior to Contractor's scheduled needed date. Contractor will coordinate with Owner. Contractor shall provide Door Counts, Panel Counts and locations, Reader Counts and input, output counts. Contractor shall also supply any special devices or operations that may require special programing. This and any fees associated with the programing shall be included in Contractor's Bid. Contractors Bid shall be for a complete turnkey, total functional system.
2. Provide all initial system information for SMS setup including, but not limited to following:
   a. SMS Card Reader Information
      1) Coordinate all card reader values and text, including descriptors, alarm messages, map call up and identification with Owner.
   b. Input and output points for SMS. Coordinate all input and output priorities and text, including descriptors, alarm messages, Video Camera call up, and map call up and identification with Engineer.
   c. Initial system users, including levels of access. This shall include designation of Owner's representative at "Administrator" level immediately upon SMS initialization.
   d. Provide Elevator access per cardholder by cab and floor.
3. Furnish and install all SMS wire and cable including LAN cabling.
4. Provide code-compliant fire proofing techniques for all penetrations of fire rated partitions and slabs, where penetrations are made by or used for installation of SMS.
5. 120 VAC power dedicated to security system shall be on provided Emergency Generator Power when available. Servers shall be on properly sized UPS units on Emergency Generator backup circuits when available.
6. Connect to AC power with UL listed power supplies and transformers to distribute low voltage power to system components as required.
7. Provide hinged cover UL listed terminal cabinets with tamper switches for all power supplies, transformers, and power distribution terminal strips. Provide all conduit and wiring from AC power facilities to terminal cabinets.
8. Provide protection against spikes, surges, noise, and or line problems for all system equipment and components.
9. Provide protection on all exterior, control, power, signal cables and conductors against power surges. Each surge protector shall be UL Listed.
10. In no instance, shall any UL labeled door or frame be drilled, cut, penetrated, or modified in any way.
11. Contractor shall be responsible for replacing any labeled door or frame that is modified.
12. Label all controls as necessary to agree with their function.
13. Label all Wire and Cable in common at both ends using a permanent method such as self-laminating cable marking tape.
    a. Tags shall be attached to wire and cable nylon cable ties in an accessible location so that they can easily be read.
    b. Tags shall be installed when wire and cables are installed.
    c. Labeling shall be consistent with existing cable labeling system and agree with Record Documentation.
14. Place wire identification numbers at each end of conductor involved by using sleeve type, heat shrinkable markers. Markers shall be installed so as to be readable from left to right or top to bottom.
15. Mark all connectors with common designations for mating connectors. Connector designations shall be indicated on record drawings.

16. Coil all spare conductors in device back box, panel wire way, or top of panel where wire way is not provided. Conductors shall be neatly bundled and tagged.
17. Install integrated security and communication system in accordance with manufacturer's instructions at locations indicated on the Drawings.
18. Mount equipment plumb, level, square, and secure. For video entrance stations and video door stations, comply with manufacturer's design requirements to provide optimum picture quality of station monitoring.
19. Allow (4) four hours programing time for owner/Engineered furnished lock down schedule.

3.3 DEMONSTRATION AND TRAINING

A. Demonstration: Demonstrate that integrated security and communication system functions properly. Perform demonstration at final system inspection by qualified representative of manufacturer working with Owner's representatives.

B. Contractor shall be on call during Warranty period to answer any questions Owner might have. The Owner reserves the right to use any excess training hours, not used by time of system completion, for future training as requested by Owner until total number of training hours has been used.

C. Owner Training:
1. Training course for system covered in this section shall be a minimum of 8-hours.
2. Maximum number of students to be (6).
   a. Training materials shall be provided to all students.
3. Record, label, and catalog all training via video recordings. Provide media to Owner for future in-house training sessions and / or reviews. Furnish all temporary equipment necessary for recording all training sessions. Maintain accurate and up-to-date time sheets of all training sessions.
4. The Owner reserves the right to use any excess training hours, not used by time of system completion, for future training as requested by Owner until total number of training hours has been completed.

3.4 SYSTEM START-UP

A. Start-up includes all Contractor-Furnished, Contractor-Installed (CFCI) systems and equipment.

B. Work shall be complete and ready to operate prior to final acceptance.

C. Adjust integrated security and communication system for proper operation in accordance with manufacturer's instructions.

3.5 SYSTEM ACCEPTANCE

A. Final acceptance testing of Work will be coordinated and observed by owner or owner representatives.

B. Prior to testing, Contractor shall submit two sets of preliminary (draft) Record Drawings to Engineer. Preliminary Record Drawings are to be used to conduct system final test.

C. At completion of Work, remove all waste materials, rubbish, Contractor's and subcontractors' tools, construction equipment, machinery, and all surplus materials.

3.6 PROTECTION

A. Protect installed integrated security and communication system from damage during construction.

END OF DOCUMENT 281000

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SECTION 282000 - VIDEO SURVEILLANCE

PART 1 - GENERAL

1.1 SCOPE

A. This section details product and execution requirements for the Video Management System for the project.

B. Work includes furnishing all labor, materials, tools, equipment, licensing, and documentation required for a complete turnkey working system as specified in this Section. VMS shall consist of but not be limited to, Cameras, Monitors, Servers, Conduit, Boxes, Cable, and Wired Devices. Programming and camera view setup is considered part of installation as well in coordination with WCPSS.

C. Coordinate with WCPSS's IT for Network Switch and POe requirements.

D. Unless noted otherwise, "Contractor" shall refer to VMS Integrator & Installer.

E. Communications routing from VMS Server to cameras controllers shall be via WCPSS's LAN.

F. Coordinate with all trade contractors as required to provide a fully functioning system.

G. Unless noted otherwise, "Contractor" shall refer to security system integrator & installer.

H. Video surveillance can be restricted or prohibited by law. This document details technical considerations only. It is assumed that registration, licensing, policies regarding disclosure and privacy (notification, processing of images, time, and date stamping, recording of sound, etc.), and or legal obligations are responsibility of Owner.

I. The surveillance software shall be non-proprietary and operate with multiple servers, camera, and network hardware manufacturers while based on commercial-off-the-shelf (COTS) hardware and software. The approved Enterprise Surveillance Manager software is IPConfigure. All video surveillance management systems must integrate with WCPSS's existing enterprise surveillance manager, IPConfigure. All proposed equals must submit working demo systems for a minimum 30–60-day review process by Energy and Physical Plant and the Security Department.

1.2 RELATED SECTION

1. 260000 - Electric Specifications
2. 270000 - Communication Systems Specifications

1.3 REFERENCES AND STANDARDS

A. Work under this Section is subject to requirements of Contract Documents including General Conditions and Supplementary Conditions

B. All work and materials shall conform in every detail to rules and requirements of National Fire Protection Association and Kentucky Electrical Code.

C. All materials shall be listed by UL and shall bear UL label. If UL has no published standards for a particular item, then other national independent testing standards shall apply, and such items shall bear those labels. Where UL has an applicable system listing and label entire system shall be so labeled.

D. Other applicable standards are as follows:
1. ANSI/IEEE C2 - National Electrical Safety Code
2. NFPA 70 - National Electrical Code
3. IEEE/ANSI 142 – Recommendations for Grounding of Industrial & Commercial Power Systems.
4. NTSC/EIA RS-170A Video Standard
5. Nation Defense Authorization Act Current Requirements
6. IEEE 802.3 standards for CSMA/CD (Ethernet) based LANs
7. Emissions: FCC 15, Class A; CE: EN55022 (Emissions)
8. CE: EN50082-01 (Immunity)
9. CE, UL 1950; CUL 1950 CE: EN60950 (Safety)
10. FDCC- Fédéral Desktop Core Configuration
11. Section 508-Accessibilty Act

1.4 DEFINITIONS AND ABBREVIATIONS

A. VMS – Video Management System

B. LAN – Local Area Network

C. NDAA – Nation Defense Authorization Act

1.5 SUBMITTALS

A. Manufacture Product Data: Submit the manufacture's data sheet indicating systems and components for use.

B. With Manufacture Product Data Submittal, submit documentation verifying cameras used for this project are NDAA compliant under the current requirements.

C. Shop Drawings: Submit complete shop drawings indicating system components, wiring diagrams and load calculations.

D. Record Drawings: During construction maintain record drawings indicating location of equipment and wiring. Submit an electric version of record drawings for the Security Management System no later than Substantial Completion of the project.

E. Operation and Maintenance Data: Submit manufacture's operation and maintenance data, customized to the Security Management System installed. Include system and operator manuals.

F. Testing: Proposed Contractor test result forms, a list of instrumentation to be used for systems testing.

G. A complete point-to-point floor plan diagram indicating camera locations and all required cabling to connect systems.

1.6 QUALITY ASSURANCE

A. Video Management System Contractor shall:
1. Have successfully completed two (2) similar system projects in equal magnitude of the building systems specified in following sections.
2. Installer must have a minimum of 1 (one) technician that has successfully completed the VMS manufacture's certification training course that is present on the project site to supervise the installation and system testing.

3. Installer shall be fully certified by the VMS/SMS manufacturer for sales and installation of specified equipment.
4. Proper proof of manufacturer credentials and certification will be submitted at time of Bid.
5. Comply with all certification requirements set out in Division 27 as it related to the installation of any cabling.
6. Contractor will comply with the requirement of all cabling being installed by BICSI certified installers and installation supervised by a registered, in good standing RCDD and must be a full-time employee of the project contractor.
7. Deliver materials in original packaging. Store and handle in accordance with the manufacture's requirements.

1.7 GUARANTEE

A. Warranty requirements for Video Management System (VMS) shall be one (1) year on all parts and one (1) on labor commencing on Date of Substantial Completion. Those requirements apply to all software and hardware components covered in this section. If manufacture's equipment warranties extend past one (1) year, the term of those warranties extend to the life of this project warranty. Provide warranty information and duration as part of the submittal process.

PART 2 - PRODUCTS

2.1 GENERAL

A. VMS system shall deliver high quality; color video over an IP, UTP structured cable system using H.264 / H.265 compression and shall provide for monitoring and recording of all cameras in system as indicated herein and on project Drawings. The VMS allows event-based monitoring of campus and situational awareness though IP cameras centrally managed by a storage device. The VMS utilizes analytics to identify potential situations on campus and preserving evidence for authorities to review. The VMS has the capability to be securely monitored via mobile devices or off-campus locations, video sharing with outside public safety-first responders.

B. Video shall be configurable from a workstation using standard Browser software.

C. Allows monitoring of live and recorded video over wireless IP networks from Apple or Android mobile devices.

D. Allows Bookmarking. Supports creating bookmarks for recorded video. These can be viewed from multiple sources and displayed on a timeline during playback.

E. Supports protecting a bookmark so that associated video data is never overwritten until released.

F. Be capable of supporting unlimited cameras, encoders, servers, locations, and users.

G. Be designed to stream live and record at 30 frames per second (NTSC) per video channel for all resolutions in accordance with video hardware specifications.

H. Shall be compatible with the existing enterprise surveillance manager, IPConfigure.

2.2 IP VIDEO CAMERA

A. Install interior cameras using mounts and hardware approved or supplied by the manufacture.

B. Use mounts as required to obtain desired coverage or lower to avoid obstructions.

C. Install camera where it is free from building obstructions. Prints show the general area of installation however contractor is to ensure cameras are installed in a location to obtain the intended view.

D. Install exterior building cameras at the same elevation. Camera pathways are intended to be on the interior of building and/or in the building structure. Coordinate with electrical for pathways.

E. Install per manufactures specifications.

F. Protect from damage during the construction process.

G. All cameras shall be as shown on attachments or approved as equals by WCPSS maintenance department. Provide suggested manufacturers and models for approval.

H. Cameras shall typically have the following characteristics:

1. Power – Power over ethernet IEEE 802.3.af
2. Connectors – Terminal block for 1 alarm input and 1 output.
3. Edge storage – SD/SDHC/SDXC Slot supporting memory card up to 64GB Resolution – 1.3 MP (1280x960) or better as applicable
4. Image Sensor – Progressive scan RGB CMOS
5. Lens – Varifocal, remote focus and zoom, IR corrected, P-iris control, Megapixel resolution.
6. Day and Night Style – Automatically removable infrared-cut filter
7. Video Compression – H.264 Baseline
8. Video Streaming – Multiple, individually configurable streams in H.264/H.265 and Motion JPEG. Controllable frame rate and bandwidth, VBR/CBR
9. Open application programming interface for software integration
10. Event Triggers – Motion detection, external input, edge storage events
11. Built-in aids – Remote zoom, remote focus, pixel counter

I. Indoor Dome Ceiling or Wall Mount.
1. Provide with all required Licenses for a minimum of one (1) year.
2. Axis M3086-V

J. Indoor Dome Ceiling or Wall Mount.
1. Provide with all required Licenses for a minimum of one (1) year.
2. Axis P3267-LV

K. Panoramic Camera
1. Provide with all required Licenses for a minimum of one (1) year
2. Axis P3727-PLE

L. Outdoor Dome Wall Mount
1. Provide with all required Licenses for a minimum of one (1) year
2. Axis- P3247-LVE

2.3 NETWORK VIDEO STORAGE

A. Manufacturer:
1. Video Storage:
IPConfigure

2.4 ENCLOSURES

A. For all exterior enclosures, provide the following:
1. NEMA type 4X
a. Use appropriate mount and mounting hardware.
b. Size enclosure large enough to accommodate all equipment and make necessary terminations. Enclosure shall be large enough to service equipment.

2.5 WIRE AND CABLE

A. General
1. Coordinate with Division 270000 contractor for proper placement of CAT6 cabling.
2. Provide and install Surge protection units for exterior cameras.
3. Provide all interconnecting system cabling at Security Closets and Communication Closets as well at security device end points. All standards must be followed. Exterior cameras that exceed the normal distance for copper cable must be installed with Fiber Cable per BICSI Standards and Division 270000 requirements. At these fiber locations proper listed media converters are required.

2.6 User Interface

A. The surveillance software user interface shall:
1. Operate independently of any single operating system and be accessible through an HTML interface compatible with Edge Explorer, Chrome, or Safari browsers while not requiring the installation of client software.
2. Provide unique user login-based camera accessibility through either internal or Active Directory based user access management.
3. Provide real-time display of RSS feeds with source links.
4. Support multi-monitor viewing (Dual, Quad, etc.) of all software user interfaces (i.e. Maps, Matrix display, Archive, Alarm, LPR and Administration)

B Map graphical user interface shall:
1. Shall support JPEG or GIF images and allow UI (User Interface) based placed camera icons to include Fixed and Pan/Tilt/Zoom cameras. Provided by a/e.
2. Illustrate live camera video feeds upon mouse rollover of a camera icon.
3. Open a full resolution live camera video feed upon double clicking a camera icon with window resizing capabilities and multi-monitor support.

C Video matrix user interface shall:
1. Support the viewing of up to 30 live video feeds per monitor with the capability of supporting up to 120 live video feeds across four monitors.
2. Offer a custom camera layout based on unique user accounts.
3. Support sharing option of custom layouts to other system users.
4. Rotate (cycle) live cameras on matrix screen based on camera motion detection or timed interval.

D Archive search and playback interface shall:
1. Present video history in a calendar and search histogram that illustrates activity by each minute.
2. Support for thumbnail image search and playback of pre-alarm buffer and post-alarm buffer events.

3. Provide the option to copy video events into a user library for later retrieval while excluding library video events from the first-in-fist-out (FIFO) delete routine.
4. Allow for playback of definable segments of time.
5. Support search and playback of multiple cameras regardless of their geographic or logical location across the same period of time.
6. Provide the playback of up to 16 cameras simultaneously.
7. Display hourly summaries of recording durations and file size.
8. Support the download of either full-length video or still images.
9. Provide real-time evidentiary video authentication through file hashing based on U.S. Federal Information Processing Standard.

E Alarm monitoring interface shall:
1. Display motion-based event information and allow for playback.
2. Display system-based event information to include errors, alerts, and updates.
3. Allow for filtering of which events are displayed and the refresh rate frequency.

F License Plate Recognition software shall:
1. Detect and classify vehicle plate letters and number in the OCR detection process utilizing visible light based megapixel resolution images.
2. Detect and classify vehicle color megapixel information in the LPR detection process.
3. Support standard Internet Protocol (IP) megapixel cameras by Axis.
4. Support camera placement of up to 35 degrees off vehicle license plate centerline, totaling 70 degrees of angle of sweep at up to 120ft distance.
5. Support color non-IR reflection based JPG images for daytime visual identification of vehicle make, model and other attributes.
6. Support both non-reflective and reflective paint license plates.
7. Support speeds up to 45 miles per hour without the use of IR illumination.

2.7 Administrative interface

A The surveillance software administrative interface shall:
1. Operate independently of any single operating system and be accessible through an HTML interface compatible with Edge Explorer, Chrome, or Apple Safari browsers and not requiring the installation of PC or MAC client software.
2. Provide a single application interface to manage unlimited numbers of cameras, servers, and users.
3. Offer a pre-defined camera default configuration of basic camera settings to include IP addresses, recording criteria, and camera authentication information.
4. Offer simple map uploading and editing of camera placement on building facility floor plans.

B Camera setup interface shall:
1. Not require MAC address information in the configuration or activation of new or existing cameras.
2. Support auto discovery of supported/compatible IP camera manufacturers.
3. Support PTZ guard tours setup in the camera.
4. Allow for independent live and recording frame rate settings.
5. Offer trip-wire motion detection settings.
6. Offer depth perception motion detection settings.
7. Provide for user and security segmentation by group affiliation.

C Storage configuration shall:
1. Support any size storage volume and not be limited by the number or size of recordings in any single day.
2. Provide independent configuration of archive (recording storage) or library (user copied / saved recordings) storage.
3. Provide up to three different user defined recording retention settings: Short-term, Medium-term, and Long-term.

4. Support automated motion grooming (i.e. delete routine) of non-motion activity from continuous recordings after a user defined number of days.

D Email notification shall:
1. Be transmitted when camera connectivity or transmission failures occur.
2. Be transmitted and include a still image when motion is detected.
3. Support notifications based on a schedule.

2.8 System capabilities

A System server architecture shall:
1. Leverage a three-tier computing architecture which utilizes a web service, database service, and application service.
2. Be capable of installing on a single stand-alone server.
3. Be capable of installing on multiple distributed servers.
4. Operate on a Windows Server, Linux, or Solaris operating systems.
5. Support auto discovery of certain IP cameras.
6. Support single click mass-setting updates to selected camera.

B System performance shall:
1. Support any image resolution for live and recording that the camera is capable of streaming.
2. Be capable of recording on motion a minimum of 120 IP cameras using H.264/H.265 compression at 1280 x 720 resolution and 15 frames per second on a single server.

2.9 Server Requirements

A Server specification:
1 Shall provide storage required for number of cameras as shown on project documents at specified resolutions for storage time of 30 days.

B Security: The video server shall for each channel:
1. Support the use of HTTPS and SSL/TLS, providing the ability to upload signed certificates to encrypt and secure authentication and communication of both administration data and video streams.
2. Support IEEE 802.1x authentication.
3. Provide support for restricting access to pre-defined IP addresses only, so-called IP address filtering.
4. Restrict access to the built-in web server by usernames and passwords.
5. Be managed by group and associated with building and cameras.
6. API support
7. The software shall support IP cameras with open and published APIs (Application Programmers Interface) that will provide the necessary information for integration in the software.
8. The software shall support SQL queries for all system setting variables, events, and analytical results.

C Maintenance: The surveillance software shall:
1. Be supplied with management software which allows for configuration of the system to includes, cameras, users, and servers.
2. Offer on-demand or scheduled email reports to system administrators with enterprise-wide status of cameras, server, storage, location, and health status.
3. Offer on-demand or schedule email reports to system administrators with enterprise user activity.
4. Customer-specific settings, including statically assigned IP address, the local time and date, event functionality and video configuration, shall be stored in the cameras non-volatile memory and shall not be lost during power outages or soft reset.
5. Monitor cameras by a recording service that can automatically re-initiate recording processes if a malfunction is detected.

2.10 Client PC requirements

A The surveillance software shall:
1. Operate independently of any single operating system and be accessible through an HTML interface compatible with Edge Explorer, Chrome, or Apple Safari browsers while not requiring the installation of PC or MAC client software.

PART 3 - EXECUTION

3.1 GENERAL

A. Work performed for installation of VMS system shall be performed by Security System Integrator – "Contractor".

B. Provide equipment as indicated on Drawings and specified herein.

C. Provide all labor and materials necessary to construct systems as described herein to include furnishing and installing all system equipment, interconnecting cabling, programming and start-up, software (including software upgrades and reprogramming as necessary), termination components, mounting hardware, incidentals, accessories, testing, labeling, documentation, and training as detailed in following sections.
1. Neatly lace, dress, and support cabling.
2. Coordinate with Other trades, Design Team, and Owner.

D. Prior to installation:
1. Conduit and equipment back boxes are as required. Contractor is responsible for coordination with all trades to ensure that conduit and back boxes are correctly placed for VMS use. Contractor is responsible for coordinating installation of conduit and boxes to make sure they are installed on schedule with other trades and are coordinated as to not interfere with other systems or pathways.
2. 120V AC Power is as required and is properly located.
3. LAN structured cabling is as required and properly located, and installation has been coordinated with other trades.
4. Coordinate all devices and locations prior to equipment installation with owner.
5. Coordinate Owner-desired camera views, providing camera modeling prior to installation.
6. Coordinate Camera housing and mount finishes with Architect and Owner.

E. Install and wire equipment in accordance with BICSI Standards, manufacturer's recommendations, and accepted engineering and installation practices.

F. Mount system components as recommended by manufacturer. All equipment mounting in Communication Closets must be approved by owner prior to installation.

3.2 IP VIDEO CAMERAS

A. Mount Video Cameras per project drawings.

B. Field-verify exact locations and field-of-views with Owner prior to installation.

C. Provide video camera lenses to accommodate Owner-coordinated field-of-view per camera.
1. Field verify and confirm views with Owner prior to procurement and final installation and adjust camera positions and lens sizes as required upon installation.

D. Configure resolution, frame rate, password, etc. to match system installation. All passwords must be reset from manufacturer's default to WCPSS's provided password.

E. Coordinate with Owner prior to installation to confirm required parameters.

3.3 NETWORK CONNECTION

A. Cross-connections to building LAN in coordination with Owner.

3.4 LABELING AND IDENTIFICATION

A. Labeling protocols to match all Security System installations.
   1. Cabling, Hardware, and Equipment shall be clearly labeled using a Code identifying each piece as unique throughout Video Camera System. This code will aid in identifying hardware for servicing and maintenance.
   2. Labels and Tags shall be machine-generated using English character set in black ink on white background labels and Tags.
      a. Self-laminating permanent labels are required on cables; permanent non-marring labels are required on all other hardware/cabinets.
      b. No hand-written Labels or Tags shall be allowed.
      c. Dymo or Kroy type adhesive backed lettering is not acceptable.

B. Identify and tag all cables to denote function.
   1. Tag shall indicate:
      a. System of which cable is a part,
      b. Indication of cable destination (e.g., room or component), and
      c. Unique alpha-numeric identifier that distinguishes cable from all others in system.

C. All labels shall be machine generated. Handwritten labeling is not acceptable.

D. Label all front panel controls used in normal operation of system using plastic laminate engraved labels or approved equal.
   1. Firmly affix to panel or device.

E. Labeling Formats
   1. To be defined by Owner prior to construction following practice for all campus Security System installations.

3.5 SYSTEM TESTING AND ACCEPTANCE

A. System shall be complete and fully operational before requesting final acceptance for substantial completion.

B. Installation of all field devices will be inspected by Owner or Owner's representative. Inspection will consider overall neatness and quality of installation, functionality of each individual device, mounting, wiring, and labeling.

C. Conduct a seven-day burn-in test. Intent of burn-in test shall be to prove System by placing it in near real operating conditions prior to connection to Substantial Completion.
   1. During this period System shall be fully functional and programmed so that all points, controls, messages, prompts, etc. can be exercised and validated.

D. Provide written notification to Owner that system is completely installed, integrated, burn-in testing completed and is fully functional as specified herein.
   1. Submit schedule for acceptance testing. Representatives of Owner, Consultants and/or representative may witness test procedures.
   2. Notify Owner/Consultant in writing a minimum of two weeks in advance to allow for such participation.
   3. Describe test procedures prior to testing and submit sample test form to Owner / Representative.

E. Prior to final acceptance test, equipment rooms and similar areas should be free of accumulation of waste materials or rubbish caused by operations under Contract.

F. Equipment shall be on and fully operational during all testing procedures.
   1. Provide all personnel, equipment, and supplies necessary to perform site testing.
   2. Supply a form of communication with remote parties in the team for use during test.
   3. A manufacturer's representative shall be present on site to answer any questions that may be beyond technical capability of Contractor's employees, if Contractor so elects or by specific request of Representative Owner, at no charge to Representative or Owner.

G. During course of final acceptance test, Contractor shall be responsible for demonstrating that, without exception, provided VMS complies with contract requirements.

H. Testing shall include but not be limited to:
   1. Continuity and conductor/connector integrity on all cables.
   2. Demonstrate functionality of all cameras including:
      a. Owner-acceptable field of view.
      b. Response to alarms.
      c. Response to Access Control System inputs.
   3. Confirm remote viewing, configuration, and camera control via Browser. Confirm all Analytic uses on Cameras programmed for Analytic use.
      a. Confirm system rights settings for authorized users.
   4. Demonstrate storage and retrieval of recorded video by date/time.

I. Owner retains the right to suspend and/or terminate testing at any time when system fails to perform as specified.
   1. In event it becomes necessary to suspend test, Contractor shall work diligently to complete / repair all outstanding items to condition specified in Specification and as indicated on Security Drawings.
   2. All of Owner's / Representative Fees and expenses related to suspended test will be deducted from Contractor's retainage.
   3. Contractor shall supply Owner with a detailed completion schedule outlining phase by phase completion dates and a tentative date for a subsequent punch list retest.
   4. During final acceptance test, no adjustments, repairs, or modifications to system will be conducted without permission of Owner.

J. Upon successful completion of final acceptance test (or subsequent punch list retest) Owner or Representative will issue a letter of final acceptance.

K. Records of Test Results shall be included in System Documentation and submitted as detailed below.

L. Proof of license registration for all software, hardware, firmware, operational and administrative licenses.

3.6 OWNER TRAINING

A. Training course for system covered in this section shall be a minimum of 8-hours.

B. Maximum number of students to be (6).
   1. Training materials shall be provided to all students.

C. Record, label, and catalog all training via video recordings. Provide media to Owner for future in-house training sessions and / or reviews. Furnish all temporary equipment necessary for recording all training sessions. Maintain accurate and up-to-date time sheets of all training sessions.

D. The Owner reserves the right to use any excess training hours, not used by time of system completion, for future training as requested by Owner until total number of training hours has been completed.

3.7 DOCUMENTATION

A. All Owners manuals and or maintenance information shall be provided in printed form as well as electronic PDF format to the owner and owner representative.

3.8 WARRANTY AND SUPPORT

A. Unless otherwise noted, Contractor shall guarantee all materials, equipment, etc., one (1) year and workmanship for a period of one (1) year from date of final Owner acceptance of system. This guarantee shall include all labor, material, and travel time.

B. Contractor/Integrator and/or manufacturer(s) of system equipment must offer:
   1. Technical Support Capabilities (Technician onsite) response time onsite within 4 hours, 24- hours/7-days per week (“24/7”), and 365 days per year.
   2. 24-hour turn-around (from receipt of item) for Repair or Replacement of failed components, 7-days per week.
   3. At no additional cost, provide manufacturer's direct technical support to Owner via phone and email, including the following:
      a. Access to training and education in the form of documents, videos, and other materials via the internet.
      b. Software maintenance patches and version updates.

END OF DOCUMENT 282300

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SECTION 282300 – CCTV VIDEO MANAGEMENT SYSTEM

PART 1 - GENERAL

1.01 General Requirements

A The surveillance software shall be of manufacturer's official productline, designed for commercial and industrial use.

B The surveillance software shall be non-proprietary and operate with multiple server, camera, and network hardware manufacturers while based on commercial- off-the-shelf (COTS) hardware and software. The approved Enterprise Surveillance Manager software is Ip Configure. All video surveillance management systems must integrate with WCPSS's existing enterprise surveillance manager, Ip Configure. All proposed equals must submit working demo systems for a minimum 30-60 day review process by Energy and Physical Plant and the Security Department.

1.02 Quality Assurance

A All surveillance software installation, configuration, setup, program, and related work shall be performed by electronic technicians thoroughly trained by the manufacturer in the installation and service of the software provided.

B All software shall be backed by a minimum of a one year manufacturer warranty.

1.03 Certifications and standards

A The surveillance at minimum shall comply with the following approvals:

1. Section 508 – Accessibility Act

2. FDCC – Federal Desktop Core Configuration

B The video server shall meet or support the following standards

1. MJPEG, MPEG4, & H.264

2. Networking:

a. IEEE 802.1X (Authentication)

b. IEEE 802.3af (Power over Ethernet)

c. IPv4 & IPv6

d. SSL Encryption

e. Quality of Service (QoS)

f. Microsoft Active Directory compliant

1.04 REFERENCES:

A NFPA 70 – National Electric Code

B NFPA 72H – Guide for Test Procedures for Protective Signaling Systems

C NFPA 731 – Installation of Electronic Premises Security Systems

D NFPA 730 – Guide for Premises Security

1.05 SUBMITTALS:

A Samples: Complete manufacturer's product literature and samples (if requested) for all pre-approved substitutions to the recommended products made during the course of the Project.

B Permits: The Contractor shall obtain all required permits and provide copies to the Owner/Architect/Engineer

C Product Literature: Complete manufacturer's product literature for all electronics, cable, cable supports, cable labels, outlet devices, and other products to be used in the installation. In addition, whenever substitutions for recommended products are made, samples (when requested by the Owner/Architect/Engineer) and the manufacturer's supporting documentation demonstrating compatibility with other related products shall be included.

D Testing: Proposed Contractor test result forms, a list of instrumentation to be used for systems testing.

E A complete point-to-point floor plan diagram indicating camera locations and all required cabling to connect systems.

PART 2 - PRODUCTS

2.01 GENERAL

A The surveillance software shall:

1. Be capable of supporting unlimited cameras, encoders, servers, locations, and users.

2. Be designed to support multiple simultaneous live viewings and recording of MJPEG, MPEG-4, and H.264 video at independent resolutions, frame rates and compression settings.

3. Be designed to stream live and record at 30 frames per second (NTSC) or 25 frames per second (PAL) per video channel for all resolutions in accordance with video hardware specifications.

4. Shall be compatible with the existing enterprise surveillance manager, Ip Configure.

B Cameras:

1. Refer to attachments 28 23 00 A1, A2, A3, A4.

2. All cameras shall be as shown on attachments or approved as equals by WCPSS maintenance department. Provide suggested manufacturers and models for approval prior to listing in project specifications.

3. Cameras shall typically have the following characteristics:

a. Power – Power over ethernet IEEE 802.3.af

b. Connectors – Terminal block for 1 alarm input and 1 output

c. Edge storage – SD/SDHC/SDXC Slot supporting memory card up to 64GB Resolution – 1.3 MP (1280x960) or better as applicable

d. Image Sensor – Progressive scan RGB CMOS

e. Lens – Varifocal, remote focus and zoom, IR corrected, P-iris control, Megapixel resolution

f. Day and Night Style – Automatically removable infrared-cut filter

g. Video Compression – H.264 Baseline

h. Video Streaming – Multiple, individually configurable streams in H.264 and Motion JPEG. Controllable frame rate and bandwidth, VBR/CBR H.264

i. Open application programming interface for software integration

j. Event Triggers – Motion detection, external input, edge storage events

k. Built-in aids – Remote zoom, remote focus, pixel counter L.

2.02 User interface

A The surveillance software user interface shall:

1. Operate independently of any single operating system and be accessible through an HTML interface compatible with Internet Explorer, Mozilla Firefox, or Safari browsers while not requiring the installation of client software.

2. Provide unique user login based camera accessibility through either internal or Active Directory based user access management.

3. Provide real-time display of RSS feeds with source links.

4. Support multi-monitor viewing (Dual, Quad, etc.) of all software user interfaces (i.e. Maps, Matrix display, Archive, Alarm, LPR and Administration)

B. Map graphical user interface shall:

1. Shall support JPEG or GIF images and allow UI (User Interface) based placed camera icons to include Fixed and Pan/Tilt/Zoom cameras. Provided by a/e.

2. Illustrate live camera video feeds upon mouse rollover of a camera icon.

3. Open a full resolution live camera video feed upon double clicking a camera icon with window resizing capabilities and multi-monitor support.

C. Video matrix user interface shall:

1. Support the viewing of up to 30 live video feeds per monitor with the capability of supporting up to 120 live video feeds across four monitors.

2. Offer a custom camera layout based on unique user accounts.

3. Support sharing option of custom layouts to other system users.

4. Rotate (cycle) live cameras on matrix screen based on camera motion detection or timed interval.

D. Archive search and playback interface shall:

1. Present video history in a calendar and search histogram that illustrates activity by each minute.

2. Support for thumbnail image search and playback of pre-alarm buffer and post-alarm buffer events.

3. Provide the option to copy video events into a user library for later retrieval while excluding library video events from the first-in-fist-out (FIFO) delete routine.

4. Allow for playback of definable segments of time.

5. Support search and playback of multiple cameras regardless of their geographic or logical location across the same period of time.

6. Provide the playback of up to 16 cameras simultaneously.

7. Display hourly summaries of recording durations and file size.

8. Support the download of either full-length video or still images.

9. Provide real-time evidentiary video authentication through file hashing based on U.S. Federal Information Processing Standard.

E. Alarm monitoring interface shall:

1. Display motion based event information and allow for playback.

2. Display system based event information to include errors, alerts, and updates.

3. Allow for filtering of which events are displayed and the refresh rate frequency.

F. License Plate Recognition software shall:

1. Detect and classify vehicle plate letters and number in the OCR detection process utilizing visible light based megapixel resolution images.

2. Detect and classify vehicle color megapixel information in the LPR detection process

3. Support standard Internet Protocol (IP) megapixel cameras by Axis, Panasonic, and Bosch.

4. Support camera placement of up to 35 degree off vehicle license plate centerline, totaling 70 degrees of angle of sweep at up to 120ft distance.

5. Support color non-IR reflection based JPG images for daytime visual identification of vehicle make, model and other attributes.

6. Support both non-reflective and reflective paint license plates.

7. Support speeds up to 45 miles per hour without the use of IR illumination.

2.03 Administrative interface

A The surveillance software administrative interface shall:

1. Operate independently of any single operating system and be accessible through an HTML interface compatible with Internet Explorer, Mozilla Firefox, or Apple Safari browsers and not requiring the installation of PC or MAC client software.

2. Provide a single application interface to manage unlimited numbers of cameras, servers, and users.

3. Offer a pre-defined camera default configuration of basic camera settings to include IP addresses, recording criteria, and camera authentication information.

4. Offer simple map uploading and editing of camera placement on building facility floor plans.

B Camera setup interface shall:

1. Not require MAC address information in the configuration or activation of new or existing cameras.

2. Support auto discovery of supported/compatible IP camera manufacturers.

3. Support PTZ guard tours setup in the camera.

4. Allow for independent live and recording frame rate settings.

5. Offer trip-wire motion detection settings.

6. Offer depth perception motion detection settings.

7. Provide for user and security segmentation by group affiliation.

C Storage configuration shall:

1. Support any size storage volume and not be limited by the number or size of recordings in any single day

2. Provide independent configuration of archive (recording storage) or library (user copied / saved recordings) storage.

3. Provide up to three different user defined recording retention settings: Short- term, Medium-term, and Long-term.

4. Support automated motion grooming (i.e. delete routine) of non-motion activity from continuous recordings after a user defined number of days.

D. Email notification shall:

1. Be transmitted when camera connectivity or transmission failures occur.

2. Be transmitted and include a still image when motion is detected.

3. Support notifications based on a schedule.

2.04 System capabilities

A System server architecture shall:

A. Leverage a three-tier computing architecture which utilizes a webservice, database service, and application service.

B. Be capable of installing on a single stand-alone server.

C. Be capable of installing on multiple distributed servers.

D. Operate on a Windows Server, Linux, or Solaris operating systems.

E. Support auto discovery of certain IP cameras.

F. Support single click mass-setting updates to selected camera.

B System performance shall:

1. Support any image resolution for live and recording that the camera is capable of streaming.

2. Be capable of recording on motion a minimum of 120 IP cameras using JPEG compression at 640 x 480 resolution and 7 frames per second on a single server.

2.05 Server Requirements

A. Server specifications

1. Stand-alone architecture: based on MJPEG 640 x 480 resolution at 7 frames per second. MPEG4 & H.264 support ½ the quantity of cameras listed below based on 640 x 480 resolutions at 10 frames per second.

	8-32 Cameras @ 640x480	**32-64 Cameras @ 640x480**	**64-120 Cameras @ 640x480**
Processor Minimum	Xeon 5410 Quad Core	Xeon 5410 Quad Core	Xeon 5410 Quad Core
Sockets Minimum	1	2	4
RAM Minimum	4 GB	8 GB	16 GB
Storage Minimum	1 TB	2 TB	4 TB
Operating System	Windows Server 2003 or 2008	Windows Server 2003 or 2008	Windows Server 2003 or 2008
OS Architecture	32 / 64	32 / 64	32 / 64
Database	SQL Server Express 2005 or 2008	SQL Server Express 2005 or 2008	SQL Server Express 2005 or 2008
Drive Type	SATA, SAS, SCSI	SATA, SAS, SCSI	SATA, SAS, SCSI

2. Distributed architecture: based on 640 x 480 resolutions at 7 frames per second. MPEG4 & H.264 support ½ the quantity of cameras listed below based on 640 x 480 resolutions at 10 frames per second.

Management Server

Processor Minimum	Xeon 5410 Quad Core
Sockets Minimum	1
RAM Minimum	4 GB
Storage Minimum	1 TB
Operating System	Windows Server 2003 or 2008
OS Architecture	32 / 64
Database	SQL Server or SQL Server Express 2005 or 2008
Drive Type	SATA, SAS, SCSI

Recording Server(s)

	8-32 Cameras @ 640x480	**32-64 Cameras @ 640x480**	**64-120 Cameras @ 640x480**
Processor Minimum	Xeon 5410 Quad Core	Xeon 5410 Quad Core	Xeon 5410 Quad Core
Sockets Minimum	1	2	4
RAM Minimum	4 GB	8 GB	16 GB
Storage Minimum	1 TB	2 TB	4 TB
Operating System	Windows Server 2003 or 2008	Windows Server 2003 or 2008	Windows Server 2003 or 2008
OS Architecture	32 / 64	32 / 64	32 / 64
Database	SQL Server Express 2005 or 2008	SQL Server Express 2005 or 2008	SQL Server Express 2005 or 2008
Drive Type	SATA, SAS, SCSI	SATA, SAS, SCSI	SATA, SAS, SCSI

B. Security

1. The video server shall for each video channel: Support the use of HTTPS and SSL/TLS,

providing the ability to upload signed certificates to encrypt and secure authentication and communication of both administration data and video streams.

2. Support IEEE 802.1x authentication.

3. Provide support for restricting access to pre-defined IP addresses only, so-called IP address filtering.

4. Restrict access to the built-in web server by user names and passwords.

    1. Be managed by group and associated with building and cameras.

C. API support

1. The software shall support IP cameras with open and published APIs (Application Programmers Interface) that will provide the necessary information for integration in the software.

2. The software shall support SQL queries for all system setting variables, events, and analytical results.

D. Maintenance

1. The surveillance software shall:

    a. Be supplied with management software which allows for configuration of the system to includes, cameras, users, and servers.

    b. Offer on-demand or scheduled email reports to system administrators with enterprise wide status of cameras, server, storage, location and health status.

    c. Offer on-demand or schedule email reports to system administrators with enterprise user activity.

2. Customer-specific settings, including statically assigned IP address, the local time and date, event functionality and video configuration, shall be stored in the cameras non-volatile memory and shall not be lost during power outages or soft reset.

3. Monitor cameras by a recording service that can automatically re-initiate recording processes if a malfunction is detected.

2.06 Client PC requirements

A. The surveillance software shall:

1. Operate independently of any single operating system and be accessible through an HTML interface compatible with Internet Explorer, Mozilla Firefox, or Apple Safari browsers while not requiring the installation of PC or MAC client software.

2.07 Environmental

A. The surveillance software shall:

1. Operate in a temperature ranges that are compliant with supporting hardware.

2. Operate in a humidity ranges that are compliant with supporting hardware.

PART 3 - EXECUTION

3.01 Installation

A The Contractor shall carefully follow instructions in documentation provided by the manufacturer to ensure all steps have been taken to provide a reliable, easy-to- operate system.

B All software shall be tested and configured in accordance with instructions provided by the manufacturer prior to installation.

C All software products shall be the latest versions and most up-to-date builds provided by the manufacturer.

D All equipment requiring users to log on using a password shall be configured with user/site-specific password/passwords. No system/product default passwords shall be allowed.

E Exterior cameras: Provide an exterior 4x4 gang box for all exterior cameras. The exterior camera can be mounted on surface plate of the gang box. All connections will be made inside box. BNC-crimp on connector and 2 conductor power cables in box for accessibility and repairs without having to enter the building for repairs or disconnects in walls, from the gang box to the ceiling. Provide plastic bushings or insulated throat connectors shall be used in all conduit terminations. Conduits are not required in ceilings for CCTV Systems. Provide plenum rated cables where required.

F Interior Cameras: Wire cameras to closest IDF room, coordinate installation with WCPSS Security Shop maintenance technician.

END OF SECTION 282300

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SECTION 283100 – INTRUSION DETECTION SYSTEM

PART 1 - GENERAL

1.1 GENERAL

A. This section details product and execution requirements for the Intrusion Detection System for the project.

B. Work includes furnishing all labor, materials, tools and equipment, and documentation required for a complete turnkey working system as specified in this Section. IDS shall consist of but not be limited to System Controllers, Keypads, Sensors, Switches, Conduit, Boxes, Power Supplies, Cable, and Wired Devices. Programming and user enrollment is also considered as part of installation as well as coordination with Owner.

C. The Intrusion Detection System (IDS) shall function as an alarm monitoring and notification solution device and shall integrate with the Access Control System.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, Section 260000 “General Provisions”, and 270010 “Supplemental Requirements for Communications” apply to this Section.

B. Related Sections
1. 281000 – Access Control System
2. 087000 – Door Hardware Specifications
3. 260000 - Electrical Specifications
4. 270000 - Communication Systems

1.3 SUMMARY

A. Section Includes:

1. Product
2. Product
3. Accessories

B. Related Requirements:

1.4 REFERENCES

A. IDS – Intrusion Detection System

B. PIR – Passive infrared

C. BICSI – The Building Industry Consulting Service International, Inc.

D. Control Unit: System component that monitors inputs and controls outputs through various circuits.

E. Master Control Unit: System component that accepts inputs from other control units and may also perform control-unit functions. The unit has limited capacity for the number of protected zones and is installed at an unattended location or at a location where it is not the attendant's primary function to monitor the security system.

F. Monitoring Station: Facility that receives signals and has personnel in attendance at all times to respond to signals. A central station is a monitoring station that is listed.

G. Protected Zone: A protected premises or an area within a protected premises that is provided with means to prevent an unwanted event.

H. Standard-Intruder Movement: Any movement, such as walking, running, crawling, rolling, or jumping, of a "standard intruder" in a protected zone.

I. Systems Integration: The bringing together of components of several systems containing interacting components to achieve indicated functional operation of combined systems.

J. Zone. A defined area within a protected premises. It is a space or area for which an intrusion must be detected and uniquely identified. The sensor or group of sensors must then be assigned to perform the detection, and any interface equipment between sensors and communication must link to master control unit.

1.5 SUBMITTALS

A. Manufacture Product Data: Submit the manufacture’s data sheet indicating systems and components for use.

B. Shop Drawings: Submit complete shop drawings indicating system components, wiring diagrams and load calculations.

C. Record Drawings: During construction maintain record drawings indicating location of equipment and wiring. Submit an electric version of record drawings for the Intrusion Detection System no later than Substantial Completion of the project.

D. Operation and Maintenance Data: Submit manufacture’s operation and maintenance data, customized to the Security Management System installed. Include system and operator manuals Product Data: Submit for each type of product specified.

1.6 QUALITY ASSURANCE

A. Security Management System Contractor shall:
1. Have successfully completed two (2) similar system projects in equal magnitude of the building systems specified in following sections.
2. Installer must have a minimum of 1 (one) technician that has successfully completed the manufacture’s certification training course that is present on the project site to supervise the installation and system testing.
3. Proper proof of manufacturer credentials and certification will be submitted at time of Bid.
4. Be responsible for complete turnkey system including programing.
5. Comply with all certification requirements set out in Division 27 as it related to the installation of any cabling.
6. Deliver materials in original packaging. Store and handle in accordance with the manufacture’s requirement.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Control Units, Devices, and Communications with Monitoring Station: Listed and labeled by a qualified testing agency for compliance with SIA CP-01.

D. FM Global Compliance: FM-Approved and -labeled intrusion detection devices and equipment.

E. Comply with NFPA 70.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer and Installer agree to repair or replace components of intrusion detection devices and equipment that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: One (1) year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 FUNCTIONAL DESCRIPTION OF SYSTEM

A. Description: Hard-wired modular, microprocessor-based controls, intrusion sensors and detection devices, and communication links to perform monitoring, alarm, and control functions.

B. Supervision: System components shall be continuously monitored for normal, alarm, supervisory, and trouble conditions. Indicate deviations from normal conditions at any location in system. Indication includes identification of device or circuit in which deviation has occurred and whether deviation is an alarm or malfunction.
   1. Alarm Signal: Display at master control unit and actuate audible and visual alarm devices.
   2. Trouble Condition Signal: Distinct from other signals, indicating that system is not fully functional. Trouble signal shall indicate system problems such as battery failure, open or shorted transmission line conductors, or control-unit failure.
   3. Supervisory Condition Signal: Distinct from other signals, indicating an abnormal condition as specified for the particular device or control unit.

C. System Control: Master control unit shall directly monitor intrusion detection units and connecting wiring.

D. System Control: Master control unit shall directly monitor intrusion detection devices and connecting wiring in a multiplexed distributed control system or as part of a network.

E. System shall automatically reboot program without error or loss of status or alarm data after any system disturbance.

F. Operator Commands:
   1. Help with System Operation: Display all commands available to operator. Help command, followed by a specific command, shall produce a short explanation of the purpose, use, and system reaction to that command.
   2. Acknowledge Alarm: To indicate that alarm message has been observed by operator.
   3. Place Protected Zone in Access: Disable all intrusion-alarm circuits of a specific protected zone. Tamper circuits may not be disabled by operator.
   4. Place Protected Zone in Secure: Activate all intrusion-alarm circuits of a protected zone.
   5. Protected Zone Test: Initiate operational test of a specific protected zone.

6. System Test: Initiate system-wide operational test.
7. Print reports.

G. Timed Control at Master Control Unit: Allow automatically timed "secure" and "access" functions of selected protected zones.

H. Printed Record of Events: Print a record of alarm, supervisory, and trouble events on system printer. Sort and report by protected zone, device, and function. When master control unit receives a signal, print a report of alarm, supervisory, or trouble condition. Report type of signal (alarm, supervisory, or trouble), protected zone description, date, and time of occurrence. Differentiate alarm signals from other indications. When system is reset, report reset event with the same information concerning device, location, date, and time. Commands shall initiate the reporting of a list of current alarm, supervisory, and trouble conditions in system or a log of past events.

I. Response Time: Two (2) seconds between actuation of any alarm and its indication at master control unit.

J. Circuit Supervision: Supervise all signal and data transmission lines, links with other systems, and sensors from master control unit. Indicate circuit and detection device faults with both protected zone and trouble signals, sound a distinctive audible tone, and illuminate an LED. Maximum permissible elapsed time between occurrence of a trouble condition and indication at master control unit is 20 seconds. Initiate an alarm in response to opening, closing, shorting, or grounding of a signal or data transmission line.

K. Programmed Secure-Access Control: System shall be programmable to automatically change status of various combinations of protected zones between secure and access conditions at scheduled times. Status changes may be preset for repetitive, daily, and weekly; specially scheduled operations may be preset up to a year in advance. Manual secure-access control stations shall override programmed settings.

L. Manual Secure-Access Control: Coded entries at manual stations shall change status of associated protected zone between secure and access conditions.

2.2 SYSTEM COMPONENT REQUIREMENTS

A. Compatibility: Detection devices and their communication features, connecting wiring, and master control unit shall be selected and configured with accessories for full compatibility with the following equipment:
1. 087000 – Door Hardware Specifications
2. 281000 - Access Control System
3. 283100 – Fire Alarm System

B. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor entry connection to components.
1. Minimum Protection for Power Lines 120 V and More: Auxiliary panel suppressors complying with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Listed and labeled by a qualified testing agency for compliance with NFPA 731.

C. Intrusion Detection Units: Listed and labeled by a qualified testing agency for compliance with UL 639.

D. Interference Protection: Components shall be unaffected by radiated RFI and electrical induction of 15 V/m over a frequency range of 10 to 10,000 MHz and conducted interference signals up to 0.25-V rms injected into power supply lines at 10 to 10,000 MHz.

E. Tamper Protection: Tamper switches on detection devices, control units, annunciators, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or

partially disassembled and when entering conductors are cut or disconnected. Master control-unit alarm display shall identify tamper alarms and indicate locations.

F. Self-Testing Devices: Automatically test themselves periodically, but not less than once per hour, to verify normal device functioning and alarm initiation capability. Devices transmit test failure to master control unit.

G. Antimasking Devices: Automatically check operation continuously or at intervals of a minute or less, and use signal-processing logic to detect blocking, masking, jamming, tampering, or another operational dysfunction. Devices transmit detection of operational dysfunction to master control unit as an alarm signal.

H. Addressable Devices: Transmitter and receivers shall communicate unique device identification and status reports to master control unit.

I. Remote-Controlled Devices: Individually and remotely adjustable for sensitivity and individually monitored at master control unit for calibration, sensitivity, and alarm condition.

2.3 ENCLOSURES

A. Interior Sensors: Enclosures that protect against dust, falling dirt, and dripping noncorrosive liquids.

B. Interior Electronics: NEMA 250, Type 12.

C. Exterior Electronics: NEMA 250, Type 4X, stainless steel.

D. Corrosion Resistant: NEMA 250, Type 4X, stainless steel.

E. Screw Covers: Where enclosures are readily accessible, secure with security fasteners of type appropriate for enclosure.

2.4 SECURE AND ACCESS DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by:
1. Napco Gemini
2. DMP
    a. XR550
3. Bosh
4. Honeywell

B. Keypad and Display Module: Arranged for entering and executing commands for system-status changes and for displaying system-status and command-related data.

C. Key-Operated Switch: Change protected zone between secure and access conditions.

2.5 DOOR CONTACTS

A. DPDT Door Contacts are provided by access control system contractor. Coordinate with access control system contractor for installation of devices.

2.6 PIR SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by:
   1. DMP
   2. Bosh
   3. Honeywell

B. Listed and labeled by a qualified testing agency for compliance with SIA PIR-01.

C. Description: Sensors detect intrusion by monitoring infrared wavelengths emitted from a human body within their protected zone and by being insensitive to general thermal variations.
   1. Wall-Mounted Unit Maximum Detection Range: 125 percent of indicated distance for individual units and not less than 50 feet.
   2. Ceiling-Mounted Unit Spot-Detection Pattern: Full 360-degree conical.
   3. Ceiling-Mounted Unit Pattern Size: 50 feet mounted at 8 to 12 feet above the floor.

D. Device Performance:
   1. Test Indicator: LED test indicator that is not visible during normal operation. When visible, indicator shall light when sensor detects an intruder. Locate test enabling switch under sensor housing cover.
   2. Remote Test: When initiated by master control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.

2.7 AUDIBLE AND VISUAL ALARM DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Napco Gemini
   2. DMP
   3. Bosh
   4. Honeywell

B. Siren: 30-W speaker with siren driver, rated to produce a minimum sound output of 103 dB.
   1. Enclosure: Weather-resistant steel box with tamper switches on cover and on back of box.

2.8 FIRE ALARM INTEGRATION

A. Provide (1) DMP # XR-55 transmitter, (1) DMP #714-16 16-zone security expander with lockable metal NEMA1 enclosure, (1) DMP #714-8 8-zone security expander with lockable metal NEMA1 enclosure, and (1) DMP #505-12-G power supply to be located in stacked vertical arrangement in open wall space next to FACP. Provide 8 conductor #18 AWG cable from fire alarm network controller communication card and DMP #XR-550. Cable shall be used to report alarm, trouble, and supervisory signals to DMP #XR-550 via contact closures. Single source 120V power to DMP #XR-550 transmitter and DMP #505-12G and FACP will be provided under Division 26. Provide separate security lockable key switch and surge suppression device TPS3 or approved equal for power feed to DMP Unit. Provide (1) DMP #ICOMSLF contact ID communication card to be installed in FACP. Interconnect FACP and DMP #ICOMSLF with two pair 24 AWG voice cable connection.

B. Coordinate with FACP contractor for further integration with fire alarm system.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of intrusion detection.

B. Examine roughing-in for embedded and built-in anchors to verify actual locations of intrusion detection connections before intrusion detection installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of intrusion detection.

D. Inspect built-in and cast-in anchor installations, before installing intrusion detection, to verify that anchor installations comply with requirements. Prepare inspection reports.
   1. Remove and replace anchors where inspections indicate that they do not comply with requirements. Reinspect after repairs or replacements are made.
   2. Perform additional inspections to determine compliance of replaced or additional anchor installations. Prepare inspection reports.

E. For material whose orientation is critical for its performance as a ballistic barrier, verify installation orientation.

F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SYSTEM INTEGRATION

A. Integrate intrusion detection system with the following systems and equipment:
   1. Mercury Security System Based Controllers

3.3 SYSTEM INSTALLATION

A. Comply with UL 681 and NFPA 731.

B. Equipment Mounting: Install master control unit in Telecommunication Room. Coordinate with owner and other trades for location of wall mounted or rack mounted equipment. Provide 2-hour battery back up in case of AC power failure to equipment.

C. Install and terminate motion detectors, door contacts, door holders and other intrusion devices. Devices to be installed per manufacture’s recommendation.

D. Programming of owner provided information to be completed by contractor.
   1. Owner provided material may consist of but not limited to:
      a. Software or System Users
      b. Monitoring Services
      c. Access Codes
      d. Time Schedules
      e. Zones

3.4 WIRING INSTALLATION

A. Wiring Method: Cable, concealed in accessible ceilings, walls, and floors when possible.

B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Use lacing bars and distribution spools. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer. Install conductors parallel with or at right angles to sides and back of enclosure. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with intrusion system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

C. Wires and Cables:
1. Conductors: Size as recommended in writing by system manufacturer unless otherwise indicated.
2. 120-V Power Wiring: Coordinate with Division 26 contractor for requirements.
3. Control and Signal Transmission Conductors: Install unshielded, twisted-pair cable unless otherwise indicated or if manufacturer recommends shielded cable.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

E. Install power supplies and other auxiliary components for detection devices at control units unless otherwise indicated or required by manufacturer. Do not install such items near devices they serve.

F. Identify components with engraved, laminated-plastic or metal nameplate for master control unit and each terminal cabinet, mounted with corrosion-resistant screws.

G. Comply with Division 270010 – Supplemental Requirements for Communications, Division 270526 – Grounding and Bonding for Communications Systems, Division 270528 – Pathways for Communications Systems.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with identification requirements in Section 270553 "Identification for Electrical Systems."

B. Install instructions frame in a location visible from master control unit.

3.6 GROUNDING

A. Ground the master control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to master control unit.

B. Ground system components and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

C. Install grounding electrodes of type, size, location, and quantity indicated. Comply with installation requirements in 270526 – Grounding and Bonding for Communications Systems.

3.7 FIELD QUALITY CONTROL

A. Pretesting: After installation, align, adjust, and balance system and perform complete pretesting to determine compliance of system with requirements in the Contract Documents. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new ones and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.
   1. Report of Pretesting: After pretesting is complete, provide a letter certifying that installation is complete and fully operable; include names and titles of witnesses to preliminary tests.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

E. Tests and Inspections: Comply with provisions in NFPA 731, Ch. 9, "Testing and Inspections."
   1. Inspection: Verify that units and controls are properly labeled, and interconnecting wires and terminals are identified.
   2. Test Methods: Intrusion detection systems and other systems and equipment that are associated with detection and accessory equipment shall be tested according to Table "Test Methods" and Table "Test Methods of Initiating Devices."

F. Documentation: Comply with provisions in NFPA 731, Ch. 4, "Documentation."

G. Tag all equipment, stations, and other components for which tests have been satisfactorily completed.

3.8 ADJUSTING

A. Occupancy Adjustments: When requested within twelve (12) months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three (3) visits to Project during other-than-normal occupancy hours for this purpose. Visits for this purpose shall be in addition to any required by warranty.

3.9 DEMONSTRATION AND TRAINING

A. Train Owner's maintenance personnel to adjust, operate, and maintain the intrusion detection system. Comply with documentation provisions in NFPA 731, Ch. 4, "Documentation and User Training.

B. Demonstration: Demonstrate that integrated security and communication system functions properly. Perform demonstration at final system inspection by qualified representative of manufacturer working with Owner’s representatives.

C. Contractor shall be on call during Warranty period to answer any questions Owner might have. The Owner reserves the right to use any excess training hours, not used by time of system completion, for future training as requested by Owner until total number of training hours has been used.

D. Owner Training:
   1. Training course for system covered in this section shall be a minimum of 8-hours.

2. Maximum number of students to be (6).
   a. Training materials shall be provided to all students.
3. Record, label, and catalog all training via video recordings. Provide media to Owner for future in-house training sessions and / or reviews. Furnish all temporary equipment necessary for recording all training sessions. Maintain accurate and up-to-date time sheets of all training sessions.
4. The Owner reserves the right to use any excess training hours, not used by time of system completion, for future training as requested by Owner until total number of training hours has been completed.

3.10 SYSTEM START-UP

A. Start-up includes all Contractor-Furnished, Contractor-Installed (CFCI) systems and equipment.

B. Work shall be complete and ready to operate prior to final acceptance.

C. Adjust integrated security and communication system for proper operation in accordance with manufacturer's instructions.

3.11 SYSTEM ACCEPTANCE

A. Final acceptance testing of Work will be coordinated and observed by owner or owner representatives.

B. Prior to testing, Contractor shall submit two sets of preliminary (draft) Record Drawings to Engineer. Preliminary Record Drawings are to be used to conduct system final test.

C. At completion of Work, remove all waste materials, rubbish, Contractor's and subcontractors' tools, construction equipment, machinery, and all surplus materials.

3.12 PROTECTION

A. Protect installed integrated security and communication system from damage during construction.

END OF DOCUMENT 281000

SECTION 284600 -ADDRESSABLE FIRE ALARM SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

1.2 SUMMARY

A. Description: This section of the specification includes the furnishing, installation, connection, and testing of the microprocessor controlled, intelligent reporting fire detection equipment required to form a complete, operative, coordinated system.

B. Section Includes:

1. Analog-Addressable fire-alarm system.
2. Fire-alarm control unit (FACU).
3. Manual fire-alarm boxes.
4. System Detectors.
5. Fire-alarm notification appliances.
6. Fire-alarm annunciators.
7. Fire-alarm addressable interface devices.
8. Fire-alarm system communications.
9. Fire-alarm system accessories.
10. Fire-alarm conductors and cabling.

1.3 REFERENCES

A. Abbreviations and Acronyms

1. DACT: Digital alarm communicator transmitter.
2. FACU (FACP): Fire-alarm control unit (panel).
3. NAC: Notification Appliance Circuit
4. NICET: National Institute for Certification in Engineering Technologies.
5. NRTL: Nationally Recognized Testing Laboratory.
6. SLC: Signaling Line Circuit

B. Definitions

1. Circuit: Wire path from a group of devices or appliances to a control panel or transponder.
2. Zone: Combination of one or more circuits or devices in a defined building area

C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest date as of the date of the Contract Documents, unless otherwise specified.

1. National Electrical Contractors Association (NECA):

a. NECA 305, “Standard for Fire Alarm System Job Practices”.

1.4 SUBMITTALS

A. Approved Permit Submittal: Submittals must be approved by authorities having jurisdiction prior to submitting them to Architect.

B. Product Data: For each type of product, including furnished options and accessories.

C. Shop Drawings: Provide for the fire alarm system.

1. Comply with recommendations and requirements in "Documentation" section of "Fundamentals" chapter in NFPA 72.
2. Include floor plans drawn to scale which clearly show locations of devices, equipment. Indicate electrical power connections, approximate location and size of conduit/wiring runs, and other information required to clearly describe the proposed system. Plans should include identification numbers and wiring connections for all equipment and devices in entire fire alarm system.
3. Include enlarged plans, drawn to a scale not less than 1/4 -inch equals 1 foot, for all equipment rooms and any fire command centers with dimensioned equipment layouts.
4. Include detailed riser diagrams based on the project floor plans, with all devices indicated along with proposed circuit routing. The conductor composition for each conduit section shall be provided. Show consecutive connections for all devices with addresses, candela ratings, and speaker wattages.
5. Provide scaled elevations, sections, and details, including critical dimensions and details of attachments to other Work.
6. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
7. Detail assembly and support requirements.
8. Annunciator panel details as required by authorities having jurisdiction.
9. Include current draw for each device submitted and the listed minimum voltage required to operate.
10. Include voltage drop calculations for notification-appliance circuits. Provide maximum allowable voltage drop for panel and for individual NAC circuits.
    a. Identify Notification Appliance Circuits (NAC) current draws and voltage drops for each circuit. Vendor must utilize the “end of line” method for voltage drop calculations. The “mid-point” method is not acceptable. In no case shall the calculated voltage at any notification appliance fall below the minimum listed operating voltage for the devices used.
    b. The voltage drop at EOL must not exceed 14% of the expected battery voltage, after the required standby time plus alarm time. Determine "worst case" voltage at far end of each NAC, by subtracting its calculated V-drop from the expected battery voltage. The result must be no less than the minimum listed operating voltage for the alarm notification appliances used. All these calculations must be placed on a dedicated sheet, for future reference by fire alarm service technicians.
11. Include battery-size calculations showing battery capacity and supervisory and alarm standby power requirements.
    a. Use manufacturer's battery discharge curve to determine expected battery voltage after specified time period of providing standby power. Then use calculated Notification Appliance Circuit current draw in the alarm mode to determine expected voltage drop at End of the Line Resistor (EOL), based on conductor resistance per conductor manufacturer's data sheet or NEC.
12. Include system response matrix showing the fire alarm system's actions (outputs) required for each type of alarm, supervisory, and trouble signal. Any non-compliant features must be fully described.
13. Include written statement from manufacturer that equipment and components have been tested as a system and comply with requirements in this Section and in NFPA 72.
14. Include performance parameters and installation details for each type of detector.
15. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.

16. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.
    a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
    b. Provide control wiring diagrams and show equipment required for HVAC unit shutdown on alarm and override by firefighters' smoke-evacuation system.
    c. Locate detectors in accordance with manufacturer's written instructions.
17. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
18. Include manufacturer's detailed installation instruction for the Fire Alarm Control Panel and all duct mounted smoke detectors, flow switches, tamper switches, supervisory switches, and similar items which require mechanical installation.

D. Delegated Design: For notification appliances and detectors, in addition to submittals listed herein, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by qualified professional responsible for their preparation.

1. Drawings showing location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of device.
2. Design Calculations: Calculate requirements for selecting spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
    a. The system shall be designed for interior building audibility level of 15 dBA-fast over ambient condition and intelligibility. Intelligibility shall be designed to maintain Common Intelligibility Standard (CIS) rating of 0.7 or Sound Transmission Index of 0.5 in all areas required to have intelligible audio.
3. Indicate audible appliances required to produce square wave signal per NFPA 72.

E. Qualification Data: For Certified System Designer, Lead Technician, and Installers including names, license numbers, and certifications as described under Quality Assurance.

F. Sample Warranty.

G. Field quality-control reports.

H. Closeout Submittals

1. Operation and Maintenance Data: For fire-alarm systems and components to include in operation and maintenance manuals.
2. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
    a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
    b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
    c. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:
        1) Equipment tested.
        2) Frequency of testing of installed components.
        3) Frequency of inspection of installed components.
        4) Requirements and recommendations related to results of maintenance.
        5) Manufacturer's user training manuals.
    d. Software and Firmware Operational Documentation: Provide operating manuals and backups of software database on USB media. The database provided shall be useable by any

authorized and certified distributor of the product line and shall include all applicable passwords necessary for total and unrestricted use and modification of the database.

1.5 MAINTENANCE MATERIAL

A. Extra Stock Materials: Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Increase any resulting decimal quantities of spare parts to the next higher whole number.

1. Fuses: Two of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.
2. Manual Fire Alarm Boxes: 2% of installed quantity.
3. Audible and Visual notification appliances: 4% of installed quantity for each type.
4. Addressable Detectors/Bases: 4% of installed quantity for each type.
5. Addressable Control Relays: 2% of installed quantity.
6. Monitor Modules (Addressable Interface): 2% of installed quantity.
7. Isolation Modules/Isolation Bases: 2% of installed quantity.
8. Keys and Tools: Two extra sets for access to locked or tamper-proofed components.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications

1. Manufacturer must be regularly engaged in manufacture of fire alarm systems of types, sizes, and electrical characteristics required, and whose products are Listed and Labeled.
2. Manufacturer shall maintain an authorized distributor within 100 miles of the project location which stocks a full complement of parts for all equipment to be furnished.

B. Installer Qualifications

1. Obtain certification by NRTL in accordance with NFPA 72.
2. Licensed or certified by authorities having jurisdiction to perform fire alarm installations in the specified jurisdiction.
3. Be in business a minimum of 5 continuous years with documented experience installing fire alarm systems similar in size and scope.
4. Installer must be responsible for all program changes and must be present for all testing and inspections.
5. All connections to the FACP and the system's programming shall only be done by the manufacturer, or by an authorized distributor.

C. Project Personnel Requirements: Installer must have the following certified full-time employees on staff and assigned to the project.

1. All personnel must be trained and certified by manufacturer for installation of units required for this Project.
2. System Designer: Preparation of shop drawings, cabling administration drawings, and field-testing program development by a NICET certified Level IV technician who shall be trained and certified in fire alarm system design by the approved manufacturer within the last 36 months and be licensed by the authorities having jurisdiction.
3. Lead Technician: Minimum NICET certified Level III technician who shall provide all devices, connections, and programming for the fire alarm system. Technician shall be certified by the approved manufacturer within the last 36 months and licensed by the authorities having jurisdiction. The lead technician shall be present at all times when work of this Section is performed at the project site.

4. Installer Qualifications: Any work related to this section shall be installed by personnel trained and certified by the approved manufacturer within the last 24 months.

1.7 WARRANTIES

A. Manufacturer Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship for a period of 3 years from date of Substantial Completion.

B. The manufacturer, or authorized distributor, must maintain software version (VER) records on the system installed. The system software shall be upgraded free of any charge if a new VER is released during the warranty period. For new VER to correct operating problems, free upgrade shall apply during the entire life of the system.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency acceptable to the authority having jurisdiction and marked for intended location and application.

B. All components provided shall be listed for use with the selected system.

2.2 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following:
1. SimplexGrinnell
2. Siemens
3. Mircom

B. Being listed as an acceptable Manufacturer in no way relieves obligation of the Contractor to provide all equipment and features in accordance with these specifications.

2.3 ADDRESSABLE FIRE ALARM SYSTEM

A. Noncoded, UL-certified, FM Global-approved analog/addressable system, with multiplexed signal transmission and voice/strobe or horn/strobe evacuation.

2.4 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:

1. Manual stations.
2. Heat detectors.
3. Smoke detectors.
4. Automatic sprinkler system water flow.
5. Fire standpipe system.
6. Dry system pressure flow switch.

B. Fire-alarm signal must initiate the following actions:

1. Continuously operate alarm notification appliances, including voice evacuation notices.
2. Activate voice/alarm communication system.
3. Identify alarm and specific initiating device at fire-alarm control unit and any remote annunciators or network connected control panels. The system alarm LED shall flash and a local audible signal in the control panel shall sound.
4. Transmit an alarm signal to the remote alarm receiving station.
5. Unlock electric door locks in designated egress paths.
6. Release fire and smoke doors held open by magnetic door holders.
7. Switch HVAC equipment controls to fire-alarm mode.
8. Close smoke dampers in air ducts of designated air-conditioning duct systems.
9. Activate pre-action system.
10. Recall elevators to primary or alternate recall floors.
11. Activate elevator power shunt trip.
12. Activate emergency lighting control.
13. Activate emergency shutoffs for gas and fuel supplies, except for shutoffs serving legally required life-safety systems such as emergency generators.
14. Record events in system memory.
15. Indicate device in alarm on graphic annunciator.
16. Activate smoke-control system (smoke management) at firefighters' smoke-control system panel.
17. Activate stairwell and elevator-shaft pressurization systems.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.
2. Duct smoke detectors.
3. Device tamper.
4. High- or low-air-pressure switch of dry-pipe or pre-action sprinkler system.
5. Waterflow Alarm by sprinkler zone
6. Elevator shunt-trip supervision.
7. Elevator Hoistway smoke detector for Recall.
8. Carbon Monoxide detectors.
9. Fire pump is running.
10. Fire pump loss of phase.
11. Fire pump phase reversal.
12. Fire pump connected to alternate source.
13. Fire pump switch/breaker open.
14. Fire pump controller/system trouble.
15. Zones or individual devices have been disabled.
16. Independent fire-detection and -suppression systems.

D. System Supervisory Signal Actions:

1. Identify specific device initiating the event at fire-alarm control unit and remote annunciators. The corresponding system LED shall flash and a local piezo-electric signal in the control panel shall sound.
2. Record the event on system printer.
3. Transmit a supervisory signal to the remote alarm receiving station with no time delay.

E. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in circuits.
2. Opening, tampering with, or removing alarm-initiating device, alarm appliance, plug-in relay, system module, battery connection, and supervisory signal-initiating devices.
3. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, printer interface, ethernet module, or networked panel.

4. Loss of primary power at fire-alarm control unit.
5. Ground or a single break in internal circuits of fire-alarm control unit.
6. Abnormal AC voltage at fire-alarm control units.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at fire-alarm control unit or annunciator.
10. Voice signal amplifier failure.
11. Smoke Detector Contamination.
12. Carbon Monoxide Detector End of Life.
13. Hose Cabinet Door Open.

F. System Trouble Signal Actions:

1. Identify specific device initiating the event at fire-alarm control unit and remote annunciators. The system trouble LED shall flash and a local piezo-electric signal in the control panel shall sound.
2. Record the event on system printer.
3. Transmit a trouble to the remote alarm receiving station after a programmable time delay of 200 seconds.
4. A trouble signal from loss of primary power shall not be transmitted unless maintained after a programmable time delay of 1 to 3 hours.
5. Fire alarm signal shall override trouble signals, but any pre-alarm trouble signal shall reappear when the panel is reset.

2.5 FIRE ALARM CONTROL PANEL (FACP)

A. General Requirements for Fire Alarm Control Panel:

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864 for protection of the CPU and its associated equipment from voltage surges or line transients.

    a. System software and all control-by-event programs shall be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining the information through failure of primary and secondary power supplies.
    b. Include a real-time clock for time annotation of events on the event recorder and printer. Time-of-Day and date shall be retained through failure of primary and secondary power supplies.
    c. The Central Processing Unit (CPU) shall communicate with, monitor, and control all other modules within the control panel. Removal, disconnection, or failure of any control panel module shall be detected and reported to the system display by the CPU.
    d. Provide communication between the FACP and intelligent detectors, addressable modules, local and remote operator terminals, remote circuit interface panels, annunciators, and other system-controlled devices.
    e. The FACP shall be listed for connection to a central-station signaling system service.
    f. Provide nonvolatile memory for system database, logic, and operating system and event history. The system shall require no manual input to initialize in the event of a complete power down condition. The FACP shall provide a minimum 500-event history log.
    g. The system is to have multiple access levels, so owner's authorized personnel can disable individual alarm inputs or normal system responses (outputs) for alarms, without changing the system's executive programming or affecting operation of the rest of the system. The process on how to do this must be included in the training required to be given to the owner's designated personnel and must also be part of the written documentation provided by the fire alarm equipment supplier. A minimum of two different password levels shall be accessible through the display interface assembly to prevent unauthorized system control or programming.

h. System shall supervise and monitor all intelligent addressable detectors and monitor modules connected to the system for normal, trouble and alarm conditions.
i. Supervise all initiating, signaling, and notification circuits throughout the facility by way of connection to monitor and control modules, or end of line resistor.

2. Addressable Initiation Device Circuits: The FACP shall indicate which communication zones have been silenced and shall provide selective silencing of alarm notification appliance by building communication zone.
3. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.
4. The system shall perform time-based control functions including automatic changes of specified smoke detector sensitivity settings.
5. Digitized electronic signals shall employ check digits or multiple polling. In general, a single ground or open on any system signaling line circuit shall not cause system malfunction, loss of operating power, or the ability to report an alarm.
6. Loss of Power: Alarm signals arriving at the main FACP shall not be lost following a power failure (or outage) until the alarm signal is processed and recorded.
7. The FACP must have an Alarm Silence switch and be equipped with the Subsequent Alarm (alarm resound) feature. Any remote annunciators or graphic displays located away from the alarm area must also include an audible signal with alarm resound feature.

B. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, three lines of 80 characters, minimum.
2. Alphanumeric Touch Keypad: Arranged to permit entry and execution of programming, display, and control commands.
3. Four color coded system status LEDs to indicate status of the following system parameters:
   a. AC Power (GREEN)
   b. System Alarm (RED)
   c. System Trouble (AMBER)
   d. Signal Silence
4. Provide operator's interface which allows the following minimum functions. In addition, the operator's interface shall support any other functions required for system control and/or operation:
   a. Acknowledge (ACK/STEP) Switch
   b. Signal Silence Switch
   c. System Reset Switch
   d. System Test Switch
   e. Lamp Test Switch
   f. Programmable, supervised switches for fire safety function bypasses. i.e. NAC Bypass, Elevator Capture Bypass, HVAC Shutdown Defeat, Smoke Control Bypass, etc. Switch operation shall be password protected.
   g. Interface shall allow programming of the system without any external programming equipment. Systems that require the use of external programmers or change of EPROMs are not acceptable.

C. Signaling Line Circuit (SLC) Interface Board: The FACP shall contain SLC interface boards as required to communicate with the SLC. Each SLC board shall monitor and control a minimum of 198 intelligent addressable devices. This includes 99 analog detectors (Ionization, Photoelectric, or Thermal) and 99 monitor or control modules.

1. Each SLC interface board shall contain its own microprocessor and shall be capable of operating in a local mode (any SLC input activates all or specific SLC outputs) in the event of a failure in the main CPU of the control panel. The SLC interface board shall not require any jumper cuts or address switch settings to initialize SLC Loop operations. SLC interface boards shall provide power and

communicate with all intelligent addressable detectors and modules connected to its SLC Loop on a single pair of wires. This SLC Loop shall be capable of operation as NFPA 72 Class A (Style 6) or Class X (Style 7).

2. Each SLC interface board shall receive analog information from all intelligent detectors and shall process this information to determine whether normal, alarm, or trouble conditions exist for that specific detector. The SLC interface board software shall include software to automatically maintain the detector's desired sensitivity level by adjusting for the effects of environmental factors, including the accumulation of dust in each detector. The analog information may also be used for automatic detector testing and for the automatic determination of detector maintenance requirements.

D. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:

1. Signaling Line Circuits (SLC): NFPA, Class B.
   a. Provide a minimum of one signaling line circuit per floor.
2. Notification Appliance Circuits (NAC): NFPA 72, Class B.
3. Network Circuit Between Addressable Panels: NFPA 72, Class B.
4. System shall be capable accommodating up to 198 addressable devices on each signaling-line circuit (SLC) and a minimum of 1980 initiating points per system.
5. Each signaling line circuit and notification appliance circuit shall be sized to allow a minimum additional capacity of 20%.

E. Serial Interfaces:
1. One dedicated RS 485 port for central-station operation using point ID DACT.
2. One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).
3. One USB port for on-site programming or system modification with a PC.
4. One RS 232 port for voice evacuation interface.

F. Smoke-Alarm Verification:

1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
2. Activate an approved "alarm-verification" sequence at fire-alarm control unit and detector.
3. Record events by the system printer.
4. Sound general alarm if the alarm is verified.
5. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.

G. Notification-Appliance Circuit:

1. Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.
2. Where notification appliances provide signals to sleeping or dwelling areas, the alarm signal shall be a 520-Hz square wave with an intensity 15 dB above the average ambient sound level or 5 dB above the maximum sound level, or at least 75 dBA, whichever is greater, measured at the pillow.
3. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.

H. Elevator Recall and Shutdown:

1. Elevator recall shall be initiated only by one of the following alarm-initiating devices:
   a. Elevator lobby detectors except the lobby detector on the designated floor.
   b. Smoke detector in elevator machine room.
   c. Smoke detectors in elevator hoist way.

2. Elevator controller shall be programmed to move the cars to the alternate recall floor if lobby detectors located on the designated recall floors are activated.
3. Heat Detectors or Water-flow alarm associated with sprinklers in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.

a. Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.

I. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke-barrier walls shall be connected to and powered by fire-alarm system.

J. Remote Smoke-Detector Sensitivity Adjustment and Testing: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory and print out final adjusted values on system printer. The system shall also annunciate a trouble condition when any smoke detector approaches 80% of its alarm threshold due to gradual contamination, with an annunciation of the location of the smoke detector requiring service. If any specialized equipment must be used to program any function of the smoke detector devices, then one must be furnished as part of the system.

K. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station in accordance with parameters specified herein.

L. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided as a special module that is part of fire-alarm control panel.

1. Indicate number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of the central-control microphone. Amplifiers shall comply with UL 1711.

a. Allow the application of, and evacuation signal to, indicated number of zones and, at the same time, allow voice paging to the other zones selectively or in any combination.
b. Programmable tone and message sequence selection.
c. Standard digitally recorded messages for "Evacuation" and "All Clear."
d. Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification-appliance circuits of fire-alarm control unit.
e. Allow paging mode; While paging mode is selected during either automatic or manual evacuation mode, the evacuation signal shall continue to sound until the microphone button is pressed for a paged signal. Once the microphone button is released, the evacuation tone shall again sound when in the manual or automatic evacuation mode.
f. A function selector switch shall permit emergency voice and alarm transmission to be made to selected areas by the use of zone selection switches. The alarm tone shall continue to sound in those zones not selected for voice transmission.
1) The function selector switch shall allow all alarm tones to be silenced and selective voice transmission only shall be permitted via zone selection switches.
2) If the function selector switch is not returned to the normal position, prior to closing the access panel, an audible and visual trouble signal shall be initiated.
3) Facility for total building evacuation or paging shall be accomplished by means of a dual function "all circuit" switch.
4) Each alarm zone shall be provided with an individual selection switch for the purpose of selective voice and/or tone transmission. Zone selection switches shall be maintained contact type with visual indication operation. The voice communication system shall have provision for at least a separate zone for the following:
a) Each floor of each building.
b) Penthouse level.
c) Exit stairwells (one zone each stairwell).
d) Elevator lobbies per local code authority.
e) Elevator cabs.

f) Each area of rescue assistance.

2. Status Annunciator: Indicate the status of various voice/alarm speaker zones.
3. Preamplifiers, amplifiers, and tone generators shall automatically transfer to backup units, on primary equipment failure.

M. Primary Power: Obtained from dedicated 120-V ac branch circuit and a high efficiency power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory and digital alarm communicator transmitters shall be powered by 24-V dc source.

1. Power supply modules shall have a continuous rating adequate to power all equipment and functions in full alarm continuously. All modules and drivers must be able to withstand prolonged short circuits in the field wiring, either line-to-line or line-to-ground, without damage. The power supply shall be expandable for additional notification appliance power in 3.0 Ampere increments.
2. Each system power supply shall be individually supervised.
3. Alarm current draw of entire fire-alarm system shall not exceed 60 percent of the power-supply module rating to allow for future system expansion.
4. Install lock clips on circuit breakers in the "ON" position.

N. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch for system operation in the event of primary power source failure. Transfer from normal to auxiliary (secondary) power or restoration from auxiliary to normal power shall be automatic and shall not cause transmission of a false alarm.

1. Batteries: Maintenance-free, rechargeable, sealed, lead acid with rated lifespan of 10 years.
2. Provide sufficient capacity to operate the complete alarm system in normal, supervisory, or trouble conditions, including audible trouble signal devices, mode for a period of 24 hours. Following this period of operation on battery power, the battery shall have sufficient capacity to operate all components of the system, including all alarm notification devices in alarm mode for a period of 15 minutes. Battery capacity must include a 25% safety factor.
3. Locate batteries either within the control panel or in a separate substantial steel cabinet, finished on inside and outside with enamel paint. Provide a non-corrosive base and cylinder lock keyed to match FACP. Separate cells to prevent contact between terminals of adjacent cells and between terminals and other metal parts. If providing separate battery cabinet, identify as FIRE ALARM SYSTEM BATTERY CABINET with a red and white engraved plastic sign permanently affixed to the face of the panel.
4. Battery Charger: Provide solid state automatic float type, capable of dual rate charging techniques that will recharge a fully discharged battery to a minimum 70% capacity in 12 hours or less. Locate charger within the control panel or within the battery cabinet. Provide voltmeter and ammeter to indicate battery voltage and charging current.
5. All standby batteries shall be continuously monitored by the power supply. The power supply shall be able to perform an automatic test of batteries and indicate a trouble condition if the batteries fall outside a predetermined range.

O. Enclosure: The FACP shall be housed in a listed cabinet suitable for surface or semi-flush mounting. Cabinet and front shall be corrosion protected, given a rust-resistant prime coat, and manufacturer's standard finish. The door shall provide a key lock and shall include a glass or other transparent opening for viewing of all indicators. For convenience, the door may be hinged on either the right or left side (field selectable).

P. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

Q. The fire alarm control panel shall be provided with the following additional features:

1. Upload/Download to PC computer
2. Charger Rate Control
3. Drift Compensation
4. Automatic Day/Night Sensitivity Adjust
5. Device Blink Control
6. Pre-Alarm Control Panel Indication
7. Trouble Reminder
8. NFPA 72 Smoke Detector Sensitivity Test
9. System Status Reports
10. Periodic Detector Test
11. Alarm Verification, by device, with tally
12. Non-Alarm Module Reporting
13. Block Acknowledge
14. Control by Time

2.6 MANUAL FIRE ALARM BOXES

A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes must be finished in red with molded, raised-letter operating instructions in contrasting color; must show visible indication of operation; and must be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type with visual indicator of operation; with screw terminals and integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control panel. When the station is operated, the handle shall lock in a manner showing visual indication of operation.
2. Station Test/Reset: Key-operated test/reset switch. Stations shall be keyed alike with the fire alarm control panel.
3. Manual pull stations that initiate an alarm condition when opening the unit are not acceptable.
4. Weatherproof Protective Shield: At wet locations, provide factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.
5. Material: High impact Lexan Polycarbonate or Cast Metal.
6. Suitable for ambient temperatures up to 120 deg F.
7. Where required, provide weatherproof backbox and device listed for outdoor applications.

2.7 SYSTEM DETECTORS

A. General Requirements:

1. Operating Voltage: 24VDC, nominal. Two-wire type.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACP through a signaling line circuit (SLC).
3. Device Identification: Detectors shall permanently store an internal identifying type code that the control panel shall use to identify the type of device.
4. Base Mounting: Detector and associated electronic components shall be ceiling mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring. The base shall have integral terminal strips for circuit connections, rather than wire pigtails.
5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.

6. Integral Visual-Indicating Light: dual LED type. LEDs shall flash under normal conditions, indicating that the device is operational and in regular communication with the control panel. The flashing mode operation of the detector LEDs shall be optional through the system field program.
7. Automatic Device Mapping: Detector address must be accessible from FACP and must be able to identify detector's location within system and its sensitivity setting.
8. Detectors shall be rated for operation in the following environment unless noted otherwise:
    a. Temperature: 32 deg F to 120 deg F
    b. Humidity: 0-93% relative humidity, non-condensing
9. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.
    a. Rate-of-rise temperature characteristic of combination smoke- and heat-detection units shall be selectable at fire-alarm control unit for 15 or 20 deg F per minute.
    b. Fixed-temperature sensing characteristic of combination smoke- and heat-detection units shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135 or 155 deg F.
    c. Multiple levels of detection sensitivity for each sensor.
    d. Sensitivity levels based on time of day.
    e. Compensate for detector sensitivity changes due to ambient conditions and dust build-up within detectors.
10. Test Means: The detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the control panel. Such a test may be initiated at the detector itself (by activating a magnetic switch) or initiated remotely on command from the control panel when in the "test" condition. Actual or synthetic smoke must be used during the 100% testing to assure smoke entry into the sensing chamber.
11. Self-Diagnostics

B. Photoelectric Smoke Detector: Comply with UL 268.

1. Intelligent photoelectric smoke detectors shall use the photoelectric (light-scattering) principal to measure smoke density and shall, on command from the control panel, send data to the panel representing the analog level of smoke density.
2. Plug-in type, each having a separate base, to facilitate replacement and maintenance.
3. Each detector shall utilize an environmental compensation algorithm that shall automatically adjust for background environmental conditions such as dust, temperature, and pressure.
    a. The detector shall provide a maintenance alert signal when 80% of the available compensation range has been used.
    b. The detector shall provide a dirty fault signal when 100% or greater compensation has been used.
4. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor compensation range (normal, dirty, etc.).

C. Duct Smoke Detector: Comply with UL 268A.

1. Listed for air velocity, temperature, and humidity present in specific duct application with standard Intelligent Photoelectric Detector and detector mounting base.
2. Duct Housing Enclosure: NRTL listed for use with supplied detector for smoke detection in HVAC system ducts. Provide gasketed NEMA 4X housing for harsh environments.
3. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
4. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.

D. Heat Detector: Comply with UL 521.

1. Heat detectors shall use an electronic sensor to measure thermal conditions caused by a fire and shall, on command from the control panel, send data to the panel representing the analog level of such thermal measurements.
2. Fixed Temperature Type: Actuated by fixed temperature of 135 deg F.
3. Combination Type: Actuated by fixed temperature of 135 deg F or rate of rise that exceeds 15 deg F per minute unless otherwise indicated.
4. Rated for ceiling installation at a minimum of 50 ft centers and suitable for wall mount applications.

E. Multicriteria Detector

1. Multi-criteria optical smoke sensor with integrated rate of rise sensing and optional carbon monoxide detection.
2. Integrated nuisance rejection to reduce unwanted alarms.
3. Provide two independent signals to the control panel for detectors with CO sensors.

F. Electro-chemical Carbon Monoxide (CO) Detector: Comply with UL 2075.

1. Sounder base for local audible notification.
2. Transmit a maintenance condition to the control panel when the sensor approaches the end of its useful life.
3. Capable of a functional gas test using a canned test agent to test the functionality of the CO sensing cell.

2.8 NOTIFICATION APPLIANCES

A. General Requirements

1. Connected to system notification-appliance signal circuits, zoned as noted, equipped for mounting as indicated, and within and out screw terminals for system connections.
2. All visual appliances shall be synchronized. Light and audible output levels shall be designed to meet ADA and NFPA requirements.
3. Audible/Visual Combination Devices shall comply with all applicable requirements for both Audible Notification and Visible Notification Appliances.
4. Devices located in a damp or wet location shall be listed for environment. Exterior mounted devices shall be provided with a weatherproof backbox.
5. Devices located in sleeping areas shall produce a low frequency alarm signal that has a fundamental frequency of 520Hz +- 10% and shall be a square wave.
6. All notification appliances shall be factory finished red unless noted otherwise on the drawings

B. Fire Alarm Audible Notification Appliances:

1. Description: Electric vibrating polarized Horns or other notification devices that cannot output voice messages.
2. Performance Criteria: Comply with UL 464.
3. Locate audible devices to provide audibility requirements of “Notification Appliances” chapter in NFPA 72.
4. Voltage: 24VDC nominal
5. Mounting: Flush mount on a standard electrical box.
6. Minimum rated sound pressure level of 85dBA at 10 feet for a three pulse temporal pattern.

C. Fire Alarm Voice-Tone Notification Appliances:

1. Description: Notification appliances capable of outputting voice evacuation messages.
2. Performance Criteria: Comply with UL 1480.

3. Speakers for Voice Notification: Locate speakers for voice notification to provide intelligibility requirements of "Notification Appliances" and "Emergency Communications Systems" chapters in NFPA 72.
4. Speaker Operating Voltage: 25V or 70V.
5. Mounting: Flush mount on a standard electrical box.
6. Minimum rated sound pressure level of 84dBA at 10 feet for 1-watt tap.
7. Matching Transformers: Tap range at 1/4-watt, 1/2-watt, 1-watt, and 2-watt, selected to match acoustic environment of speaker location. Speakers shall be tapped at 1 watt for design purposes.

D. Fire Alarm Visible Notification Appliances: LED strobe lights with clear high impact polycarbonate lens mounted on an aluminum faceplate, complying with UL 1971. The word "FIRE" is engraved in minimum 1-inch- high letters on the lens.

1. Rated Light Output:15/30/75/110 cd, switch selectable at the device. Selected strobe rating shall be visible when the horn-strobe is in its installed position.
2. Voltage: 24VDC nominal
3. Mounting: Wall or ceiling mounted to standard electrical box unless otherwise indicated.
4. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
5. Flashing shall be in a temporal pattern, synchronized with other units. Maximum pulse duration: 2/10ths of one second.
6. Strobe Leads: Factory connected to screw terminals.

E. Bell: Vibrating under dome type with 10-inch gong, utilize a heavy-duty mechanism, polarized for supervised operation.

1. Voltage: 24VDC nominal.
2. Mounting: Semi-Flush mount on a standard electrical box.

2.9 ANNUNCIATORS

A. Fire Alarm Remote Annunciator

1. Description: Annunciator functions must match those of FACP for alarm, supervisory, and trouble indications. Manual switching functions must match those of FACP, including acknowledging, silencing, resetting, and testing.
2. Mounting: Flush cabinet, NEMA 250, Type 1.
3. Annunciator shall communicate with the fire alarm control panel via a supervised RS-485 communications loop that supports multiple annunciators and shall individually annunciate all zones in the system.
4. Display Type and Functional Performance: Large format LCD Alphanumeric display, containing minimum of 80 characters and LED indicating lights must match those of FACP. Provide manual control switches to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.
5. Power shall be supplied directly from the FACP or listed auxiliary power supply, ensuring a reliable and monitored power source.
6. Provide remote microphone to facilitate live page announcements over the FACP system from the remote annunciator. The remote microphone shall feature a Push-to-Talk switch, local and remote page active LEDs, and a trouble LED.

B. Fire Alarm Graphic Annunciator Panel: Mounted in aluminum frame with nonglare, minimum 3/16 inch thick, clear acrylic cover over graphic representation of facility. Detector locations must be represented by red LED lamps. Normal system operation must be indicated by lighted, green LED. Trouble and supervisory alarms must be represented by amber LED.

1. Comply with UL 864.

2. Operating voltage must be 24 VDC provided by local battery backed up 24 V power supply provided with annunciator.
3. Include built-in voltage regulation, reverse polarity protection, RS 232/422 serial communications, and lamp test switch.
4. Semi flush mounted in NEMA 250, Type 1 cabinet, with key lock and no exposed screws or hinges.
5. Graphic representation of facility must be CAD drawing and each initiating device must be represented by LED in its actual location. CAD drawing must be at 1:100 scale or larger.
6. LED representing detector must flash two times per second while detector is in alarm.

2.10 ADDRESSABLE INTERFACE DEVICES

A. General Requirements:

1. Arrange to monitor or control one or more system components that are not otherwise equipped for addressable communication. Modules shall be used for monitoring of waterflow, valve tamper, non-addressable devices, and for control of AHU systems.
2. All Circuit Interface Devices shall be supervised and uniquely identified by the control unit. Module identification shall be transmitted to the control unit for processing according to the program instructions.
3. Each module shall be equipped with two (2) diagnostic indicators; a green LED to confirm communications and a red LED to display active status. LEDs shall be visible through the finished cover plate. The module shall be capable of storing a unique serial number and up to 24 diagnostic codes, hours of operation, number of alarms and troubles, and time of last alarm in its memory which can be retrieved for troubleshooting.
4. Include electronic address-setting means on the module.

B. Monitor Module: Microelectronic module providing system address for alarm-initiating devices for wired applications with normally open contacts.

1. Indication of Operation: An LED shall be provided that shall flash under normal conditions, indicating that the Monitor Module is operational and in regular communication with the control panel.
2. Supervision: Unless specifically noted otherwise on the drawings provide one monitor module for each sprinkler switch.

C. Control Relay Module: Allows control of external appliances or equipment.
1. Provide one form C dry relay contacts rated 24VDC at 2 amps.

D. Isolation Module: Provides short circuit protection for signaling line circuits.
1. When a short circuit is detected, the module isolates the affected segment on the circuit, allowing the remaining devices to continue functioning.
2. Self-restoring and automatically reconnects to the circuit segment when the fault is removed.
3. SLC isolation shall be provided for each floor or protection zone of building.

2.11 DIGITAL ALARM COMMUNICATIONS

A. UL 864 listed as conforming to the requirements of NFPA 72 for Central Station connections.

B. Digital alarm communications transmitter (DACT): capable of sending system events to remote central station receivers over conventional telephone lines.
1. Dual telephone line, rotary or touch-tone-dial DACT interface to public switched telephone network

C. IP/Cellular digital alarm communications transmitter (IP DACT): capable of sending system events to compatible remote central station receivers over a cellular or IP path.

1. UL 864 listed as conforming to the requirements of NFPA 72 for Central Station connections.
2. TCP/IP Ethernet Communicator supporting encrypted communications.
3. Cellular Communicator: LTE fall back cellular connection through the cellular module. Provide antenna extension kits where required to ensure a high-quality connection.

D. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture a transmission line and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If primary service is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of primary line to the remote alarm receiving station over the remaining transmission line. Transmitter shall automatically report transmission channel restoration to the central station. If service is lost on both transmission channels, transmitter shall initiate the local trouble signal.

E. Digital Data Transmission must include the following at a minimum:

1. Address of alarm-initiating device.
2. Address of supervisory signal.
3. Address of trouble-initiating device.
4. Loss of ac supply, where exceeding programmable time delay.
5. Loss of power.
6. Low battery.
7. Abnormal test signal.
8. Communication bus failure.

F. Local functions and display at the digital alarm communicator transmitter shall include the following:
1. Supervised communications.
2. Programmable
3. Auxiliary relay to indicate alarm or trouble.
4. LED display with audible trouble alarm.
5. Manual test report function and manual transmission clear indication.
6. Communications failure with the central station or fire-alarm control unit.

G. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.12 SYSTEM ACCESSORIES

A. Magnetic Door Holders: wall or floor mounting and complete with matching doorplate. The door portion shall have a plated steel pivot mounted armature with shock absorbing nylon bearing. Material and finish to match door hardware.

1. Operation: Under normal conditions, the magnets shall attract and hold the door open. Upon activation of the building fire alarm system, the devices shall be de-energized, thus releasing the doors on the circuit.
2. Electromagnets: Require no more than 1 W to develop 35-lbf holding force.
3. Wall-Mounted Units: Flush mounted in a single gang electrical box unless otherwise indicated.
4. Rating: 24-V dc operating on power from the fire alarm control panel.
5. Power source shall be supervised.
6. Door hold open magnets shall be furnished with keepers, door chains, and other accessories as required to properly hold open doors as indicated on the Drawings.
7. Operation: Under normal conditions, the magnets shall attract and hold the door open. Upon activation of the building fire alarm system, the devices shall be de-energized, thus releasing the doors on the circuit.

B. Surge Suppression Devices:

1. AC circuits: UL 1449 listed, 120VAC, 20A branch circuit surge suppressor with EMI filtering. Ditek DTK-120SRD or equal. Shunt type devices are not permitted.
2. DC circuits: UL 497B listed, 24VDC, 5A multistage hybrid design surge suppressor. Ditek DTK-2MHLP24BWB or equal. Devices using only MOV active elements are not permitted.

C. Wire Guards: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.

1. Factory fabricated and furnished by manufacturer of device.
2. Finish: Paint of color to match the protected device.

D. Remote Indicator Lights: key type switch for testing of the annunciated device.

2.13 FIRE ALARM CONDUCTORS AND CABLE

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Allied Wiring and Cable
2. Belden
3. Comtran Corporation
4. General Cable
5. Honeywell Genesis
6. Radix Wire & Cable
7. Southwire
8. Superior Essex
9. West Penn Wire

B. General Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.

1. Type FPLR or FPLP, red jacket, suitable for indoor locations.
2. Type PLTC, suitable for underground or wet locations.
3. Twisted, shielded pair, low capacitance, not less than No. 18 AWG unless recommended otherwise by system manufacturer.
4. Circuit Integrity Cable: Classification CI, for power-limited fire-alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a two-hour rating.
5. Multiconductor Metal Clad Cable: NFPA 70, Type MC/FPLP, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, steel armor with red identifier stripe, NTRL listed for fire-alarm and cable tray installation, plenum rated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EQUIPMENT INSTALLATION

A. All equipment supplied must be specifically listed for its intended use and shall be installed in accordance with the manufacture's recommendations. The contractor shall consult the manufacturer's installation manuals for all wiring diagrams, schematics, physical equipment sizes, etc., before beginning system installation.

B. Comply with NECA 305, NFPA 70, NFPA 72, and requirements of AHJ for installation and testing of fire-alarm equipment. Install electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

1. Devices placed in service before all other trades have completed cleanup shall be replaced.
2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.

C. Securely fasten all system components to wall and ceiling assemblies using fasteners and supports rated to support the required load in accordance with Section 260500, "Common Work Results for Electrical Systems".
1. Ceiling mounted devices shall not be supported solely by suspended ceilings.

D. Install wall-mounted equipment, with tops of cabinets not more than 78 inches above finished floor. Locate annunciators at a height that enable easy viewing.

E. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm boxes in the normal path of egress within 60 inches of the exit doorway.
2. Mount manual fire-alarm box on a background of a contrasting color.
3. The operable part of manual fire-alarm box shall be between 42 inches and 48 inches above floor level. All devices shall be mounted at the same height unless otherwise indicated.

F. Audible and Visual Notification Devices:

1. Comply with NFPA 72 and ADA criteria for visual intensity and placement.
2. Install wall devices with entire lens between 80-inches and 96-inches above the floor but not less than 6 inches below the ceiling. Install devices on flush-mounted back boxes with the audible device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.

G. End of Line (EOL) Resistors: Devices containing end-of-line resistors shall be appropriately labeled with NAC panel and circuit number in such a manner that removal of the device is not required to identify the EOL device. Locate EOL devices no more than 12-feet above finished floor.

H. Smoke and Heat Detectors:

1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
2. Comply with the "Heat-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
3. Smooth ceiling spacing for smoke detectors shall not exceed 30 feet except in corridors where increased spacing are allowed in accordance with NFPA 72.
4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Annex A or Annex B in NFPA 72.
5. HVAC: Locate detectors not closer than 36 inches from air-supply diffuser or return-air opening.

6. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.
7. When installed in a room, detectors shall be oriented, so their alarm light is visible from the nearest door to the corridor.
8. Unless suitably protected against dust, paint, etc., spot type smoke detectors shall not be installed until the final construction clean-up has been completed. In the event of contamination during construction, the detectors must be replaced by the contractor at no additional cost to the Owner. Covers supplied with smoke detector heads do not provide protection against heavy construction dust, spray painting, etc., and must not be used for that purpose. They are suitable only during final, minor cleanup or touchup operations.

I. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches long shall be supported at both ends. Extend the intake tube through the far side of the duct, seal around the tube where it penetrates the duct wall and plug the end with a rubber stopper to facilitate visual inspection and intake tube cleaning.

1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to final acceptance.
2. Locate duct detectors in a manner that provides suitable, convenient access for required periodic cleaning and calibration.
3. The numbers of detectors per duct shall be per NFPA 72 requirements based on the size of the air duct, air duct configuration, air speed, and duct manufacturer's installation requirements.
4. Indicate airflow direction on the duct, adjacent to the detector, using stencil or permanent decal.
5. Provide each duct smoke detector with a remote keyed test switch and alarm indicator.

J. Remote Status and Alarm Indicators: Install in visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position. Locate in the nearest corridor or public area and identify with engraved label.

K. Carbon Monoxide Detectors:

1. Ceiling mounted CO detectors should be kept 12-inches from sidewalls.
2. Wall mounted CO detectors should be at least 48-inches above the finished floor, but less than 6-inches from the ceiling.
3. Locate at least 60-inches from fuel burning appliances.
4. Install CO detectors no closer than 36 inches from air supply diffusers or return-air openings.

L. Elevator Shafts: Locate devices to meet NFPA 72 and ANSI A17.1 elevator code requirements for elevator recall and shutdown.

1. Coordinate initiating device temperature ratings and location with sprinkler rating and location. Select temperature rating nominal 10 degrees F less than the adjacent fire sprinkler.
2. Ensure device operating ranges for temperature and humidity are suitable for installed environment. Do not install smoke detectors in sprinklered elevator shafts unless required otherwise by AHJ.

M. Addressable Interface Modules:
1. Addressable interface modules (used to monitor all contact type initiating devices) must be in a conditioned space, unless they are tested, listed, and marked for continuous duty across the range of temperatures and humidity expected at their installed location.
2. Sprinkler system supervisory circuits for monitoring valve position, air pressure, water temperature, pump status, etc., must cause distinct audible and visible indications at the FACP.

N. Isolation Modules: Provide in the following locations to minimize the impact of wiring faults:
1. After each 20 initiating devices and control points on the addressable loop, or a lesser number where recommended by the manufacturer.
2. Near the point any addressable circuit extends outside the building, except for those attached to the building exterior walls and well sheltered by walkways.

3. For loops covering more than one floor, install isolator at terminal cabinet on each floor with additional isolator[s] on any floor with over 20 addresses.
4. Each isolation module must be clearly labeled, readily accessible for convenient inspection (not above a lay-in ceiling).

O. HVAC Unit Shutdown
1. All shutdown relays must be directly controlled and monitored by the fire alarm system. The Building Automation System (BAS) shall not be used for life safety functions unless the BAS is supervised by the Fire Alarm System for off normal conditions. Relays should be wired fail safe.
2. A supervised "AHU Shutdown Defeat" switch must be provided in/adjacent to the FACP with an informative engraved label at the FACP about this function. The switch must cause a system "trouble" indication when it's placed in the off-normal ("Shutdown Defeated") position. This is to provide the owner with a convenient means to temporarily resume HVAC operation in the event an unwanted alarm will not clear, prior to arrival of the fire alarm service technician, or for testing purposes.

3.3 PATHWAYS AND CONDUCTORS

A. Wiring Methods: Install all fire alarm wiring in metal conduit, minimum 3/4-inch, in accordance with Section 260533, “Raceways and Boxes for Electrical Systems” and manufacturer’s recommendations. Conceal raceway, except in unfinished spaces.
1. MC Fire Alarm cable is permitted for fire alarm wiring in concealed locations not subject to physical damage.
2. Unenclosed wiring methods may be used in accessible ceiling spaces.
3. Install plenum rated cable in environmental air spaces, including plenum ceilings.

B. Provide red finish for fire alarm raceways in assessable areas above ceilings, and exposed unfinished spaces. Match adjacent architectural finish for exposed fire alarm raceways in finished areas with red junction box covers.

C. All junction box covers shall be painted red on both sides to designate use for Fire Alarm conductors. The interior of junction boxes shall not be painted.

D. Where allowed, surface boxes shall be as manufactured by the device manufacturer for the installed device and shall match devices in size.

E. There shall be no splices in the system other than at device terminal blocks, or on terminal blocks in cabinets. "Wire nuts" and crimp splices will not be permitted. All terminal block screws shall have pressure wire connectors of the self-lifting or box lug type.

F. For underground raceways, provide moisture resistant PLTC cable.

G. All fire alarm and communications circuits that extend beyond the building footprint and are run outdoors shall be provided with a surge protective device.

H. All circuits leaving the riser on each floor or building area shall feed through a labeled terminal block in a hinged enclosure accessible from the floor. Terminal block screws shall have pressure wire connectors of the self-lifting or box lug type.

3.4 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 087100 "Door Hardware." Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.

B. Coordinate connections to electronic access-controlled doors with door hardware specifications and actual door hardware. Provide all connections for release of locking mechanisms in egress paths as required.

C. Verify exact connection requirements to all equipment and devices of other trades with those trades prior to ordering equipment.

D. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Smoke dampers in air ducts of designated HVAC duct systems.
2. Magnetically held-open doors.
3. Electronically locked doors.
4. Alarm-initiating connection to elevator recall system and components.
5. Alarm-initiating connection to activate emergency lighting control.
6. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
7. Supervisory connections at each valve supervisory switches.
8. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
9. Supervisory connections at elevator shunt-trip breaker.
10. Supervisory connections at fire-pump power failure including a dead-phase or phase-reversal condition.
11. Supervisory connections at fire-pump engine control panel.

3.5 IDENTIFICATION

A. Comply with Section 270553, “Identification for Communications Systems”
1. Identify system components, wiring, cabling, and terminals. Identify all fire alarm circuits at terminal and junction locations.
2. Fire alarm system: Install a nameplate on each fire alarm panel and power supply to indicate the panelboard and circuit number supplying the fire alarm system.
3. Branch circuit overcurrent protective devices powering fire alarm equipment shall be identified as FIRE ALARM CIRCUIT with a red and white engraved label permanently affixed to the equipment.
4. Provide engraved label for each remote alarm indicator.

B. Basic operating instructions shall be framed and permanently mounted at the FACP. (If the owner concurs, they may instead be affixed to the inside of the FACP's door.) In addition, the NFPA 72 "Record of Completion" must either be kept at the FACP, or its location shall be permanently indicated there by an engraved label. All System documentation shall be provided and housed in a Documentation Cabinet at the control panel or other approved location in accordance with NFPA 72.

3.6 GROUNDING

A. Ground FACP and surge protective devices for associated circuits in accordance with Section 260526, “Grounding and Bonding for Electrical Systems”.

B. Ground shielded cables at control panel location only. Insulate shield at device location.

3.7 FIELD QUALITY CONTROL

A. All wiring shall be checked for grounds, opens, and shorts, prior to termination at panels and installation of detector heads. The minimum resistance to ground or between any two conductors shall be 10 megohms, as verified with an insulation tester.

B. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.

C. Visual Inspections: Conduct prior to testing.
1. Inspection must be based on completed record Drawings and system documentation that is required by "Completion Documents, Preparation" table in "Documentation" section of "Fundamentals" chapter in NFPA 72.
2. Comply with "Visual Inspection Frequencies" table in "Inspection" section of "Inspection, Testing and Maintenance" chapter in NFPA 72; retain "Initial/Reacceptance" column and list only installed components.

D. System Testing: Comply with "Test Methods" table in "Testing" section of "Inspection, Testing and Maintenance" chapter in NFPA 72.
1. Test audible appliances for public operating mode in accordance with manufacturer's written instructions. Perform test using portable sound-level meter complying with Type 2 requirements in ASA S1.4 Part 1/IEC 61672-1.
2. Verify candela settings and test visible appliances for public operating mode in accordance with manufacturer's written instructions.
3. Test all site-specific software functions and provide a detailed report showing the system’s operational matrix. Each initiating device shall activate the proper response and system notification.
4. Verify all other system functions, including (where applicable) elevator capture and the control of HVAC systems, door locks, pressurization fans, fire, or smoke doors/dampers/shutters, etc.
5. Verify digital communicators are on-line and tested for proper communication to the receiving station.
6. All supervised circuits must also be tested to verify proper supervision.
7. Verify the voltage drop of each NAC circuit by testing and recording the voltage at the origin and at the EOL for each NAC circuit, under battery power only.

E. Reacceptance Testing: Perform reacceptance testing to verify proper operation of added or replaced devices and appliances, software modification, or wiring modifications. Such re-testing shall be included as part of the base bid and provided at no additional cost to the Owner.

F. Fire-alarm system will be considered defective if it does not pass tests and inspections.

G. Factory-authorized service representative must prepare "Fire Alarm System Record of Completion" in "Documentation" section of "Fundamentals" chapter in NFPA 72 and "Inspection and Testing Form" in "Records" section of "Inspection, Testing and Maintenance" chapter in NFPA 72. Submit certified results to the Fire Marshal, Owner, Architect, and Engineer.

H. Prepare test and inspection reports.

I. Provide one year of monitoring with owners preferred vendor.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

B. The manufacturer's authorized representative must instruct the owner's designated employees in operation of the system, and in all required periodic maintenance. A minimum of 8 hours on-site time will be allocated for this purpose. Two copies of a written, bound summary will be provided, for future reference.

C. Training shall cover as minimum the following topics:

1. Preventive maintenance service techniques and schedules, including historical data trending of alarm and trouble records.
2. Overall system concepts, capabilities, and functions. Training shall be in depth, so that the owner shall be able to take any device out of service and return any device to service without need of Manufacturer’s approval or assistance.
3. Explanation of all control functions, including training to program and operate the system software.
4. Methods and means of troubleshooting and replacement of all field wiring devices.
5. Methods and procedures for troubleshooting the main fire alarm control panel, including field peripheral devices as to programming, bussing systems, internal panel and unit wiring, circuitry, and interconnections.
6. Manuals, drawings, and technical documentation. Actual system software used for training shall be provided in digital form and shall be left with the Owner at the completion of training for the Owner’s use in the future.

D. A receipt shall be obtained from the Owner that this has been accomplished, and a copy included in the close-out documents.

END OF SECTION 284600

SECTION 284800 - TWO WAY EMERGENCY COMMUNICATIONS SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

1.2 SUMMARY

A. Description: This section includes equipment for providing two-way emergency voice communication for elevator landings or areas of refuge.

B. Section Includes:
1. Analog two-way emergency communications systems for rescue assistance.

1.3 REFERENCES

A. Abbreviations and Acronyms
1. ECS: Emergency Communication System.
2. PSTN: Public Switched Telephone Network.
3. UPS: Uninterruptable Power Supply

B. Reference Standards
1. Underwriters Laboratories (UL)
   a. UL 2525, “Standard for Two-Way Emergency Communications Systems for Rescue Assistance”
   b. UL 60950, “Information Technology Equipment – Safety”

1.4 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Provide the following

1. Wiring Diagrams detailing wiring for power, signal and control differentiating clearly between manufacturer installed wiring and field installed wiring.
2. Arrangement of Components

C. Closeout Submittals
1. Operation and Maintenance Data: For two-way communication system to include in operation and maintenance manuals.
2. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
   a. Operating instructions laminated and mounted adjacent to operating console location.

1.5 QUALITY ASSURANCE

A. Installer Qualifications:
1. Installation, configuration, setup, program, and related work shall be performed by a manufacturer's authorized representative who is thoroughly trained by the manufacturer in the installation and service of the equipment provided.
2. Installer shall maintain a fully staffed and equipped service office within 100 miles of the project that regularly offers maintenance and service for systems this design and size.

1.6 WARRANTIES

A. Manufacturer Warranty: Manufacturer agrees to repair or replace system, all of its component parts, wiring, and controls that fail within specified warranty period of 3 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency acceptable to authorities having jurisdiction and marked for intended location and application.

B. Comply with UL 2525.

2.2 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following:

1. Alpha Refuge
2. Rath
3. Talk-a-phone

2.3 COMPONENTS

A. Master Control Unit

1. Flush mounted steel enclosure with hinged door
2. Integral monitoring panel with LEDs to provide visual indication of the following:
    a. Activation status of each remote call station
    b. Trouble status of each call station pathway
    c. Primary and Secondary power supply status
    d. Telephone connection status
3. Handset with a coiled cord and keypad.
4. Audible and Visual sounder/strobe with trouble reset switch.
5. Public Switched Telephone Network (PSTN) Interface
    a. The command unit shall be equipped with one (1) PSTN port.
    b. The PSTN port shall interface through a terminal block.

6. Equipped with analog call station ports in order to support required number of analog remote call stations.
7. Programmable through the local command unit phone.
8. Primary Power Supply: Obtained from dedicated 120-V ac branch circuit and a high efficiency power-supply module to supply 24-V dc.
9. Secondary Power Supply: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch for 4 hours of system operation in the event of primary power source failure.

B. Analog Remote Call Station

1. Vandal proof stainless steel with engraved lettering.
2. ADA compliant, flush mounted.
3. "PUSH FOR HELP" button.
4. Red LED indicators to confirm transmission of "Help Requested" signal.
5. Piezoelectric alarm.
6. Hands-free internal speaker and microphone.
7. Dual audio and visual alarms for the hearing and visually impaired.
8. Powered from master control unit unless noted otherwise.
9. Programmable with built in supervised communications and failure relay output.

C. Power Supply

1. The command unit shall be powered by a built-in Uninterruptible Power Supply (UPS).
2. Provide minimum of four hours backup time in the event of primary power source failure.
3. Each analog call station interface port shall provide power to one (1) analog call station through one (1) twisted, shielded pair

D. Signage

1. Provide code required tactile signs with raised letter and braille at each remote call station with directions for using the call stations.
2. Comply with ICC/ANSI A117.1, *Accessible and Usable Buildings and Facilities*, requirements for visual characters.

E. Cabling

1. Provide 2-hour fire-rated circuit integrity cable or other 2-hour rated cabling system.

2.4 SYSTEM SEQUENCE OF OPERATION

A. When in use the system shall provide two-way audio communications between the Master control station unit, remote call station and/or a call to "9-1-1". Communication at the remote call station shall be hands-free after initial contact from the area station. Call out to "9-1-1" shall be a timed occurrence when the master station has not been picked up after a call from a remote station.

B. When an emergency call is placed by the master unit, it provides the following indications at the area remote call station to assure the caller that the call is being processed. After pressing the "PUSH FOR HELP" call button:

1. Audio and visual confirmation:
   a. A "HELP REQUESTED" LED shall illuminate.
   b. An audible alarm shall sound.

C. The Master control unit allows Emergency Personnel to check status of each remote call station and to talk with each remote call station on an individual basis or all of them together.

D. A lighted green LED labeled "RESCUE SERVICES" indicates that an emergency is in progress.

E. If an emergency call is in progress, by lifting the handset on the master control unit you can automatically join the conversation. At this point you can place any or all remote call stations on hold by pushing the hold button corresponding to that unit, which will leave them talking to the called party. Or you can disconnect the called party by pressing the "DISCONNECT TO CALL SERVICES" button, which will leave you talking to the remote area unit.

F. If there is no emergency call in progress, you can call into any or all remote call station by pressing the corresponding talk button to that unit.

G. By hanging up the master station you disconnect from the conversation while leaving the remote area station continuing any ongoing conversation with the called party.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive system components for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with Manufacturers installation and programming instructions.

B. Mount devices plumb and rigid without distortion of boxes. Ensure recessed devices are flush with wall finish and mating with back box.

C. Locate devices and signage to ensure conformance with ADA requirements.

D. Ground any cable shields at common point only at master control unit. Preserve continuity of shields at connecting points.

E. Wiring
1. Provide telephone line to DEMARC in main telecom room for system PSTN interface.
2. Monitor Integrity of all communication circuits between the remote call stations and the master control unit.

3.3 IDENTIFICATION

A. Comply with requirements in Section 260553, "Identification for Electrical Systems"
1. Identify system components, wiring, cabling, and terminals.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Electrical and mechanical tests and inspections: Perform manufacturer's recommended tests and inspections.

C. Operational Tests: After electrical circuitry has been energized, test for compliance with performance requirements:

1. Perform operational tests that include activation of each remote call stations and ensuring proper communication with master control unit.
2. Verify the call out function to “9-1-1” properly calls out after the set duration.

D. Nonconforming Work:

1. System will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

E. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain two-way communication system.

END OF SECTION 284800

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SECTION 285129 - EMERGENCY RESPONDER COMMUNICATION ENHANCEMENT SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

1.2 SUMMARY

A. Description: This section includes labor, material, and equipment to furnish, install and test a complete and operating In-Building Emergency Responder Communication Enhancement System for the purpose of amplifying and distributing throughout the entire building. The radio signals and frequency bands shall be those in use by the Emergency Responders serving this facility. Signal strength levels and coverage in 90% of all areas each floor and 99% of critical areas in accordance with the Fire Code shall be provided.

B. This specification is a performance-based specification. Final and complete design and layout will be provided by the bidder and submitted as part of the shop drawing process.

1.3 REFERENCES

A. Abbreviations and Acronyms:

1. AHJ: Authority Having Jurisdiction.
2. BDA: Bi-directional amplifier.
3. DAQ: Delivered Audio Quality.
4. EMRES: Emergency Responder Radio Enhancement System.
5. FCC: Federal Communications Commission.
6. RF: Radio Frequency.

1.4 COORDINATION

A. Coordinate system scope and layout requirements, attachment methods, and envelope penetrations with architectural and MEP roof plans, elevations, and sections.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations with Division 07 Section "Roof Accessories."

1.5 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Provide the following.

1. Floor plans and ceiling plans showing accurately scaled components and spatial relationship to associated equipment. Include mounting heights with all equipment labeled.

2. Include equipment locations, routing of the distributed antenna system, cabling, antennas, power connections, splitters, couplers, filters, amplifiers, grounding, lightning protection, fire alarm connections, and routing of all cabling.
3. Include building elevation depicting the location of any outdoor antennas associated with the proposed system. Include height of antenna centerline above building, orientation, and location of all external grounding connections and lightning/surge protection.
4. Include enlarged plan views of Equipment Rooms housing head-end and or other consolidated equipment showing all enclosures required for the system. Indicate emergency power sources, location and circuit requirements both AC power and battery power. Include calculations for battery run time.
5. Wiring Diagrams: Detailed one-line schematic wiring diagrams of the system and the interconnection wiring.

C. Delegated Design Submittals: Indicate compliance with performance requirements and design criteria listed herein, including analysis data signed and sealed by qualified professional responsible for their preparation.

D. Test and Inspection Reports

1. Include documentation of all testing procedures and findings.

E. Qualification Data: For qualified designer.

F. Closeout Submittals

1. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
   a. Final test results.
   b. Signed product certificates certifying system complies with specified performance requirements.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Five continuous years, minimum, design, and manufacture of the systems specified.
2. Manufacturing facilities certified to ISO 9001 International Quality Standard with third-party certification verifying quality assurance in design/development, production, installation, and service.
3. Maintain, within 100 miles of Project site, a service center capable of providing training, parts, maintenance, emergency repairs to equipment, and response times less than eight hours.
4. Employ trained staff that are available 24/7 to provide scheduling support and assist with reporting needs.

B. Installer Qualifications:

1. Manufacturer’s authorized representative who is trained and certified by the manufacturer for installation and testing of the specified product.
2. Minimum of five years successful installation experience with Projects of similar size and complexity.
3. Upon request, be able to provide a minimum of three reference accounts at which similar work, both in scope and complexity, have been completed by The Contractor within the last three years.
4. Project Personnel Requirements: Installer must have the following certified full-time employees on staff and assigned to the project:
   a. Designer of system and lead installation personnel shall hold a valid FCC issued general radio operators license and certification of in-building system training issued by a nationally

recognized organization, school or a certificate issued by the manufacturer of the equipment being installed.

1.7 WARRANTIES

A. Manufacturer Warranty: Manufacturer agrees to repair or replace specified product, and all of its components that fail in materials or workmanship within 12 months from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency acceptable to authorities having jurisdiction and marked for intended use.

B. All equipment shall have required FCC approvals.

2.2 SYSTEM PERFORMANCE REQUIREMENTS

A. Delegated Design Criteria:

1. Coordinate with the AHJ to ascertain operating frequencies in use. Include local fire, police, EMS, Sheriff and any state, city, or county first responder frequencies as required by the AHJ.
2. Provide equipment compatible with the existing state, county and local Fire/Police communications system utilized by the Public Safety and Emergency Responder agencies.
3. Fully coordinate with all agencies involved and any state, federal or county agencies required and fully comply with requirements of such agencies.
4. Provide a FCC certified and compliant system.
5. Signal strength for the installed system shall be considered to have acceptable coverage when signal strength measurements in 90% of all areas on each floor and 99% in all critical areas as determined by the AHJ of the building meet a minimum signal strength into (downlink) the building of -95dBm and a minimum signal strength out (uplink) of the building of -100dBm when received by the agency's radio system when transmitted from within the building.
6. Provide an antenna distribution system installed to provide in-building amplification for all in use bandwidths tuned to the frequencies utilized. Provide building mounted "donor" antennas for all frequencies. The antennas will feed into a BDA (bi-directional amplifier), one for each band, which will distribute the boosted signal throughout the facility with a distributed antenna system utilizing point source fixed antennas, or other proposed solution by designer.
7. The system will be designed and installed per the requirements of NFPA, Building Code, Fire Code, and FCC.
8. Optional methods of achieving conformance to the code and distributing the signal throughout the building may be submitted.

2.3 MANUFACTURERS

A. Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. ADRF.
2. Bird Technologies.

3. Comba.
4. Commscope/Andrew.
5. Comprod.
6. Corning.
7. Dali.
8. Fractal Antenna Systems.
9. G-Wave.
10. Laird Antenna.
11. Motorola.
12. RFS Celwave.

B. Source Limitations: Obtain components through one source who assumes responsibility of system component compatibility.

2.4 SYSTEM COMPONENTS

A. Bi-Directional Amplifier:
1. BDA's shall incorporate appropriate RF filters, firmware/software upgradeable band migration, output level control, degrade performance capabilities, and incremental adjustable gain. BDA gain shall be determined by this contractor and sufficient to increase signal to meet or exceed Code levels throughout the building.
2. BDA's shall be class A channelized amplifiers. Full spectrum or Class B amplifiers shall not be used.

B. Donor Antenna:
1. The "donor" antenna signal level shall provide as much head end gain off system as possible but shall be a minimum of 9dB – 15dB above the source under all operating conditions.
2. Antenna Masts: Wind rated per AASHTO Wind Charts with an additional 10 mph rating and a 1.3 gust factor. Contractor to provide all required supports, mounting hardware, and anchoring required for components per manufacturer's requirements. Coordinate materials with Roofing Manufacturer/Contractor if roof mounted and maintain roof warranty.

C. Power Supply:
1. Power supplies for amplifiers and head end equipment shall be served from two independent reliable sources if available. Emergency 120V Generator power (if available) shall be obtained from a local emergency panel.
2. Amplifiers shall be located as determined by designer or as shown on drawings. It is preferable to be as centrally located as possible and if room permits, in the Main Technology Closet or Electrical Room.
3. Each BDA shall be served by a dedicated 20A branch circuit and breaker with a handle lock on device. The secondary power source shall be a dedicated battery, capable of operating the in-building radio system for at least 12 hours at 100% operation capacity.
4. Battery system shall be self/automatic charging system and contained in an enclosure. All signal booster and battery components shall be contained in a NEMA 4 or 4 X type enclosures per NFPA requirements. All enclosures shall be red in color.

D. All signal boosters shall have FCC certification prior to installation. All signal boosters shall be compatible with both analog and digital communications simultaneously at the time of installation. The AHJ shall provide the maximum acceptable propagation delay standard. Contractor shall coordinate with the AHJ.

E. System Monitoring
1. Provide monitoring of system integrity in accordance with NFPA requirements. Provide monitor modules for each BDA and battery cabinet enclosure, quantity as required.

2. Extend addressable fire alarm loop or if zoned system, provide zone modules and zone wiring to these monitor modules and mount the modules near the BDA enclosures.
3. System and Signal Booster Supervisory Signals shall include the following:
   a. Donor Antenna Malfunction
   b. Signal Components Failure
   c. Active RF Emitting Device Failure
4. Power Supply Supervisory Signals shall include the following for each signal booster:
   a. Loss of Normal AC Power
   b. Failure of Battery Charger
   c. Low-Battery Capacity, Alarming at 70 percent of battery capacity
   d. Integrity of communications link between fire alarm system and ERCES.

F. Annunciator:
1. Provide a dedicated annunciator located next to the BDA enclosures to annunciate the status of all signal booster locations. The monitoring panel shall provide visual and labeled indication of the following for each signal booster:
   a. Normal AC Power
   b. Signal booster trouble
   c. Loss of normal AC power

G. Cabling:
1. Coaxial cable bandwidth shall be as required for frequencies used. Verify that any stopbands built into the cable do not block the frequencies used.
2. Unless specified or approved by the Engineer, radiating coaxial cable shall not be used.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas for compliance with manufacturer's installation requirements. Confirm installation tolerances and other conditions affecting performance.

B. Examine substrates and conditions for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance of the Work.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Wiring Methods: Install all cabling in metal conduit, minimum 3/4-inch, in accordance with Section 260533, "Raceways and Boxes for Electrical Systems" and manufacturer's recommendations. Conceal raceway, except in unfinished spaces.

1. Riser runs shall be routed in 2 hour rated shafts.
2. Horizontal runs shall meet NFPA requirements for Survivability level 1 or 2 as required by code based on building construction and systems.

B. Antennas and cabling shall be kept a minimum of 24" from any high voltage cabling/raceways/bus duct or other EMI producing sources. Coordinate routing with field conditions and other trades.

C. Survey facility for any other RF producing components such as mobile radio or base stations and maintain proper separation of antennas so as to not cause interference. Perform adjustments to power output or antenna locations as required to mitigate interference. Coordinate with Owner.

D. Utilize cable manufacturers stripping and crimping tools.

E. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

F. Where a tightening torque is indicated as a numeric value on equipment or in installation instructions provided by the manufacturer, use a calibrated torque tool to achieve that indicated torque value, unless the equipment manufacturer has provided installation instructions for an alternative method of achieving the required torque.

3.3 GROUNDING AND BONDING

A. Comply with requirements in Section 260526 “Grounding and Bonding for Electrical Systems”.
1. Ground cable shields and equipment per manufacturer’s requirements.
2. Provide grounding blocks and surge protection for exterior coaxial cabling.
3. Ground antenna mast in accordance with NEC and manufacturer’s requirements.

3.4 IDENTIFICATION

A. Comply with requirements in Section 260553 “Identification for Electrical Systems”.

1. Identify all interior antennas to coincide with schematic diagram inside BDA.
2. Identify all exterior RF Antenna cables outside and inside at their point of entry.
3. Permanently affix schematics of the system within the main BDA enclosure.
4. Affix FCC information as to the license holder, call letters, frequencies in use and other pertinent information on the exterior of the BDA.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.

B. Provide written 7-day advance notice of any testing to allow The Engineer and Owner’s Representative the option to witness the tests.

C. Visual and Mechanical Inspections

1. Inspect connectors for correct pin depth and torque, weatherproofing and damage from minimum bending radius, crushed or deformed cable.
2. Document and label donor antenna(s) physical location(s), cable type and cable length.
3. Ensure all cables are securely captivated with an approved clamp or strap and that the outer jacket has not been compromised from over tightening.
4. Verify all interior antennas have an identifying number visible from the traffic path location.
5. Check NEMA Box enclosure and filters for proper ventilation.
6. Confirm/Verify that the antenna(s) BDA(s) and applicable AC/DC power source are installed to R56 standards and working clearances.

D. Electrical Tests

1. Confirm proper antenna orientation via signal strength test. Coordinate with system municipality the closest and/or strongest tower/signal source to orientate to.
2. Sweep donor antenna(s) using a calibrated FTDR for Return Loss and Distance to Fault.
3. Measure and record donor antenna grounding hardware and ground resistance for adherence to manufacturer or R56 specifications utilizing a megger documenting reading(s) and exact location(s).

4. Measure and record received signal strength of all applicable frequencies at input.
5. Verify BDA amplified power output with spectrum analyzer in both directions from RF in/out.
6. Test amplifiers for proper gain output and signal level.
7. Check spectral purity of amplified signal for harmonics, spurs, and distortion in both directions.
8. Perform an over the air sweep test for excessive harmonic content, spurs, and distortion.
9. Sweep entire cable plant of each frequency band utilizing a FTDR for Return Loss and Distance to Fault from BDA out to building.
10. Cabling and connectors shall be tested with a FTDR Meter for continuity and signal levels for RF power. Testing shall be for input and output paths.
11. Check and log AC input voltages and document circuit number, breaker, and physical location for both the BDA and AC/DC supply.
12. Test battery output under load for 1 hour for proper output. Test charging circuitry for proper performance.

E. Acceptance Tests

1. The radio frequencies used by the ER shall be tested to ensure two-way coverage on each floor of the building to ensure the following:
   a. Measurements in 95 percent of all areas on each floor of the building shall meet the following signal strengths:
      1) Minimum signal strength into the building shall be -95 dBm.
      2) Minimum signal strength out of the building shall be -95 dBm.
   b. Critical areas such as fire command centers, fire pump rooms, exit stairs, exit passageways, elevator lobbies, standpipe cabinets, sprinkler sectional valve locations, and other areas deemed critical by the AHJ, shall be provided with 99 percent floor area radio coverage.
2. RF Signal Strength Testing
   a. The signal strength test shall be conducted using a calibrated (within last 12 months) spectrum analyzer utilizing antennas similar in use by the emergency responders.
   b. Where signal strength out of the building cannot be efficiently measured, a DAQ Test shall be conducted using a calibrated portable radio of the latest brand and model used by the agency talking through the agency's radio communications system.
   c. Each floor of the building shall be divided into a grid of 20 approximately equal test areas.
   d. A test location approximately in the center of each test area shall be selected for the test, with the radio enabled to verify two-way communications to and from the outside of the building through the public agency's radio communications system. Once the test location has been selected, that location shall represent the entire test area. Failure in the selected test location shall be considered failure of that test area. Additional test locations shall not be permitted.
   e. Measurements shall be made with the antenna held in a vertical position at three (3) to four (4) feet above the floor to simulate portable radios worn on the belt or turnout coat pocket.
   f. A maximum of one (1) (or 5 percent) of nonadjacent test areas shall be allowed to fail the test per floor.
   g. In the event that two or more (or > 5 percent) of the test areas fail the test, in order to be more statistically accurate, the floor shall be permitted to be divided into 40 equal test areas. Failure of more than two (or 5 percent) nonadjacent test areas shall result in failure of the test. If the building fails the 40 area test, the building shall be deemed in non-conformance to Code. The facility shall be equipped with an in-building RF amplification antenna system to meet a 90 percent coverage requirement per floor and retested.
   h. The gain values of all amplifiers shall be measured, and the test measurement results shall be kept on file with the building Owner so that the measurements can be verified during annual tests.
3. Voice Signal Quality Testing
   a. For quality purposes, DAQ readings shall be taken at the same time as the above RF signal strength measurements. The DAQ scale is as follows:
      1) DAQ 1: Unusable. Speech present but not understandable.
      2) DAQ 2: Speech understandable with considerable effort. Requires frequent repetition due to noise or distortion.

3) DAQ 3: Speech understandable with slight effort. Requires occasional repetition due to noise or distortion.
4) DAQ 3.4: Speech understandable without repetition. Some noise or distortion present.
5) DAQ 4: Speech easily understandable; little noise or distortion.
6) DAQ 4.5: Speech easily understandable; rare noise or distortion.
7) DAQ 5: Perfect; no distortion or noise discernible

b. A DAQ level of 3 or better throughout the building shall be deemed acceptable and passing. Areas not achieving this level shall be deemed as failing.

4. Test Fire Alarm Supervisory and Trouble Signals in accordance with NFPA 72 and project fire alarm specifications. Verify proper annunciation.

F. Test and Inspection Reports: Prepare a written report to certify compliance with test parameters and record the following:

1. Test procedures used.
2. Date, time, and weather conditions during testing.
3. Results that comply with requirements.
4. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
5. Prepare information in a format required by the AHJ.

G. Products will be considered defective if they do not pass tests and inspections. Remove and replace malfunctioning units and retest as specified above.

3.6 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Completion, provide on-site assistance in adjusting antennas to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.7 DEMONSTRATION

A. Provide 4 hours of system training and maintenance instruction to Owner’s personnel. Record training and submit DVD with O&M.

END OF SECTION 285129

SECTION 311000 - SITE CLEARING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Removing existing vegetation.
2. Clearing and grubbing (if needed).
3. Stripping and stockpiling topsoil (if needed).
4. Removing above- and below-grade site improvements.
5. Disconnecting, capping or sealing, removing site utilities, and abandoning site utilities in place.
6. Temporary erosion- and sedimentation-control measures.

1.2 DEFINITIONS

A. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.

B. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil; but in disturbed areas such as urban environments, the surface soil can be subsoil.

C. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil and is the zone where plant roots grow. Its appearance is generally friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 2 inches in diameter; and free of subsoil and weeds, roots, toxic materials, or other non-soil materials.

D. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction, and indicated on Drawings.

E. Tree-Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction, and indicated on Drawings defined by a circle concentric with each tree with a radius 1.5 times the diameter of the drip line unless otherwise indicated on plans.

F. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

1.3 MATERIAL OWNERSHIP

A. Except for stripped topsoil and other materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.4 SUBMITTALS

A. Record Drawings: Identifying and accurately showing locations of capped utilities and other subsurface structural, electrical, and mechanical conditions.

1.5 QUALITY ASSURANCE

A. Pre-installation Conference: Conduct conference at the Project site.

1.6 PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.
1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

B. Utility Locator Service: Notify “North Carolina OneCall (811)” for area where Project is located before site clearing.

C. The Contractor shall be responsible for locating underground utilities prior to commencing work and / or excavation. If necessary, the construction manager may obtain the services of a commercial utilities locator and/or various utility companies who may have lines inside the area. In addition, Contractors

shall contact the Owner's Representative at least five days prior to excavation. The Contractor will be responsible for utility interruptions caused by construction operations including excavations

D. Do not commence site clearing operations until temporary erosion- and sedimentation-control measures are in place and erosion control permit is obtained and posted at job-site.

E. Soil Stripping, Handling, and Stockpiling: Perform only when the topsoil is dry or slightly moist.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Division 31 Section "Earth Moving."
   1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Install temporary construction fencing per Section 01 “Temporary Facilities and Controls”.

C. Locate and clearly identify trees, shrubs, and other vegetation to remain or to be relocated. Wrap a 1-inch blue vinyl tie tape flag around each tree trunk at 54 inches above the ground.

D. Protect existing site improvements to remain from damage during construction.
   1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL

A. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion- and sedimentation-control Drawings and requirements of the Wake County and NCDENR.

B. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.

C. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.

D. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

3.3 EXISTING UTILITIES

A. Owner will arrange for disconnecting and sealing indicated utilities that serve existing structures before site clearing, when requested by Contractor.
   1. Verify that utilities have been disconnected and capped before proceeding with site clearing.

B. Locate, identify, disconnect, and seal or cap utilities indicated to be removed or abandoned in place.
   1. Coordinate with Owner prior to shutting off any utilities.
   2. Arrange with utility companies to shut off indicated utilities.

C. Locate, identify, and disconnect utilities indicated to be abandoned in place.

D. Interrupting Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
   1. Notify Owner, and Engineer not less than (72) hours in advance of proposed utility interruptions.
   2. Do not proceed with utility interruptions without Engineer’s written permission.

E. Excavate for and remove underground utilities indicated to be removed.

3.4 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.

1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
2. Grind down stumps and remove roots, obstructions, and debris to a depth of 18 inches below exposed subgrade.
3. Chip removed tree branches and dispose of off-site.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.
   1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches, and compact each layer to a density equal to adjacent original ground.

3.5 TOPSOIL STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Strip topsoil to a minimum depth of 6 inches in a manner to prevent intermingling with underlying subsoil or other waste materials.
   1. Remove subsoil and non-soil materials from topsoil, including clay lumps, gravel, and other objects more than 2 inches in diameter; trash, debris, weeds, roots, and other waste materials.

C. Stockpile topsoil away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.
   1. Limit height of topsoil stockpiles to 72 inches.
   2. Dispose of surplus topsoil. Surplus topsoil is that which exceeds quantity indicated to be stockpiled or reused.
   3. Stockpile surplus topsoil to allow for re-spreading deeper topsoil.

3.6 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.

B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.
   1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut along line of existing pavement and concrete to remain before removing adjacent existing pavement or concrete. Saw-cut faces vertically.

3.7 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.

B. Separate recyclable materials produced during site clearing from other non-recyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities. Do not interfere with other Project work.

END OF SECTION 311000

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SECTION 312000 - EARTH MOVING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. North Carolina Department of Transportation and Town of Cary Standard Specifications and Details where applicable.

1.2 SUMMARY

A. Section Includes:

1. Preparing subgrades for slabs-on-grade, walks, pavements, turf and grasses, and plants.
2. Excavating and backfilling for structures.
3. Subbase course for concrete walks and pavements.
4. Subbase course and base course for asphalt paving.
5. Subsurface drainage backfill for walls and trenches.
6. Excavating and backfilling trenches for utilities and pits for buried utility structures.

B. Related Sections:

1. Division 01 Section "Construction Progress Documentation” for recording pre-excavation and earth moving progress.
2. Division 01 Section "Temporary Facilities and Controls" for temporary controls, utilities, and support facilities; also for temporary site fencing if not in another Section.
3. Division 31 Section "Site Clearing" for site stripping, grubbing, stockpiling topsoil, and removal of above- and below-grade improvements and utilities.
4. Division 31 Section “Erosion and Sedimentation Control”.
5. Division 33 Section “Storm Utility Drainage Piping”.

1.3 UNIT PRICES

A. Work of this Section is affected by unit prices and quantity allowances for earth moving specified in Division 01 Section "Unit Prices".

B. Rock Measurement: Volume of rock actually removed, measured in original position, but not to exceed the following. Unit prices for rock excavation include replacement with approved materials for that condition.

1. 24 inches outside of concrete forms other than at footings.
2. 12 inches outside of concrete forms at footings.
3. 6 inches outside of minimum required dimensions of concrete cast against grade.
4. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
5. 6 inches beneath bottom of concrete slabs-on-grade.
6. 6 inches beneath pipe in trenches, and the greater of 24 inches wider than pipe or 42 inches wide.

1.4 DEFINITIONS

A. Backfill: Soil material or controlled low-strength material used to fill an excavation.

1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
2. Final Backfill: Backfill placed over initial backfill to fill a trench.

B. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.

C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.

D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

E. Design Subgrade: Final subgrade elevation shown on site grading plan.

F. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.

G. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.

1. Authorized Additional Excavation: Excavation below design subgrade elevations or beyond indicated lines and dimensions as directed by Engineer or Owner's Testing Agency. Authorized additional excavation and replacement material will be paid for according to Contract provisions for unit prices.
2. Bulk Excavation: Excavation more than 10 feet in width and more than 30 feet in length.
3. Unauthorized Excavation: Excavation below design subgrade elevations or beyond indicated lines and dimensions without direction by Engineer or Owner's Testing Agency. Unauthorized excavation, as well as remedial work directed by Engineer, shall be without additional compensation.

H. Fill: Soil materials used to raise existing grades.

I. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material that exceed 1 cu. yd. for bulk excavation or 3/4 cu. yd. for footing, trench, and pit excavation that cannot be removed by rock excavating equipment equivalent to the following in size and performance ratings, without systematic drilling, ram hammering, ripping, or blasting, when permitted:

1. Excavation of Footings, Trenches, and Pits: Late-model, track-mounted Caterpillar 330 (or equivalent) using new rock teeth.
2. Bulk Excavation: Late-model, Caterpillar D-8 (or equivalent) pulling a single-tooth ripper.

J. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

K. Structural Fill: Soil free of trash, refuse, frozen material, or other deleterious materials, and contains less than 3% organics. Shall be free of rock or gravel larger than allowed for fill or backfill material as specified hereinafter or as shown on the drawings.

L. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.

M. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

1.5 SUBMITTALS

A. Product Data: For each type of the following manufactured products required:

1. Geosynthetics.
2. Lime and/or cement utilized for soil/base modification.
3. ABC stone
4. Detector warning tapes.

B. Material Test Reports: For each off-site soil material proposed for fill and backfill as follows:

1. Classification according to ASTM D 2487 or method approved by Owner Representative.
2. Laboratory compaction curve according to ASTM D 698 or method approved by Owner Representative.

C. Blasting plan approved by authorities having jurisdiction and only if Owner pre-approves of blasting.

D. Seismic survey report from seismic survey agency.

E. Pre-excavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces that might be misconstrued as damage caused by earth moving operations. Submit before earth moving begins.

1.6 QUALITY ASSURANCE

A. Blasting: Comply with applicable requirements in NFPA 495, "Explosive Materials Code," and prepare a blasting plan reporting the following:

1. Types of explosive and sizes of charge to be used in each area of rock removal, types of blasting mats, sequence of blasting operations, and procedures that will prevent damage to site improvements and structures on Project site and adjacent properties.
2. Seismographic monitoring during blasting operations.

B. Seismic Survey Agency: An independent testing agency, acceptable to authorities having jurisdiction, experienced in seismic surveys and blasting procedures to perform the following services:

1. Report types of explosive and sizes of charge to be used in each area of rock removal, types of blasting mats, sequence of blasting operations, and procedures that will prevent damage to site improvements and structures on Project site and adjacent properties.
2. Seismographic monitoring during blasting operations.

C. Owner’s Testing Agency Qualifications: Qualified according to ASTM E 329 and ASTM D 3740 for testing indicated.

D. Pre-excavation Conference: Conduct conference at the Project Site prior to commencement of site grading.

1.7 PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth moving operations.

1. Do not close or obstruct streets, parking lots, access drives, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.

2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

B. Improvements on Adjoining Property: Authority for performing earth moving indicated on property adjoining Owner's property will be obtained by Owner before award of Contract.

1. Do not proceed with work on adjoining property until directed by Owner.

C. Utility Locator Service: Notify “North Carolina OneCall (811)” for area where Project is located before beginning earth moving operations.

D. Do not commence earth moving operations until temporary erosion- and sedimentation-control measures, specified in Division 31 Sections "Site Clearing" and “Erosion and Sedimentation Control” are in place.

E. Do not commence earth moving operations until a Town of Wendell Permit and NCDEMLR Erosion Control Plan Letter of Approval are obtained and posted at the project site.

F. Do not commence earth moving operations until plant-protection measures shown on the Construction Drawings are in place.

G. The following practices are prohibited within protection zones:

1. Storage of construction materials, debris, or excavated material.
2. Parking vehicles or equipment.
3. Foot traffic.
4. Erection of sheds or structures.
5. Impoundment of water.
6. Excavation or other digging unless otherwise indicated.
7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.

H. Do not direct vehicle or equipment exhaust towards protection zones.

I. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

B. Satisfactory Soils: Unified Soil Classification System (USCS) Groups SM, SC, SW, SP, ML, and CL according to ASTM D 2487, or a combination of these groups; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, greater than 3% organic material, and other deleterious matter; have a standard Proctor maximum dry density of at least 90 pounds per cubic foot (pcf). USCS groups CH and MH found at the project site can be used, provided the moisture content can be controlled, but should not be placed within 2 feet of final subgrade elevations.

1. Compact to not less than 95% of the standard Proctor maximum below 12” and not less than 98% of the standard Proctor maximum for the last 12”.

C. Unsatisfactory (or Unsuitable) Soils: Soils not meeting Satisfactory Soils as described in 2.1.B.

1. On-site borrow materials with natural moisture contents at time of excavation below or up to 10 percent wet of the soil's optimum moisture content shall not be classified as unsatisfactory if the material otherwise meets the material requirements for satisfactory materials. The contractor shall wet or dry these materials to the acceptable moisture range, chemical dry, or replace with off-site borrow at no additional cost to the Owner
2. On-site borrow materials with moisture contents more than 10 percent wet of the soil's optimum moisture content may be considered unsatisfactory. If unsatisfactory soils are found, a meeting with owner and owners testing agency will be required prior to hauling off material.
3. Additional materials deemed unsatisfactory or unsuitable by Owner's Representative.

D. Base Course: Aggregate meeting the ABC stone requirements specified in section 1005-3 and 1005-4 of the North Carolina Department of Transportation Standard Specifications for Roads and Structures, Current Edition.

E. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.

F. Structural Fill: Same as Satisfactory Soils.

G. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; except with 100 percent passing a 1-inch sieve and not more than 8 percent passing a No. 200 sieve.

H. Drainage Course: Narrowly graded mixture of washed crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch sieve and 0 to 5 percent passing a No. 8 sieve.

I. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D 448; coarse-aggregate grading Size 67; with 100 percent passing a 1-inch sieve and 0 to 5 percent passing a No. 4 sieve.

J. Sand: ASTM C 33; fine aggregate.

K. Topsoil: Due to previous project work on campus, there is a current stockpile of topsoil onsite. Based on recommendations from the current Project Representatives onsite it is believed that the topsoil needed for this project is stockpiled onsite.

2.2 GEOTEXTILES

A. Subsurface Drainage / Separation Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; complying with AASHTO M 288 and the following, measured per test methods referenced:

1. Grab Tensile Strength: 205 lb; ASTM D 4632.
2. Grab Tensile Elongation: 50%; ASTM D 4632.
3. Trapezoidal Tear Strength: 80 lb; ASTM D 4533.
4. CBR Puncture Strength: 500 lb; ASTM D 6241.
5. Apparent Opening Size: No. 80 sieve, maximum; ASTM D 4751.
6. Permittivity: 0.2 per second, minimum; ASTM D 4491.
7. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.

B. Stabilization Geotextile: Woven geotextile fabric, manufactured for separation applications, made from polyolefins or polyesters; with elongation less than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:

1. Grab Tensile Strength: 247 lbf; ASTM D 4632.
2. Sewn Seam Strength: 222 lbf; ASTM D 4632.
3. Tear Strength: 90 lbf; ASTM D 4533.
4. Puncture Strength: 90 lbf; ASTM D 4833.
5. Apparent Opening Size: No. 60 sieve, maximum; ASTM D 4751.
6. Permittivity: 0.02 per second, minimum; ASTM D 4491.
7. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.

2.3 ACCESSORIES

A. Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility; colored as follows:

1. Red: Electric.
2. Yellow: Gas, oil, steam, and dangerous materials.
3. Orange: Telephone and other communications.
4. Blue: Water systems.
5. Green: Sewer systems.

B. Detectable Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored as follows:

1. Red: Electric.
2. Yellow: Gas, oil, steam, and dangerous materials.
3. Orange: Telephone and other communications.
4. Blue: Water systems.
5. Green: Sewer systems.

C. Detectable Tracer Wire: In accordance with NC General Statute 87-121 (g), Wake County requires a #12 solid bare copper wire is to be installed with gravity sewer mains and services, storm drainage systems, reuse mains and services, and any nonmetallic water service tubing. It is not required for DIP water mains or copper water services.

PART 3 - EXECUTION

3.1 PREPARATION

A. Follow Construction Sequence provided on Drawings.

B. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth moving operations.

C. Protect and maintain erosion and sedimentation controls during earth moving operations.

D. Remove from site, material encountered in grading operations that does not meet the definition of Satisfactory Soils (2.1.B). Dispose of in manner satisfactory to Owner and local governing agencies. Backfill areas with layers of satisfactory material and compact as specified herein. Materials encountered within the top 6 inches of existing site elevations (prior to stripping) are the responsibility of the Contractor at no additional cost to the Owner (i.e. allowances only apply to depths below top 6 inches of existing site elevations, prior to stripping).

E. Prior to placing fill in low areas, such as previously existing creeks, or ponds, perform following procedures:

1. Drain water out by gravity with ditch having flow line lower than lowest elevation in low area. If drainage cannot be performed by gravity ditch, use adequate pump to obtain the same results.
2. After drainage of low area is complete, remove muck, mud, debris, and other unsatisfactory material by using acceptable equipment and methods that will keep natural soils underlying low area dry and undisturbed. Materials encountered within the top 6 inches of existing site elevations (prior to stripping) are the responsibility of the Contractor at no additional cost to the Owner (i.e. allowances only apply to depths below top 6 inches of existing site elevations, prior to stripping).
3. All muck, mud, and other materials removed from low areas shall be dried on-site by spreading in thin layers for observation. Material shall be inspected and, if found to be satisfactory for use as fill material, shall be incorporated into lowest elevation of site filling operation, but not within 5’-0” of perimeter of paving or retaining wall subgrade. If, after observation, material is found to be unsatisfactory, it shall be removed from site.

F. After topsoil stripping, notify Owner’s Testing Agency. Proof-roll exposed subgrades in fill areas with a pneumatic-tired and loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons to identify soft pockets and areas of excess yielding. Do not proof-roll wet or frozen subgrades.

1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.
2. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Engineer or Owner’s Testing Agency, and replace with compacted backfill or fill as directed. Materials encountered within the top 6 inches of existing site elevations (prior to stripping) are the responsibility of the Contractor at no additional cost to the Owner (i.e. allowances only apply to depths below top 6 inches of existing site elevations, prior to stripping).

G. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

3.2 DEWATERING

A. Design:

1. Designate and obtain the services of a qualified dewatering specialist to provide dewatering plan as may be necessary to complete the Work.
2. Contractor shall be responsible for the accuracy of the drawings, design data, and operational records required.
3. Contractor shall be responsible for the design, installation, operation, maintenance, and any failure of any component of the system.

B. Damages:

1. Contractor shall be responsible for an shall repair any damage to work in place, other contractor’s equipment, utilities, residences, highways, roads, railroads, private and municipal well systems,

adjacent structures, natural resources, habitat, existing wells, and the excavation. Contractor responsibility shall also include, damage to the bottom due to heave and including but not limited to, removal and pumping out of the excavated area that may result from Contractor's negligence, inadequate or improper design and operation of the dewatering system, and any mechanical or electrical failure of the dewatering system.

2. Remove subgrade materials rendered unsatisfactory by excessive wetting and replace with approved backfill material at no additional cost to the Owner.

C. Maintaining Excavation in Dewatering Condition

1. Dewatering shall be a continuous operation. Interruptions due to power outages or any other reason will be permitted.
2. Continuously maintain excavation in a dry condition with positive dewatering methods during preparation of subgrade, installation of pipe, and construction of structures until the critical period of construction or backfill is completed to prevent damage of subgrade support, piping, structure, side slopes, or adjacent facilities from flotation or other hydrostatic pressure imbalance.
3. Provide standby equipment on site, installed, wired, and available for immediate operation if required to maintain dewatering on a continuous basis in the vent any part of the system becomes inadequate or fails. If dewatering requirements are not satisfied due to inadequacy or failure of dewatering system, perform such work as may be required to restore damaged structures and foundation soils at no additional cost to Owner.
4. System maintenance shall include but not be limited to 24-hour supervision by personnel skilled in the operation, maintenance, and replacement of system components and any other work required to maintain excavation in dewatered condition.

D. System Removal: Upon completion of the work, remove dewatering equipment from the site, including related temporary electrical service.

E. Wells shall be removed or cut off a minimum of 3 feet below final ground surface, capped and abandoned in accordance with regulations by agencies having jurisdiction.

3.3 EXPLOSIVES

A. Explosives: Obtain written permission from authorities having jurisdiction including Owner before bringing explosives to Project site or using explosives on Project site.

1. Perform blasting without damaging adjacent structures, property, or site improvements.
2. Perform blasting without weakening the bearing capacity of rock subgrade and with the least-practicable disturbance to rock to remain.

3.4 EXCAVATION, GENERAL

A. Unclassified Excavation: Excavate to design subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include pavements, underground structures, utilities, obstructions, and other items indicated to be removed; together with soil, boulders, and rock. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation, removal of obstructions, or unsuitable soils to subgrade elevation.

1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory materials. Contractor will be paid for disposal and replacement of unsatisfactory materials encountered at depths greater than 6 inches below the existing ground surface elevation, prior to stripping.
2. Remove rock to lines and grades indicated to permit installation of permanent construction without exceeding the following dimensions:

a. 24 inches outside of concrete forms other than at footings. 12 inches outside of concrete forms at footings.
b. 6 inches outside of minimum required dimensions of concrete cast against grade.
c. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
d. 6 inches beneath bottom of concrete slabs-on-grade subbase materials.
e. 6 inches beneath pipe in trenches, and the greater of 24 inches wider than pipe or 42 inches wide.

B. Unsatisfactory Soils: Volume of soils not meeting the definition of Satisfactory Soils (2.1.B), or determined by the Owner's Testing Agency to be unstable or unsuitable for subgrade support, measured in original position, and replaced with satisfactory structural fill/subgrade/foundation material that meets the allowable design bearing pressure, compaction requirements, and settlement limitations specified in the geotechnical report and construction documents for the site and structure. Unsatisfactory soils shall not be removed until approved and cross-sectioned by Owner's Testing Agency. Changes in the Contract Sum or the Contract Time will be in accordance with Allowances and Unit Prices provisions for removal and replacement of unsuitable soils. No changes in the Contract Sum or the Contract Time if unsatisfactory materials are encountered within 6 inches below the existing ground surface elevation, prior to stripping.

3.5 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.

1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
2. Deep Foundations: Stop excavations 6 to 12 inches (150 to 300 mm) above bottom of pile cap before deep foundations are placed. After foundations have been installed, remove loose and displaced material. Excavate to final grade, leaving solid base to receive concrete caps.
3. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 inch (25 mm). Do not disturb bottom of excavations intended as bearing surfaces.

B. Excavations at Edges of Tree- and Plant-Protection Zones:

1. Excavate by hand to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
2. Cut and protect roots according to requirements in Division 01 Section "Temporary Tree and Plant Protection."

3.6 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.7 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated gradients, lines, depths, and elevations.

1. Excavate trenches to allow installation of top of pipe below frost line.

B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit.

1. Clearance: 6 inches each side of pipe or conduit.

C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.

1. For pipes and conduit less than 6 inches in nominal diameter, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.
2. For pipes and conduit 6 inches or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe or conduit circumference. Fill depressions with tamped sand backfill.
3. For flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support conduit on an undisturbed subgrade.
4. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

D. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation, removal of obstructions, or unsuitable soils to trench bottom.

E. Trenches in Tree- and Plant-Protection Zones:

1. Hand-excavate to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
2. Do not cut main lateral roots or taproots; cut only smaller roots that interfere with installation of utilities.
3. Cut and protect roots according to requirements in Division 01 Section "Temporary Tree and Plant Protection."

3.8 SUBGRADE EVALUATION

A. Notify Owner’s Testing Agency when excavations have reached required subgrade.

B. If Owner’s Testing Agency determines that Unsatisfactory Soils (3.4.B) are present, continue excavation and replace with compacted backfill or fill material as directed.

C. Proof-roll final subgrade below pavements with a pneumatic-tired and loaded 10-wheel, tandem-axle dump truck weighing not less than 20 tons to identify soft pockets and areas of excess yielding. Do not proof- roll wet or frozen subgrades.

1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.
2. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Engineer or Owner’s Testing Agency, and replace with compacted backfill or fill as directed.

D. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation, removal of obstructions, or Unsatisfactory soils to subgrade elevation.

E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Engineer, without additional compensation.

3.9 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavations as directed by Engineer.

3.10 STORAGE OF SOIL MATERIALS

A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.

1. Stockpile soil materials away from edge of excavations.
2. Place silt fence approximately 3-ft from edge of stockpile.
3. Do not store within drip line of remaining trees.

3.11 BACKFILL

A. Place and compact backfill in excavations promptly, but not before completing the following:

1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
2. Surveying locations of underground utilities for Record Documents.
3. Testing and inspecting underground utilities.
4. Removing concrete formwork.
5. Removing trash and debris.
6. Removing temporary shoring and bracing, and sheeting.
7. Installing permanent or temporary horizontal bracing on horizontally supported walls.

B. Place backfill on subgrades free of mud, frost, snow, or ice.

3.12 UTILITY TRENCH BACKFILL

A. Place backfill on subgrades free of mud, frost, snow, or ice.

B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

C. Trenches under Footings: Backfill trenches excavated under footings and within 18 inches of bottom of footings with satisfactory soil.

D. Trenches under Roadways: After installing and testing piping or conduit less than 30 inches below surface of roadways, completely encase piping or conduit in a minimum of 4 inches of concrete before backfilling or placing roadway subbase course. Concrete is specified in Division 03 Section "Cast-in-Place Concrete."

E. Backfill voids with satisfactory soil compacted in accordance with specifications provided herein while removing shoring and bracing.

F. Place and compact initial backfill of subbase material and satisfactory soil, free of particles larger than 1 inch in any dimension, to a height of 12 inches over the pipe or conduit.

1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.

G. Place and compact final backfill of satisfactory soil to final subgrade elevation.

H. All underground piping and utilities (both metallic and non-metallic), except lawn irrigation lines, shall have two stages of identification and/or warning by a combination of non-detectable and detectable warning tapes.

I. Install warning tape (detectable warning tape) directly on top of the pipeline and permanently secured to the pipeline at 10’ intervals.

J. Install identification tape (non-detectable warning tape) approximately 18” to 30” above the service pipe, but a minimum of 10” and a maximum of 24” below finished grade.

K. Install tracer wire to bottom of pipe taped at a maximum of 10’ intervals. An insulated copper tracer wire or other approved conductor shall be installed along the length of the pipe to all nonmetallic piping, including irrigation lines, and metallic pipe with compression gasket fittings installed underground. Access shall be provided to the tracer wire or the tracer wire shall terminate aboveground at the end of the nonmetallic piping. The tracer wire size shall be copper single-conductor 10AWG minimum and the insulation type suitable for direct burial with type “UF” (Underground Feeder) insulation and shall be continuous along the pipeline passing through the inside of each valve box or manhole.

3.13 SOIL FILL

A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

B. Place and compact fill material in layers using satisfactory fill (or structural fill) to required elevations.

C. Place soil fill on subgrades free of mud, frost, snow, or ice.

3.14 SOIL MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 3 percent of optimum moisture content.

1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
2. On-site borrow materials with natural moisture contents below or up to 10 percent wet of the soil’s optimum moisture content shall not be classified as unsatisfactory if the material otherwise meets the material requirements for satisfactory materials. The contractor shall wet or dry these materials to the acceptable moisture range, chemical dry, or replace with off-site borrow at no additional cost to the Owner.
3. On-site borrow materials with moisture content more than 10 percent wet of the soil’s optimum moisture content may be considered unsatisfactory.
4. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 3 percent and is too wet to compact to specified dry unit weight.

3.15 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Place backfill and fill soil materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

B. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.

C. Compact as follows:

Location	Percent of Maximum Laboratory Density ASTM D698
Subgrade and Fill below Structures and Pavement (top 12 inches)	98
Subgrade and Fill below Structures and Pavement (below top 12 inches)	95
Subgrade & Fill in All other Areas	90

3.16 GRADING

A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

1. Provide a smooth transition between adjacent existing grades and new grades.
2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:

1. Turf or Unpaved Areas: Plus or minus 1 inch.
2. Walks: Plus or minus 1 inch.
3. Pavements: Plus or minus 1/2 inch.

3.17 SUBSURFACE DRAINAGE

A. Subdrainage Pipe: Specified in Division 33 Section "Subdrainage."

B. Subsurface Drain: Place subsurface drainage geotextile around perimeter of subdrainage trench. Place a 6-inch course of filter material on subsurface drainage geotextile to support subdrainage pipe. Encase subdrainage pipe in a minimum of 12 inches of filter material, placed in compacted layers 6 inches thick, and wrap in subsurface drainage geotextile, overlapping sides and ends at least 6 inches.

1. Compact each filter material layer to 95 percent of maximum dry unit weight according to ASTM D 698 with a minimum of two passes of a plate-type vibratory compactor.

C. Drainage Backfill: Place and compact filter material over subsurface drain, in width indicated, to within 12 inches of final subgrade, in compacted layers 6 inches thick. Overlay drainage backfill with one layer of subsurface drainage geotextile, overlapping sides and ends at least 6 inches.

1. Compact each filter material layer to 95 percent of maximum dry unit weight according to ASTM D 698 with a minimum of two passes of a plate-type vibratory compactor.
2. Place and compact impervious fill over drainage backfill in 6-inch- thick compacted layers to final subgrade.

3.18 BASE COURSES UNDER PAVEMENTS AND WALKS

A. Place base course on subgrades approved by the Owner’s Testing Agency free of mud, frost, snow, or ice.

B. On prepared subgrade, place base course under pavements and walks as follows:

1. Place base course material over subgrade under hot-mix asphalt pavement.
2. Shape base course to required crown elevations and cross-slope grades.
3. Place base course 10 inches or less in compacted thickness in a single layer.
4. Place base course that exceeds 10 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 4 inches thick.

5. Compact base course at moisture content within +/- 2% of optimum moisture to required grades, lines, cross sections, and thickness to not less than 98 percent of maximum dry unit weight according to AASHTO T-180 as modified by NCDOT.

C. Pavement Shoulders: Place shoulders along edges of base course to prevent lateral movement. Construct shoulders, at least 12 inches wide, of satisfactory soil materials and compact simultaneously with each base layer to not less than 98 percent of maximum dry unit weight according to the standard Proctor maximum dry density (ASTM D698).

3.19 FIELD QUALITY CONTROL

A. Owner's Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.

B. Allow testing agency to evaluate and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.

C. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Engineer.

D. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:

1. Paved: At subgrade and at each compacted fill and backfill layer, at least one test for every 2500 sq. ft. or less of paved area, but in no case fewer than three tests.
2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every 100 feet or less of wall length, but no fewer than two tests.
3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 150 feet or less of trench length, but no fewer than two tests.

E. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.20 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

1. Scarify or remove and replace soil material to depth as directed by Engineer; reshape and recompact.

C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.

1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

D. Maintain subgrades to receive base course stone within compaction and moisture requirements continuously until stone is placed.

3.21 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Transport surplus satisfactory soil and topsoil to designated storage areas on Owner's property or remove from site and legally dispose as directed by Engineer. Stockpile or spread soil as directed by Engineer.

1. Remove waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 312000

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SECTION 312317 – TRENCHING

PART 1 - GENERAL

1.1 GENERAL NOTES

A. Prior to beginning Work, Contractor to request a field inspection with the Owner and Engineer for inspection before project start and before project acceptance.

B. Trenches for underground piping, where necessary shall be excavated to the required depth and bell holes shall be provided where necessary to insure uniform bearing. Trench excavation lines shall provide sufficient clearance for proper execution of underground work.

C. Trenches shall be open cut from the surface. Irregularities at bottom of trench, or where excavation is below required depth shall be refilled to required grade with compacted soil, or flowable fill at direction of onsite geotechnical engineer.

D. The Contractor shall be held responsible for the sufficiency of sheeting and bracing and for all damages to property or injury to persons resulting from improper quality, strength, placing and maintenance of trench shoring, sheeting or bracing.

E. Existing utility lines to be retained that are shown on construction drawings or locations of which are made known to the Contractor prior to excavation operations, shall be protected from damage during excavation and backfilling, and if damaged shall be repaired by Contractor, at own expense.

F. Existing utility lines found during excavations that were not shown on construction drawings or made known to Contractor prior to excavation shall be protected and remain uninterrupted until approval by Owner or Engineer to proceed.

G. The Contractor shall be responsible for providing and maintaining a pedestrian and traffic control plan in accordance with Owner standards.

H. All underground utilities encountered during the projects construction shall be located by a Professional Land Surveyor licensed in North Carolina.

1.2 DEFINITIONS

A. Standard Specifications: When referenced in this section, shall mean Department of Transportation Standard Specifications For Roads And Structures, January 2018. Parts of these Standard Specifications that are specifically referenced shall become part of this section as though stated herein in full. In case of a discrepancy between the requirements of the Standard Specifications and the requirements stated herein, the requirements herein shall prevail.

1.3 SUMMARY

A. Section Includes:

1. Excavating trenches for utilities from 5 feet outside any building to terminating connection.
2. Compacted fill from top of utility bedding to finished grade.
3. Backfilling and compaction.

1.4 SUBMITTALS

A. Excavation Protection Plan: Describe sheeting, shoring, and bracing materials and installation required to protect excavations and adjacent structures and property; include structural calculations to support plan.

B. Product Data: Geotextile fabric indicating fabric and construction.

C. Materials Source: Name of imported fill materials suppliers.

1.5 QUALITY ASSURANCE

A. Use this Article to specify compliance with overall reference standards affecting products and installation.

B. Perform Work according to NCDOT, Town of Cary, and Wake County standards.

C. Prepare excavation protection plan under direct supervision of professional engineer experienced in design of this Work and licensed in State of North Carolina.

1.6 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.7 COORDINATION

A. Verify Work associated with lower elevation utilities is complete before placing higher elevation utilities.

PART 2 - PRODUCTS

2.1 FILL MATERIALS

A. Subsoil Fill: Type as specified in Standard Specifications.

B. Structural Fill: Type as specified in Standard Specifications.

C. Granular Fill: Type as specified in Standard Specifications.

D. Concrete:

1. Lean concrete.

2.2 ACCESSORIES

A. Geotextile Fabric: Non-biodegradable, non-woven. Use NCDOT standard for fabric application and type by use.

PART 3 - EXECUTION

3.1 LINES AND GRADES

A. Lay pipes to lines and grades indicated.

1. Engineer may make changes in lines, grades, and depths of utilities when changes are required for Project conditions.

B. Use laser-beam instrument with qualified operator to establish lines and grades.

3.2 PREPARATION

A. Call local utility line information service at 811 not less than three working days before performing Work.

1. Request underground utilities to be located and marked within and surrounding construction areas.

B. Identify required lines, levels, contours, and datum locations.

C. Protect plant life, lawns, and other features remaining as portion of final landscaping.

D. Protect benchmarks, existing structures, trees, sidewalks, paving, and curbs from excavating equipment and vehicular traffic.

E. Maintain and protect above and below grade utilities indicated to remain.

F. Establish temporary traffic control and detours when trenching is performed in public right-of-way. Relocate controls and reroute traffic as required during progress of Work.

3.3 TRENCHING

A. Excavate subsoil required for utilities.

B. Remove lumped subsoil, boulders, and rock over 6 inches.

C. Perform excavation within 24 inches of existing utility service according to utility's requirements.

D. Do not advance open trench more than 200 feet ahead of installed pipe.

E. Cut trenches sufficiently wide to enable installation and allow inspection. Remove water or materials that interfere with Work, dewater in accordance with Section 31 23 19.

F. Excavate bottom of trenches to a maximum of 2 feet past outside diameter dimensions or outside of concrete cradle.

G. Excavate trenches to depth indicated on Drawings. Provide uniform and continuous bearing and support for bedding material and pipe.

H. When Project conditions permit, slope side walls of excavation starting 24 inches above top of pipe. When side walls cannot be sloped, provide sheeting and shoring to protect excavation as specified in this Section.

I. When subsurface materials at bottom of trench are loose or soft, excavate to greater depth as directed by onsite Owner's Testing Agency until suitable material is encountered.

J. Cut out soft areas of subgrade not capable of compaction in place. Backfill with flowable fill or Owner's Testing Agency approved fill and compact to density equal to or greater than requirements for subsequent backfill material.

K. Trim excavation. Hand trim for bell and spigot pipe joints. Remove loose matter.

L. Correct areas over excavated areas with compacted backfill as specified for authorized excavation or replace with fill concrete as directed by Engineer.

M. Remove excess subsoil not intended for reuse, from Site.

N. Stockpile excavated material in area designated on Site according to Section 31 25 00.

3.4 SHEETING AND SHORING

A. Sheet, shore, and brace excavations to prevent danger to persons, structures and adjacent properties and to prevent caving, erosion, and loss of surrounding subsoil.

B. Support trenches excavated through unstable, loose, or soft material. Provide sheeting, shoring, bracing, or other protection to maintain stability of excavation or at direction of onsite geotechnical engineer.

C. Design sheeting and shoring to be removed at completion of excavation Work.

D. Repair damage caused by failure of sheeting, shoring, or bracing and for settlement of filled excavations or adjacent soil.

E. Repair damage to new and existing Work from settlement, water or earth pressure or other causes resulting from inadequate sheeting, shoring, or bracing.

3.5 BACKFILLING

A. Backfill trenches to contours and elevations with Satisfactory Soils per Section 312000.

B. Systematically backfill to allow maximum time for natural settlement. Do not backfill over porous, wet, frozen, or spongy subgrade surfaces.

C. Place fill material in continuous layers and compact to 95 percent of the material's standard Proctor maximum dry density ASTM D698), except in the top 12 inches where this shall be increased to 98 percent.

D. Protect open trench to protect the public.

3.6 FIELD QUALITY CONTROL

A. Perform laboratory material tests according to ASTM D1557.

B. Perform in place compaction tests according to following:

1. Density Tests: ASTM D1556.
2. Moisture Tests: ASTM D3017.

C. When tests indicate Work does not meet specified requirements, remove Work, replace, compact, and retest.

D. Test as required in Section 31200, "Field Quality Control".

3.7 PROTECTION OF FINISHED WORK

A. Reshape and re-compact fills subjected to vehicular traffic during construction.

END OF SECTION 312317

SECTION 312319 – DEWATERING

PART 1 - GENERAL

1.1 GENERAL NOTES

A. Excavations should be kept dry at all times by means of cofferdams, trenches, sumps, pumps or other equipment or arrangements required and approved.

B. Prevent surface water from flowing into excavations, ponding on prepared subgrades and from flooding Project site and surroundings.

C. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation and/or subsurface seepage.

D. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations or trenches. Establish and maintain temporary drainage ditches and other diversions outside excavation limits as required and approved by Owner or Engineer.

E. Do not use excavations or trenches as temporary drainage ditches.

1.2 SUMMARY

A. Section Includes:

1. Construction site dewatering.

1.3 DEFINITIONS

A. Dewatering includes the following:

1. Removing surface or ground water from within excavations or trenches.
2. Disposing of removed water.

B. Surface Water Control: Removal of surface water within open excavations.

1.4 PERFORMANCE REQUIREMENTS

A. Dewatering Performance: Design, furnish, install, test, operate, monitor, and maintain dewatering system of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades.

1. Delegated Design: Design dewatering system, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Continuously monitor and maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes, that excavation does not flood, and that damage to subgrades and permanent structures is prevented.
3. Prevent surface water from entering excavations by grading, dikes, or other means.
4. Accomplish dewatering without damaging existing buildings, structures, and site improvements adjacent to excavation.
5. Remove dewatering system when no longer required for construction.

1.5 QUALITY ASSURANCE

A. Pre-installation Conference: Conduct conference at Project site.

1. Review methods and procedures related to dewatering including, but not limited to, the following:
   a. Inspection and discussion of condition of site to be dewatered including coordination with temporary erosion control measures and temporary controls and protections.
   b. Proposed site clearing and excavations.

1.6 PROJECT CONDITIONS

A. Survey Work: Engage a qualified land surveyor to survey adjacent structures and site improvements, establishing exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.

1. During dewatering, regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations for comparison with original elevations. Promptly notify Engineer if changes in elevations occur or if any damage is evident in adjacent construction.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Conduct additional borings and investigations to supplement subsurface investigations identified as required to complete dewatering system design.

B. Call Local Utility Line Information service at 811 not less than three working days before performing Work.

1. Request underground utilities to be located and marked within and surrounding construction areas.

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.

1. Prevent surface water and subsurface or ground water from entering excavations, from ponding on prepared subgrades, and from flooding site and surrounding area.
2. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.

B. Install dewatering system to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.

C. Provide temporary grading to facilitate dewatering and control of surface water.

D. Monitor dewatering systems continuously.

E. Promptly repair damages to adjacent facilities caused by dewatering.

F. Protect and maintain temporary erosion and sedimentation controls, which are specified in Section 31 25 00 during dewatering operations.

3.3 INSTALLATION

A. Contractor shall furnish, install, operate, and maintain any pumping equipment, etc. needed for removal of water from various parts of the site at no additional cost to the Owner.

B. Work shall be in accordance with NCDOT standards.

3.4 FIELD QUALITY CONTROL

A. Provide continual observation to ensure that subsurface soils are not being removed by the dewatering operation.

END OF SECTION 312319

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SECTION 312324 - FLOWABLE FILL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Flowable fill for:
   a. Structure backfill.
   b. Utility bedding.
   c. Utility backfill.
   d. Filling abandoned utilities.
   e. Concrete Cradle.

1.2 DEFINITIONS

A. Utility: Any buried pipe, duct, conduit, manhole, tank, or cable.

B. Excavatable Flowable Fill: Lean cement concrete fill used where future excavation may be required such as fill for utility trenches, bridge abutments, and culverts.

C. Non-excavatable Flowable Fill: Lean cement concrete fill used where future excavation is not anticipated such as fill below structure foundations and filling abandoned utilities.

1.3 SUBMITTALS

A. Materials Source: Name of flowable fill materials suppliers.

B. Mix Design:

1. Furnish flowable fill mix design for each specified strength. Furnish separate mix designs when admixtures are require for following:
   a. Flowable fill Work during hot and cold weather.
   b. Air entrained flowable fill Work.
2. Identify design mix ingredients, proportions, properties, admixtures, and tests.
3. Furnish test results to certify flowable fill mix design properties meet or exceed specified requirements.

C. Delivery Tickets:

1. Furnish duplicate delivery tickets indicating actual materials delivered to Project Site.

1.4 QUALITY ASSURANCE

A. Perform Work according to State of North Carolina Department of Transportation standards.

B. Manufacturer: Company specializing in manufacturing products specified in this Section with three years' experience.

1. Product source approved by authority having jurisdiction.

1.5 ENVIRONMENTAL REQUIREMENTS

A. Do not install flowable fill during inclement weather or when ambient temperature is less than 40 degrees F.

PART 2 - PRODUCTS

2.1 FLOWABLE FILL

A. Furnish materials according to State of North Carolina Department of Transportation standards.

B. Flowable Fill: Excavatable type.

C. Flowable Fill for Stormwater Control Measure cradle: Non-Excavatable Type; 750 psi minimum.

2.2 MATERIALS

A. Portland Cement: ASTM C150 Type I - Normal.

B. Fine Aggregates: ASTM C33.

C. Water: Clean and not detrimental to concrete.

2.3 ADMIXTURES

A. Furnish materials according to State of North Carolina Department of Transportation standards.

2.4 MIXES

A. Mix and deliver flowable fill according to ASTM C94/C94M, Option C.

B. Flowable Fill Design Mix:

ITEM	EXCAVATABLE	NON-EXCAVATABLE
Cement Content	75 to 100 lb/cu yd	100 to 150 lb/cu yd
Fly Ash Content	None	150 to 600 pcf
Water Content	As specified	As specified
Air Entrainment	5-35 percent	5-15 percent
28-Day Compressive Strength	Maximum 100 psi	Minimum 125 psi
Unit Mass (Wet)	80 to 110 pcf	100 to 125 pcf
Temperature, Minimum at Point of Delivery	50 degrees F	50 degrees F

C. Provide water content in design mix to produce self-leveling, flowable fill material at time of placement.

D. Design mix air entrainment and unit mass are for laboratory design mix and source quality control only.

2.5 SOURCE QUALITY CONTROL

A. Test and analyze properties of flowable fill design mix and certify results for following:

1. Properties of hardened flowable fill design mix including:
   a. Compressive strength at 1 day, 7 days, and 28 days. Report compressive strength of each specimen and average specimen compressive strength.
   b. Unit mass for each specimen and average specimen unit mass at time of compressive strength testing.

B. Prepare delivery tickets containing following information:

1. Project designation.
2. Date.
3. Time.
4. Class and quantity of flowable fill.
5. Actual batch proportions.
6. Free moisture content of aggregate.
7. Quantity of water withheld.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify excavation is complete.

B. Verify utility installation is complete and tested before placing flowable fill.

C. Verify excavation is dry and dewatering system is operating, if required.

3.2 PREPARATION

A. Support and restrain utilities to prevent movement and flotation during installation of flowable fill.

B. Protect structures and utilities from damage caused by hydraulic pressure of flowable fill before fill hardens.

C. Protect utilities to prevent intrusion of flowable fill.

3.3 INSTALLATION - FILL, BEDDING, AND BACKFILL

A. Place flowable fill by chute, pumping or other methods approved by Engineer.

1. When required, place flowable fill under water using tremie procedure.
2. Do not place flowable fill through flowing water.

B. Place flowable fill in lifts to prevent lateral pressures from exceeding structural capacity of structures and utilities.

C. Place flowable fill evenly on both sides of utilities to maintain alignment.

D. Place flowable fill to elevations indicated without vibration or other means of compaction.

3.4 INSTALLATION - FILLING ABANDONED UTILITIES

A. Perform work in accordance with Standard Specifications and Construction Drawings.

B. Verify pipes and conduits are not clogged and are sufficiently empty to permit gravity installation of flowable fill for entire length indicated to be filled.

C. Seal lower end of pipes and conduits by method to contain flowable fill and to vent trapped air caused by filling operations.

D. Place flowable fill using method to ensure there are no voids.

1. Fill pipes and conduits from high end.
2. Fill manholes, tanks, and other structures from grade level access points.

E. After filling pipes and conduits seal both ends.

3.5 FIELD QUALITY CONTROL

A. Perform testing according to ASTM C94/C94M.

1. Take samples for tests for every 150 cu yd of flowable fill, or fraction thereof, installed each day.
2. Sample, prepare and test four compressive strength test cylinders according to ASTM D4832. Test one specimen at 3 days, one at 7 days, and two at 28 days.
3. Measure temperature at point of delivery when samples are prepared.

B. Defective Flowable Fill: Fill failing to meet following test requirements or fill delivered without following documentation.

1. Test Requirements:
   a. Minimum temperature at point of delivery.
   b. Compressive strength requirements for each type of fill.
2. Documentation: Duplicate delivery tickets.

3.6 CLEANING

A. Remove spilled and excess flowable fill from Project Site.

B. Restore facilities and Site areas damaged or contaminated by flowable fill installation to existing condition before installation.

END OF SECTION 312324

SECTION 312500 - EROSION AND SEDIMENTATION CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. This section covers work necessary for stabilization of soil to prevent erosion during and after construction and land disturbance activities. The work shall include furnishing all labor, materials, tools, and equipment to perform all work and services necessary for or incidental to the furnishing and installation, complete, of all operations in connection with erosion control as shown on drawings and as specified, in accordance with provisions of the Contract Documents, and completely coordinated with work of all other trades. The Contractor shall insure that all sedimentation features are in place prior to construction as necessary. Contractor shall remove the features as ground cover is established with approval of the Engineer and/or controlling authorities.

B. The minimum areas requiring soil erosion and sediment control measures are indicated on the Drawings. The right is reserved to modify the use, location, and quantities of soil erosion and sedimentation control measures based on activities of the Contractor and as the Engineer considers to be the best interest of the Owner.

C. Any governmental agency standard as noted below should be referenced as the latest, most recent, or current version of the referenced standard.

D. The Contractor shall implement the approved Erosion and Sediment Control plan and follow all state requirements regarding sedimentation and erosion control. Construction methods shall minimize sedimentation and erosion.

E. See additional information noted on the Drawings.

1.2 DEFINITIONS

A. NCDOT: North Carolina Department of Transportation

B. NCDEQ - DEMLR: North Carolina Department of Environmental Quality - Division of Energy, Mineral, and Land Resources.

C. Standard Erosion Control Specification: North Carolina Erosion and Sediment Control Planning and Design Manual, latest version. Available at the following location: http://deq.nc.gov/about/divisions/energy-mineral-land-resources/energy-mineral-land-permit-guidance/erosion-sediment-control-planning-design-manual

1.3 GENERAL

A. All activities shall conform to the Standard Erosion Control Specification: North Carolina Erosion and Sediment Control Planning and Design Manual, latest version; the approved erosion control permit; the Specifications; and the Drawings. In the event of a conflict, the more stringent requirement shall apply.

B. The Sections of the Standard Erosion Control Specifications referenced include, but are not limited to:

Standard & Specification No	Title
6.06	Temporary Gravel Construction Entrance / Exit

6.10	Temporary Seeding
6.17	Rolled Erosion Control Products
6.20	Temporary Diversions
6.32	Temporary Slope Drains
6.51	Hardware Cloth and Gravel Inlet Protection
6.62	Sediment Fence (Silt Fence)
6.64	Skimmer Sediment Basin
6.66	Compost Sock
6.80	Construction Road Stabilization
6.83	Check Dam

C. Soil erosion stabilization and sedimentation control shall consist of the following elements:

1. Maintenance of existing permanent or temporary storm drainage piping and channel systems, as necessary.
2. Construction of temporary erosion control facilities such as silt fences, inlet protection, etc.
3. Topsoil, Temporary Seeding, and Sod:
   a. Placement and maintenance of Temporary Seeding on all areas disturbed by construction, as necessary
   b. Placement of permanent topsoil, fertilizer, and sod, etc. in areas as specified on the Drawings.
4. It is the intent that all areas in which construction activities have disturbed existing vegetation shall be temporarily seeded, as required, top soiled, and permanently sodded.

D. The Contractor shall be responsible for phasing Work in areas allocated for his / her exclusive use during this Project, including any proposed stockpile areas, to restrict sediment transport. This will include installation of any temporary erosion control devices, ditches, or other facilities that may be required to comply with NCDEQ regulations and requirements.

E. The areas set aside for the Contractor's use during the Project may be temporarily developed to provide satisfactory working, staging, and administrative areas for his / her exclusive use. Preparation of these areas shall be in accordance with other requirements contained within these Specifications and shall be done in a manner to both control all sediment transport from the project area, and to permit the area to be returned to design grades and drainage patterns upon completion of the project.

F. Upon completion of the Project, all areas that have been disturbed by the Contractor shall be stabilized by top-soiling and permanent sodding seeding as shown on the Drawings.

G. All permanent stockpiles, if any, shall be seeded with soil stabilization seed and protected by construction of two (2) rows of silt fence.

H. Sediment transport and erosion from working stockpiles shall be controlled and restricted from moving beyond the immediate stockpile area by construction of temporary silt fence, as necessary. The Contractor shall keep these temporary facilities in operational condition by regular cleaning, re-grading, and maintenance.

I. The Contractor shall maintain all elements of the Soil Erosion Stabilization and Sedimentation Control systems to be constructed during this Project for the duration of his / her activities on this Project. Formal inspections made jointly by the Contractor and the Engineer shall be conducted every week to evaluate the Contractor's conformance to the requirements of both these Specifications and NCDEQ regulations.

J. Maintenance of the Soil Erosion Stabilization and Sedimentation Control systems constructed as part of this project shall be in accordance with the Drawings and NCDEQ Standard Erosion Control Specifications.

K. Contractor shall remove all erosion control measures from the site once permit requirements for vegetation establishment have been met. All areas disturbed during the removal of erosion control measures shall be raked, stabilized, and planted per the Drawings.

1.4 SUBMITTALS

A. Submittals shall be made in accordance with the Specifications, Section 013300, "Submittal Procedures."

B. In addition, the Contractor shall provide the following specific information:

1. If Contractor plans to vary erosion control phasing from the Drawings, then he / she shall submit a written plan, including definition and locations of phased erosion and sediment control for areas that will be disturbed during staged construction sequences. This information shall be provided to the Engineer and Owner, for review, before commencing any Work on the Project.

1.5 QUALITY ASSURANCE

A. Perform Work according to NCDEQ-DEMLR standards.

1.6 INSPECTIONS AND RECORD KEEPING

A. The Contractor is responsible for self-inspection of sedimentation and erosion control devices throughout the life of the Work, including preparation of self-inspection reports and NPDES Self-Monitoring Reports, to make sure the approved erosion and sedimentation control plan is being followed. To simplify documentation of Self-Inspection Reports and NPDES Self-Monitoring Reports, Contractor shall use a combined form available at http://deq.nc.gov/about/divisions/energy-mineral-land-resources/erosion-sediment-control/forms

B. Contractor shall refer to Self-Inspection Reports Reporting Requirements on Drawings.

PART 2 - PRODUCTS

2.1 AGGREGATE

A. Temporary Construction Entrance

1. Furnish according to Standard Erosion Control Specification

B. Silt Fence Outlet

1. Furnish according to Standard Erosion Control Specification

2.2 GEOTEXTILES

A. Sediment Fence Geotextile

1. Furnish according to Standard Erosion Control Specification

B. Construction Entrance Geotextile

1. Furnish according to Standard Erosion Control Specification

C. Rolled Erosion Control Blanket

1. Rolled erosion control blankets shall have a minimum allowable shear stress of 1.5-lbs/ft2 and a minimum longevity of 12 months
2. Anchoring devices for rolled erosion control blankets shall be minimum 11 gauge staples, 1-in wide, and 6-in long or 12-in minimum length wooden stakes.

2.3 TEMPORARY SLOPE DRAINS

A. Furnish according to Standard Erosion Control Specification

2.4 SKIMMER BASIN

A. Skimmer shall meet the design requirements of the drawings and the Standard Erosion Control Specifications

B. Porous baffles shall be furnished according to Standard Erosion Control Specification

2.5 SEDIMENT FENCE STEEL POSTS

A. Furnish according to Standard Erosion Control Specification

2.6 SEDIMENT FENCE FABRIC REINFORCEMENT

A. Furnish according to Standard Erosion Control Specification

2.7 COIR FIBER WATTLE

A. Coir Fiber Wattle shall meet the following specifications:

1. 100% Coir (Coconut) Fibers
2. Minimum Diameter 12 in.
3. Minimum Density 3.5 lb/ft3 +/- 10%
4. Net Material Coir Fiber
5. Net Openings 2 in. x 2 in.
6. Net Strength 90 lbs.
7. Minimum Weight 2.6 lbs./ft. +/- 10%

2.8 PLANTING MATERIALS

A. Temporary Seeding and Soil Supplements:

1. Furnish according to Standard Erosion Control Specification

B. Permanent Seeding (if used)

1. Furnish according to Standard Erosion Control Specification

C. Sod (if used)

1. Furnish according to Owner requirements matching the existing natural turf within the project area.

PART 3 - EXECUTION

3.1 GENERAL

A. The Contractor shall install erosion and sediment control measures and maintain in accordance with the Drawings, the sequence of construction shown on the Drawings are made a part of these Contract Documents.

B. The Contractor shall install any additional measures which the Engineer or Inspector may deem necessary to comply with the Standard Erosion Control Specification general criteria or NCDEQ Erosion Control requirements, at no additional cost to the Owner.

C. The Contractor shall provide and maintain Temporary Seeding at all times.

3.2 SILT FENCE

A. Silt fence to be installed as indicated on Drawings and per the Standard Erosion Control Specification. Silt fence to be placed prior to demolition, trench installations, or other clearing activities. Silt fence may be temporarily removed and replaced to facilitate construction.

B. Maintenance shall be performed per the Standard Erosion Control Specification.

C. After ground cover has been established and approved by Engineer and NCDEQ Erosion Control Inspector, the silt fence shall be removed and disposed of in an approved off-site location at the Contractor's expense.

3.3 SILT FENCE OUTLETS

A. Install silt fence outlets per the details shown on Drawings and per the Standard Erosion Control Specification.

B. Maintenance shall be performed per the Standard Erosion Control Specification.

C. Contractor to verify silt fence outlet placement at low points as they exist or develop. Additional silt fence outlets may be required to prevent erosion during and after construction and land disturbance activities. If additional silt fence outlets are necessary, Contractor to add additional silt fence outlets per Engineer, NCDEQ Erosion Control Inspector, or Owner direction at no additional cost to the Owner.

3.4 TEMPORARY DIVERSION DITCHES AND SLOPE DRAINS

A. Install temporary diversion ditches as shown on the drawings, details and per the Standard Erosion Control Specification.

B. Where shown on the drawings, install rolled erosion control blankets and rock check dams per the details and the Standard Erosion Control Specification.

C. Install temporary slope drains per the drawings and the Standard Erosion Control Specification where runoff from diversion ditches enters the sediment basins, as shown on the drawings.

D. Maintenance shall be performed per the Standard Erosion Control Specification.

3.5 SKIMMER BASINS

A. Install skimmer basins as shown on the drawings per the details and the Standard Erosion Control Specification.

B. Maintenance shall be performed per the Standard Erosion Control Specification.

3.6 INLET PROTECTION

A. Install Inlet Protection per the detail shown on Drawings and per the Standard Erosion Control Specification.

B. Inlet protection shall be placed at the upstream side of any pipe or structure discharging outside of the disturbed limits. See Drawings for location.

3.7 CONSTRUCTION ENTRANCE

A. Install construction entrance per the detail shown on Drawings and per the Standard Erosion Control Specification.

B. Shall be maintained in a condition to prevent tracking or direct flow of mud onto adjacent roadways.

3.8 STOCKPILES

A. Install stockpiles per the detail shown on Drawings and per the Standard Erosion Control Specification.

B. Stockpile height shall not to exceed 15 feet and side slopes shall be 2 (H) to 1 (V) or flatter.

C. Stockpile shall have a minimum double row of silt fence as shown on Drawings.

3.9 GROUND STABILIZATION

A. Contractor shall provide ground stabilization per the Standard Erosion Control Specification and in accordance with the table below:

Site Area Description	Stabilization Time Frame	Stabilization Time Frame Exceptions
Perimeter Dikes, Swakes, Ditches, and Slope	7 Days	None
High Quality Water (HQW) Zones	7 Days	None
Slopes Steeper Than 3:1	7 Days	If Slopes are 10’ or less in length and are not steeper than 2:1, 14 Days
Slopes 3:1or Flatter	14 Days	7-Days for slopes greater than 50-ft in length
All other areas with slopes flatter than 4:1	14 Days	None (except for perimeters and HQW zones)

3.10 TEMPORARY SEEDING

A. Temporary Seeding is to be placed and maintained over all disturbed areas prior to Permanent Sodding per the detail shown on Drawings and per the Standard Erosion Control Specification

B. Maintain Temporary Seeding until such time as areas are approved for permanent seeding. As a minimum, maintenance shall include the following:

1. Fix-up and reseeding of bare areas or re-disturbed areas.

2. Mowing for stands of grass or weeds exceeding 6 inches in height.

END OF SECTION 312500

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SECTION 313116 - TERMITE CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Soil treatment.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include the EPA-Registered Label for termiticide products.
2. Include certificate of registration with North Carolina Department of Agriculture and Consumer Services Structural Pest Control Division (NCDOA).

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Product Certificates: For each type of termite control product.

C. Soil Treatment Application Report: After application of termiticide is completed, submit report for Owner's records and include the following:

1. Date and time of application.
2. Moisture content of soil before application.
3. Termiticide brand name and manufacturer.
4. Quantity of undiluted termiticide used.
5. Dilutions, methods, volumes used, and rates of application.
6. Areas of application.
7. Water source for application.

D. Sample Warranties: For special warranties.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: A specialist who is licensed according to regulations of authorities having jurisdiction to apply termite control treatment and products in jurisdiction where Project is located and who employs workers trained and approved by manufacturer to install manufacturer's products.

1. Installer shall be licensed as a Pest Control Operator (PCO) by NCDOA.

1.6 FIELD CONDITIONS

A. Soil Treatment:

1. Environmental Limitations: To ensure penetration, do not treat soil that is water saturated or frozen. Do not treat soil while precipitation is occurring. Comply with requirements of the EPA-Registered Label and requirements of authorities having jurisdiction.
2. Related Work: Coordinate soil treatment application with excavating, filling, grading, and concreting operations. Treat soil under footings, grade beams, and ground-supported slabs before construction.

1.7 WARRANTY

A. Soil Treatment Special Warranty: Manufacturer's standard form, signed by Applicator and Contractor, certifying that termite control work consisting of applied soil termiticide treatment will prevent infestation of subterranean termites, including Formosan termites (Coptotermes). If subterranean termite activity or damage is discovered during warranty period, re-treat soil and repair or replace damage caused by termite infestation.

1. Warranty Period: Three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain termite control products from single source from single manufacturer.

2.2 SOIL TREATMENT

1. Termiticide: EPA-Registered termiticide acceptable to authorities having jurisdiction, in an aqueous solution formulated to prevent termite infestation. Provide quantity required for application at the label volume and rate for the maximum termiticide concentration allowed for each specific use, according to product's EPA-Registered Label. Use compatible dye in termiticide to provide visible evidence of treatment.
    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
        1) BASF; Thermidor.
        2) Bayer Environmental Science.
        3) FMC Specialty Products.
        4) Syngenta.
2. Service Life of Treatment: Soil treatment termiticide that is effective for not less than three years against infestation of subterranean termites.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Applicator present, for compliance with requirements for moisture content of soil per termiticide label, interfaces with earthwork, slab and foundation work, landscaping, utility installation, and other conditions affecting performance of termite control.

B. Proceed with application only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. General: Prepare work areas according to the requirements of authorities having jurisdiction and according to manufacturer's written instructions before beginning application and installation of termite control treatment(s). Remove extraneous sources of wood cellulose and other edible materials, such as wood debris, tree stumps and roots, stakes, formwork, and construction waste wood from soil within and around foundations.

B. Soil Treatment Preparation: Remove foreign matter and impermeable soil materials that could decrease treatment effectiveness on areas to be treated. Loosen, rake, and level soil to be treated, except previously compacted areas under slabs and footings. Termiticides may be applied before placing compacted fill under slabs if recommended in writing by termiticide manufacturer.

1. Fit filling hose connected to water source at the site with a backflow preventer, according to requirements of authorities having jurisdiction.

3.3 APPLYING SOIL TREATMENT

A. Application: Mix soil treatment termiticide solution to a uniform consistency. Distribute treatment uniformly. Apply treatment at the product's EPA-Registered Label volume and rate for maximum specified concentration of termiticide to the following so that a continuous horizontal and vertical termiticidal barrier or treated zone is established around and under building construction.

1. Slabs-on-Grade and Basement Slabs: Under ground-supported slab construction, including footings, building slabs, and attached slabs as an overall treatment. Treat soil materials before concrete footings and slabs are placed.
2. Foundations: Soil adjacent to and along the entire inside perimeter of foundation walls; along both sides of interior partition walls; around plumbing pipes and electric conduit penetrating the slab; around interior column footers, piers, and chimney bases; and along the entire outside perimeter, from grade to bottom of footing.
3. Crawlspaces: Soil under and adjacent to foundations. Treat adjacent areas, including around entrance platform, porches, and equipment bases. Apply overall treatment only where attached concrete platform and porches are on fill or ground.
4. Masonry: Treat voids.
5. Penetrations: At expansion joints, control joints, and areas where slabs and below-grade walls will be penetrated.

B. Post warning signs in areas of application.

C. Reapply soil treatment solution to areas disturbed by subsequent excavation, grading, landscaping, or other construction activities following application.

3.4 PROTECTION

A. Avoid disturbance of treated soil after application. Keep off treated areas until completely dry.

B. Protect termiticide solution dispersed in treated soils and fills from being diluted by exposure to water spillage or weather until ground-supported slabs are installed. Use waterproof barrier according to EPA-Registered Label instructions.

3.5 MAINTENANCE SERVICE

A. Continuing Maintenance Proposal: Provide from termite-control-treatment Installer to Owner, in the form of a standard yearly (or other period) maintenance agreement, starting on date initial maintenance service

is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

1. Include annual inspection for termite activity and effectiveness of termite treatment according to manufacturer's written instructions.

END OF SECTION 313116

SECTION 316100 - AGGREGATE PIERS

PART 1 - GENERAL

1.1 GENERAL CONDITIONS

A. Coordinate the sequence of construction and utilize BIM to coordinate underground constructions in proximity to the aggregate piers to avoid undermining of the aggregate piers.

1.2 DESCRIPTION OF WORK

A. Work shall consist of designing, furnishing, installing, monitoring, and testing of the aggregate pier foundations to the lines and grades designated on the project foundation plan and as specified herein. The number of piers, diameters and depth of piers shall be determined by the aggregate pier designer/installer. The aggregate piers shall be columns of compacted aggregate constructed in a columnar-type configuration to produce an intermediate foundation system for support of foundation loads to achieve the degree of improvement (allowable bearing capacity and maximum allowable total and differential settlements) as indicated in paragraph "PERFORMANCE CRITERIA." The piers can be constructed with a down-hole vibrator or a down-hole tamper. It shall be the aggregate pier contractor's responsibility to determine and implement the systems and criteria to ensure specified performance is achieved.

B. For soils and groundwater conditions in which the predrilled hole remains open and stable, the aggregate can be placed by a loader into the open hole and compacted in lifts using either a down-hole vibrator or down-hole tamper. In unstable conditions, the hole stability must be maintained either with a bottom feed down-hole vibrator, casing if the tamper method is used, or other suitable method.

C. Design shall rely on subsurface information presented in the project geotechnical report.

D. The Rammed Aggregate Pier design and installation shall adhere to all methods and standards described in this Specification.

1.3 REFERENCES

A. Definitions

1. Aggregate Piers: Aggregate Piers are columns of compacted aggregate used to reinforce the ground to increase bearing capacity and reduce settlement of a structure. The aggregate piers shall be constructed with a down-hole vibrator or down-hole tamper.
2. Down-Hole Vibrators: Down-Hole Vibrators are specially-designed, high-energy depth vibrators. The horizontal vibrations are created by a motor and eccentric weight located near the tip of the vibrator. Extension tubes are bolted to the vibrator to allow it to be lowered to the necessary treatment depth.
3. Bottom Feed Vibrators: Bottom Feed Vibrators are down-hole vibrators which are equipped with a tremie pipe through which the aggregate is fed to the tip of the vibrator.

This equipment is most often used in soil conditions which are too soft or cohesionless to remain open when pre-drilled.

4. Down-Hole Tampers: Down-Hole Tampers are proprietary high-energy impact apparatus. The vertical tamping energy is provided by a hammer which is connected to a round, beveled tamper. The apparatus is lowered into a pre-drilled hole to the required treatment depth.
5. Aggregate Pier Designer: Licensed Professional Engineer in the State of North Carolina acting as the "Delegated Design Engineer" for the aggregate piers on this project.

B. American Society for Testing and Materials (ASTM) Standards

1. ASTM D 1143, Standard Test Method for Deep Foundations Under Static Axial Compressive Load.
2. ASTM D 1194, Standard Test Method for Bearing Capacity of Soil for Static Load and Spread Footings (Modified for Size).
3. ASTM D7383-08 – Axial Compressive Force Pulse (Rapid) testing of Deep Foundations (Statnamic Testing)
4. ASTM D 3689, Individual Piles Under Static Axial Tensile Load.
5. ASTM D 1241, Material for Soil-Aggregate Subbase, Base, and Surface Courses.
6. ASTM C 33, Standard Specification for Concrete Aggregates.
7. ASTM STP 399, Dynamic Cone for Shallow In-Situ Penetration Testing ASTM STP (Special Technical Publication) 399.
8. ASTM D422 - Gradation of Soils
9. ASTM C31 Standard Practice for Making and Curing Cement Test Specimens in the field
10. ASTM C39 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

C. Other Reference Standards

1. "Control of Settlement and Uplift of Structures Using Short Aggregate Piers," by Evert C. Lawton (Assoc. Prof., Dept. of Civil Eng., Univ. of Utah) Nathaniel S. Fox (President, Geopier Foundation Co., Inc.), and Richard L. Handy (Distinguished Prof. Emeritus, Iowa State Univ., Dept. of Civil Eng.), reprinted from IN-SITU DEEP SOIL IMPROVEMENT, Proceedings of sessions sponsored by the Geotechnical Engineering Division/ASCE in conjunction with the ASCE National Convention held October 9-13, 1994, Atlanta, Georgia.
2. "Settlement of Structures Supported on Marginal or Inadequate Soils Stiffened with Short Aggregate Piers," by Evert C. Lawton and Nathaniel S. Fox. Geotechnical Special Publication No. 40: Vertical and Horizontal Deformations of Foundations and Embankments, ASCE, 2, 962-974.
3. "The Design of Vibro Replacement," by Heinz J. Priebe and Keller Grundbau GmbH, reprinted from GROUND ENGINEERING, December 1995.
4. "VibroPier Design Methodology," by Hayward Baker, Inc., 2007.

1.4 MEASUREMENT AND PAYMENT

A. General: All costs in connection with design, mobilization and demobilization costs, one modulus tests, furnishing all materials, equipment, and performing all labor for the construction of the aggregate piers and inspection to achieve the degree of improvement (allowable bearing capacity for maximum allowable settlements) as indicated in paragraph "PERFORMANCE

CRITERIA" to support the column and wall footings illustrated on the contract drawings and as required per the specifications shall be paid for as lump sum. Contractor shall be responsible for the excavation and disposal of all spoil materials from excavations of aggregate piers. All measurements shall be made in the presence of the Owner's Testing Agency.

B. Additional Modulus Tests: Additional Modulus Tests, if requested by the Owner's Testing Agency, will be measured for payment on the basis of tests satisfactorily completed in accordance with paragraph "MODULUS TEST." Payment will be made for satisfactorily completed modulus tests, which shall constitute full payment for installation of test and reaction piers, for furnishing, delivering, handling, and/or installation, as applicable, all labor, materials, equipment, and instrumentation, as well as survey and Geotechnical Engineer services necessary to meet contract requirements applicable to conducting, monitoring and recording data for the modulus test. No payment will be made for modulus tests which were unsatisfactorily performed, as determined by the Owner's Testing Agency.

C. Additional Uplift Tests: Additional Uplift Tests, if requested by the Owner's Testing Agency, will be measured for payment on the basis of tests satisfactorily completed in accordance with paragraph "UPLIFT TEST." Payment will be made for satisfactorily completed uplift tests, which shall constitute full payment for installation of test and reaction piers, for furnishing, delivering, handling, and/or installation, as applicable, all labor, materials, equipment, and instrumentation, as well as survey and Geotechnical Engineer services necessary to meet contract requirements applicable to conducting, monitoring and recording data for the uplift test. No payment will be made for load tests which were unsatisfactory performed, as determined by the Owner's Testing Agency.

1.5 ADMINISTRATIVE REQUIREMENTS

A. Submit aggregate pier design report at least four (4) weeks prior to commencement of rammed aggregate piers.

B. PREINSTALLATION MEETING

1.6 ACTION SUBMITTALS

A. Product Data:

1. Equipment: Provide type and size of compaction equipment and predrill auger equipment and diameter used. Include work procedures and control criteria.
2. Modulus Test: Modulus test detail and setup and location to confirm that the installation procedure produces the pier modulus used in the design.

B. Shop Drawings:

1. Aggregate Pier Design Report: Submit a complete report describing the size and location of Aggregate Piers to the Architect and Structural Engineer of Record for review. The report shall include the following:
   a. Engineering Calculations – The aggregate pier design shall be completed by a Professional Engineer licensed in the State of North Carolina and shall sign and seal all plans. The design shall consider the bearing capacity and total and

differential settlement of all footings supported by aggregate piers, and shall be in accordance with acceptable engineering practice and these specifications. Total and differential settlement shall be considered. Aggregate piers shall be designed in accordance with the reference design standards in paragraph "REFERENCES" and “APPLICABLE DESIGN STANDARDS.” The aggregate pier design shall meet the criteria illustrated in paragraph "PERFORMANCE CRITERIA." Detailed calculations, including anticipated loads, design assumptions and relevant subsurface information, shall be provided. Drawings shall be prepared for construction use and shall include site plans showing Aggregate Pier locations and depths, and footing details showing Aggregate Pier layout beneath footings and uplift anchor connection details when applicable.

b. Minimum Modulus at Maximum design stress shall be as specified in the final design documents provided by the Aggregate Pier Designer.

2. Modulus Test: Submit a plan detailing the modulus test set-up and procedure. Submit jack, pump, and pressure gauge calibration data. The Contractor shall submit a complete report on the modulus test, within 7 days of completion of each test, including but not limited to, reaction and test pier locations, a description of the installation records for both test piers and reaction piers, complete test data, analysis of test data, and other observations made during testing plus any other items required in ASTM D 1143, or ASTM D 3689 as applicable.

1.7 INFORMATIONAL SUBMITTALS

A. A list of at least five previously completed projects of similar scope and purpose. The list shall include a description of the project, relative size, and contact person with phone number.

B. Resumes of the management, supervisory, and key personnel.

C. A ground improvement QA plan, as detailed in section 3.04 of these specifications.

D. Work procedures and control criteria.

E. Certificates:

1. Surveys: A certified copy of the survey. Lines and levels shall be established and column and wall foundations and aggregate pier locations staked and maintained.
2. Site Inspection Report: A certified copy of the Site Inspection Report shall be submitted prior to beginning installation of the aggregate piers.
3. Certification of Qualifications for Aggregate Pier Designer, Aggregate Pier Installer, and Geotechnical Engineer.

F. Site Inspection Report: A certified copy of the Site Inspection Report shall be submitted prior to beginning installation of the aggregate piers.

G. Field Reports:

1. Daily Aggregate Pier Progress Reports: Furnish a complete and accurate record of aggregate pier installation, including the type and size of compaction equipment and predrill auger diameter used, and, for each aggregate pier, the identification number and

depth of the pier tip. Note Any change in the subsurface conditions observed during the work.

2. Final Aggregate Pier Progress Reports: Upon completion of aggregate piers, a final shop drawing including all daily progress reports shall be provided. A report documenting the observations and results of all test. This report will certify that the bearing pressure has been achieved within settlement tolerances.

H. Test Reports:

1. Aggregates: Submit gradation curves, one liquid limit test, one plasticity index test, and physical property tests results. Submit letters of certification and material delivery tickets from the aggregate supplier.
2. Modulus Tests and Uplift Tests: Submit reports no later than 7 days after completion of the modulus and uplift tests.

1.8 SURVEYS

A. Lines and levels must be established and column and wall foundations and aggregate pier locations staked and maintained. A certified copy of the survey shall be submitted. Provide ground elevations in sufficient detail to estimate drilling depth elevations to within 2 inches.

1.9 SEQUENCE OF WORK

A. The sequence of aggregate pier construction shall be coordinated with other construction operations in order to minimize interferences.

1.10 SUPERVISION, INSPECTION, AND RECORDS

A. Contractor Supervision: The contractor shall provide for the continuous supervision of all phases of aggregate pier construction. Each aggregate pier excavation shall be checked by the Contractor for its depth, workmanship, and for all tolerance requirements before aggregate is placed.

B. Geotechnical Inspection: An independent licensed Professional Engineer with expertise in Geotechnical Engineering and the construction of aggregate piers, hereinbefore and hereafter referred to as the Geotechnical Engineer, shall be paid for by the Contractor and shall be provided for the aggregate pier inspection and to oversee the recording and monitoring of all aggregate pier construction including the installation and monitoring of the modulus and uplift tests. The Geotechnical Engineer shall monitor the installation of modulus test aggregate piers to document procedures and criteria used for constructing the modulus test piers. Each aggregate pier excavation shall be checked by the Geotechnical Engineer to ensure that it meets the requirements provided in the design prior to placing aggregate. The Geotechnical Engineer shall have at least 5 years of experience in aggregate pier construction and inspected similar projects in similar scope utilizing the methods being performed for the subject project (Down Hole Vibrator or Down Hole Tamper methods).

C. Records: An accurate record shall be kept by the contractor for each aggregate pier as installed. The record shall indicate the pier location, length, average lift thickness, and final elevations of

the base and top of pier, bearing strata description, water conditions, dates of excavations and aggregate placement, recording of compaction energy information, quantity of aggregate placed into piers, and other pertinent information. Detailed records for each column and wall footing, to include location, number of aggregate piers, and spacing shall also be provided. The record shall also indicate the type of size of the densification equipment used. The Aggregate Pier Installer shall immediately report any unusual conditions encountered during installation. Any corrective measures shall also be recorded. A complete tabulation of all records pertaining to approved aggregate piers shall be submitted. Records shall be signed by the inspector (Geotechnical Engineer) and the Contractor's superintendent.

1.11 QUALIFICATIONS

A. Qualifications:

1. Aggregate Pier Installer: Qualifications of the Aggregate Pier Installer shall show that he/she has been engaged in successful installation of aggregate piers for at least 5 years and completed a minimum of 10 similar projects in similar scope utilizing the methods being performed for the subject project (Down Hole Vibrator or Down Hole Tamper methods). A list of projects, including name and description of the project, relative size, and contact person with phone number shall be provided.
2. Aggregate Pier Designer: Qualifications of the Aggregate Pier Designer shall show that he/she has been engaged in successful design of aggregate piers for at least 5 years and completed a minimum of 10 similar projects in similar scope utilizing the methods being performed for the subject project (Down Hole Vibrator or Down Hole Tamper methods). A list of projects, including name and description of the project, relative size, and contact person with phone number shall be provided.
3. Geotechnical Engineer: Geotechnical Engineer performing the Geotechnical Inspection shall show that he/she has been engaged in successful inspection of aggregate piers for at least 5 years and inspected similar projects in similar scope utilizing the methods being performed for the subject project (Down Hole Vibrator or Down Hole Tamper methods).

PART 2 - PRODUCTS

2.1 EQUIPMENT

A. Down-Hole Vibrator: Should the aggregate pier contractor use a down-hole vibrator, the vibrator shall be capable of providing at least 80 HP of rated energy and a centrifugal force of 15 tons. An appropriate metering device should be provided at such a location that inspection of amperage increase may be verified during the operation of the equipment. The metering device may be an ammeter directly indicating the performance of the vibrator tip. Complete equipment specifications should be submitted prior to commencement of the fieldwork.

B. Down Hole Tamper: Displacement Rammed Aggregate Pier systems shall be constructed by advancing a specially designed mandrel with a minimum 15-ton static force augmented by dynamic vertical ramming energy to the full design depth. The hollow-shaft mandrel, filled with aggregate, is incrementally raised, permitting the aggregate to be released into the shaft, and then lowered by vertically advancing and/or ramming to densify the aggregate and force it laterally into the adjacent soil. The cycle of raising and lowering the mandrel is repeated to the

top of pier elevation. The cycle distance shall be determined by the Rammed Aggregate Pier designer.

2.2 BACKFILL MATERIALS

A. If materials from more than one source are going to be utilized, provide aggregate submittals from each source as noted in "SUBMITTALS". The source of the material shall be selected 90 days prior to the time the material will be required in the work.

B. If a change in material is observed, work shall stop immediately and the problem corrected. If the aggregate source or gradation has changed, a modulus test shall be completed at no additional cost to the Owner.

C. Down-Hole Vibrator Method: The backfill aggregate should consist of hard, angular to sub-angular durable rock fragments, with the majority of particles in the range of 1/8th inch to 1- 1/2 inches such as ASTM C 33 size No. 57, or shall be other graded aggregate selected by the aggregate pier installer, approved by the aggregate pier Designer, and successfully used in the modulus test.

D. Down-Hole Tamper Method: Aggregates used for piers constructed above the water table shall be Type I, Grade B in accordance with ASTM D 1241, or shall be other graded aggregate selected by the aggregate pier installer, approved by the aggregate pier Designer, and successfully used in the modulus test. It shall be compacted to a densification and strength which provides resistance to the dynamic penetration test (ASTM STP 399) of a minimum average of 15 blows per 1.75 inch vertical movement. The number of dynamic penetration tests performed during a workday by the Geotechnical Engineer shall depend on the consistency of achieving this minimum penetration resistance. A minimum of one aggregate pier shall be tested per column footing and one test per every 5 aggregate piers shall be completed per wall footing. Observation of questionable aggregate moisture content or questionable aggregate gradation appearance may determine the need for additional dynamic penetration testing to verify that proper densification is being achieved. Test results shall be included in the Daily Aggregate Pier Progress Reports.

1. For aggregates used for piers constructed below the water table, the gradation shall be the same as Type I Grade B, except that particles passing the number 40 sieve shall be eliminated. Alternately, No. 57 stone or other stone selected by the Aggregate Pier Installer, approved by the aggregate pier Designer, and used successfully in the modulus test may be used. Dynamic penetration resistance is inappropriate for this material.
2. When Type I Grade B material is used, potable water or other suitable source shall be used to increase the aggregate moisture content when required.

PART 3 - EXECUTION

3.1 SPECIAL INSPECTIONS

A. Special Inspections will be performed by the Special Inspector or the Special Inspection Agency.

3.2 SITE INSPECTION

A. If an adjacent building is within 15 feet of the aggregate pier work area, a relevant building examination/site inspection report shall be performed prior to initiating work to document preexisting cracks/damage. The building must also be monitored for movement during any work within 15 ft. of the structure. The work shall be stopped and the aggregate pier Designer and Engineer notified if any building settlement or cracks are observed.

3.3 AGGREGATE PIER CONSTRUCTION

A. Stable Ground Conditions: The following general procedures shall be followed when the pre-drilled hole remains open during construction.

1. Pre-drilling to the design depth will be performed with an auger diameter equal to the finished column diameter.
2. Down-Hole Vibrator Method: The quantity of aggregate initially added shall be such that the vibrator tip is able to penetrate to within 12 inches of the design depth. The vibrator will be raised and lowered repeatedly, such that on each re-penetration, the tip of the vibrator advances to within 12 inches of the previous penetration depth.
3. Down-Hole Tamper Method: Augered Rammed Aggregate Pier or Rigid Inclusion Pier elements –
    a. Augered Rammed Aggregate Pier system shall be pre-augered using mechanical drilling or excavation equipment.
    b. If cave-ins exceeding 10 percent of the lift volume occur during excavation such that the sidewalls of the hole are deemed to be unstable, steel casing shall be used to stabilize the shaft or a displacement Rammed Aggregate Pier system may be used.
    c. Aggregate shall be placed in the augered shaft in lift thicknesses as determined by the Rammed Aggregate Pier Designer.
    d. A specially-designed beveled tamper and high-energy impact densification apparatus shall be employed to densify lifts of aggregate during installation. The apparatus shall apply direct downward impact energy to each lift of aggregate. Compaction equipment that induces horizontal vibratory energy (such as Vibroflot equipment) is not permitted.
    e. For Rigid Inclusion Pier elements using Cement Treated Aggregate (CTA) the same procedures (1 through 4 apply). The CTA materials that are mixed or delivered on site shall mixed dry and shall all be used within 8 hours of mixing. The aggregate shall be removed and replaced with fresh aggregate if cave-ins occur during the aggregate placement such that the volume of caved-in soil is greater than 10 percent of the aggregate being compacted.

B. Unstable Ground Conditions: The following general procedures will be followed when a pre-drilled hole will not remain open before or during pier construction.

1. Down-Hole Vibrator Method: If the hole will remain temporarily stable, the hole may be filled with aggregate to a level above the instability as long as the vibrator is still able to penetrate to within 1 foot of the pre-drilled depth. If the hole will not remain temporarily stable, a Bottom Feed Down-Hole vibrator may be used.
2. Down-Hole Tamper Method:

a. Displacement Rammed Aggregate Pier systems shall be constructed by advancing a specially designed mandrel with a minimum 15-ton static force augmented by dynamic vertical ramming energy to the full design depth. The hollow-shaft mandrel, filled with aggregate, is incrementally raised, permitting the aggregate to be released into the shaft, and then lowered by vertically advancing and/or ramming to densify the aggregate and force it laterally into the adjacent soil. The cycle of raising and lowering the mandrel is repeated to the top of pier elevation. The cycle distance shall be determined by the Rammed Aggregate Pier designer.
b. Special high-energy impact densification apparatus shall be employed to vertically densify the Rammed Aggregate Pier elements during installation of each constructed lift of aggregate.
c. Densification shall be performed using a mandrel/tamper. The mandrel/tamper foot is required to adequately increase the lateral earth pressure in the matrix soil during installation. Compaction equipment that induces horizontal vibratory energy (such as Vibroflot equipment) is not permitted.
d. Downward crowd pressure shall be applied to the mandrel during installation.
e. For Rammed Aggregate pier elements using #57 stone and neat cement or sand cement grout mixtures a minimum of 3 cylinders shall be taken daily in accordance with ASTM C31 to perform compressive strength testing of the stone/cement mixture to show it is in accordance with the project strength requirements.
f. For GeoConcrete Columns (GCC) using structural concrete, 3 cylinders of the concrete shall be taken daily per ASTM C31 to confirm the 28-day concrete strength of the concrete.
g. GCC elements shall be installed using the displacement pier method as described above however the compacted pier shall be restricted to the lower 5 feet of the pier and concrete shall be extruded under pressure to assure a uniform diameter of pier is built above the lower bulb.
h. If the structural design requirements are not controlling the Rigid Inclusion design and as approved by the Rigid Inclusion design engineer, compressive strength testing of Rigid Inclusion Piers may be limited to initial testing of the design mix to confirm that the design strength is met.

C. Obstructions:

1. Obstructions encountered during excavation or drilling that will prevent installation of the aggregate piers to design depth or cause the aggregate pier to stray from its specified location during installation shall be removed. Removal of obstructions shall be performed at no additional cost to the Owner.
2. Obstructions include, but are not limited to, boulders, timbers, concrete, bricks, utility lines, etc., that prevent installing the aggregate piers to the required depth or cause the aggregate pier to drift from the required locations. Dense natural rock or weathered rock shall not be deemed obstructions, and piers may be terminated short of design lengths on such materials if approved by the Owner's Testing Representative and Geotechnical Engineer. The aggregate pier designer shall verify that the short piers are acceptable.

3.4 PERFORMANCE CRITERIA

A. Construct aggregate piers to a sufficient depth with granular backfill material beneath all column foundations and load-bearing wall foundations to meet the following settlement and

allowable soil bearing capacity criteria upon completion. Modulus tests shall be performed to verify the parameter values selected for the pier aggregate.

1. An allowable soil bearing capacity of 8000 PSF with a maximum total settlement of 1.0 inch and a maximum differential settlement of 0.5 inches.
2. Aggregate piers below all mat footings at braced frames shall provide an equivalent composite sliding friction coefficient of 0.50.

3.5 MODULUS TESTS

A. One Aggregate Pier Modulus Test, to verify the aggregate pier design, shall be performed at the location of the worst soil conditions and maximum anticipated column loading for the project. This location shall be proposed by the Aggregate Pier Designer and approved by the Geotechnical Engineer. Aggregate Piers that are tested to provide a safe design, and that meet the tolerances describe in this specification, may be used in the finished work. Aggregate Piers shall be tested to 150 percent of the maximum design stress as shown in the aggregate pier design report submittal. Modulus Test Procedures shall utilize appropriate portions of ASTM D 1143/D 1143M, ASTM D 1194 and ASTM D 3689, as outline below. The modulus schedule shall be as follows:

Increment	**Approximate Load (percent design)**	**Min. Duration (minutes)**	**Max. Duration (minutes)**
Seat	< 9	0	N/A
1	17	15	60
2	33	15	60
3	50	15	60
4	67	15	60
5	83	15	60
6	100	15	60
7	117	*15*	*60*
8	133	15	60
9	150	15	60
10	100	N/A	N/A
11	66	N/A	N/A
12	33	N/A	N/A
13	0	N/A	N/A

B. Each load increment shall be held for the minimum duration shown. For each load increment the deflection of the top plate shall be measured. The top plate shall be located on top of the Aggregate Pier or on top of concrete cast on top of the Aggregate Pier. If the rate of the Aggregate Pier deflection exceeds 0.01 inches per hour, the load shall be held in 15 minute increments until the rate of the Aggregate Pier deflection is less than 0.01 inches per hour (0.0025 inches per 15 minutes), or the maximum duration is reached. Test Aggregate Pier deflections shall be measured using a minimum of two dial gauges graduated to 0.001 inches. Dial gauges shall be anchored to the loading jack base, with gauge plungers set on reference beams anchored at least two diameters from the Aggregate Pier. For compression tests, deflection of uplift reactions shall be monitored using tightened strings of wire and graduated scales. The test jack, pump and pressure gauges shall have been calibrated within no longer than six months from the date of the test. If there are any questions regarding jack, pump and gauge accuracy, a confirmation calibration shall be performed after the modulus test. The results of the modulus test shall be reported on a deflection versus stress graph. The Aggregate Pier modulus shall be calculated as the maximum design stress divided by the deflection of the top plate at the maximum design stress. The deflection of the top plate shall not exceed the upper zone settlement as shown in the design calculations for any pier location.

3.6 BOTTOM STABILIZATION VERIFICATION TESTS

A. Applicable for Down-Hole Tamper Method Only. Bottom stabilization testing (BSTs) or Crowd stabilization testing (CSTs) shall be performed by the Control Technician during the installation of the modulus test pier. Additional testing as required by the Pier Designer shall be performed on selected production Pier elements to compare results with the modulus or load test pier.

3.7 PLAN LOCATION AND ELEVATION TOLERANCES

A. The center of each pier shall be within three inches of the locations indicated on the plans submitted by the Aggregate Pier Designer. The final measurement for the top of aggregate piers shall be the lowest point on the aggregate in the last compacted lift. Piers installed outside of the above tolerances and deemed not acceptable shall be rebuilt at no additional expense to the Owner.

3.8 REJECTION OF AGGREGATE PIERS

A. Aggregate piers improperly located or installed beyond the maximum allowable tolerances shall be abandoned and replaced with new piers, unless the Owner’s Testing Agency approves other remedial measures. All material and labor required to replace rejected aggregate piers shall be provided at no additional cost to the Owner.

3.9 SPOIL MATERIALS

A. Dispose of soil materials, including spoils generated by Aggregate Pier installation.

3.10 EXCAVATION OF PIER TOPS AND UTILITIES

A. Excavations conducted after aggregate pier installation shall be performed such that the horizontal distance between the edge of any aggregate pier and the nearest edge of the excavation is such that the pier is not affected. If installed aggregate piers are located within the zone of influence of excavation, the Contractor and Aggregate Pier designer shall develop solutions to excavation or construction methods that will avoid detrimental impact to the installed aggregate piers. Damage to any aggregate piers shall be repaired or replaced at no additional cost to the Owner.

3.11 BOTTOMS OF FOOTINGS

A. Prior to placement of structural concrete, aggregate pier tops shall be excavated in manner that will prevent the soil matrix surrounding the aggregate piers from softening and ensure that a direct connection between the aggregate pier and concrete footing will be achieved. The following excavation procedures shall be followed:

1. Over excavation below the bottom of footing elevation shall be limited to 3 inches. This includes limiting the teeth from excavators from over excavation beyond 3 inches below the footing elevation.
2. Aggregate pier tops and footing bearing soils shall be compacted with a motorized standard, hand operated impact compactor ("Whacker Packer," "Jumping Jack," or equal). Tampers of the "sled" variety shall not be employed. Compaction shall be performed over the entire footing bottom to compact any loose surface soil and loose surface pier aggregate.
3. Footing concrete shall be placed immediately following approval of the completed footing excavation work. If the bearing soils are expansive or sensitive, it is imperative that the footing concrete be placed on the same day that the excavation takes place.
4. If footing concrete cannot be placed on the same day that excavation takes place, a minimum 3-inch thick mud mat shall be placed immediately following approval of the footing excavation. The top of the mud mat elevation shall be at the bearing elevation of the foundation above it.

B. The following criteria shall apply and shall be verified by the Owner’s Testing Representative in a written report.

1. The footing excavation has been kept free of water since completion of excavation work. This will ensure that the unconfined matrix soil surrounding the aggregate piers has not been softened. Softening of the matrix soil may negatively impact the load bearing capability of the reinforced subgrade.
2. That at each footing location, all aggregate piers installed have been fully exposed within the limits of the footing excavation.
3. That the following specified procedures required immediately prior to construction of the footings have been followed:
    a. Inspection of each aggregate pier top after exposure by the footing excavation.
    b. Recompaction, as required, of aggregate pier tops by mechanical impact compaction equipment.
    c. Recompaction of aggregate pier tops that have or may have been disturbed by footing excavation or other actions, to the satisfaction of the Owner’s Testing Representative.

4. Assurance that no excavation has been made within a distance that will affect any completed pier, without being approved in writing by the aggregate pier Designer.

3.12 FOOTING SUBGRADE INSPECTION

A. The footing bearing surface shall be free of all water and compacted prior to placement of any reinforcement. Compaction can be by any heavy tamping type compaction equipment designed for compaction in small spaces. Reinforcement and concrete placement shall be placed in a timely manner so that no degradation of the bearing surface occurs.

END OF SECTION 316100

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SECTION 321216 - ASPHALT PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Hot-mix asphalt paving.
2. Hot-mix asphalt overlay.
3. Cold milling of existing asphalt pavement.
4. Hot-mix asphalt patching.
5. Asphalt curbs.
6. Asphalt traffic-calming devices.
7. Asphalt surface treatments.

B. Related Requirements:

1. Section 024119 "Selective Demolition" for demolition and removal of existing asphalt pavement.
2. Section 312000 "Earth Moving" for subgrade preparation, fill material, separation geotextiles, unbound-aggregate subbase and base courses, and aggregate pavement shoulders.
3. Section 321313 "Concrete Paving" for concrete pavement and for separate concrete curbs, gutters, and driveway aprons.
4. Section 321373 "Concrete Paving Joint Sealants" for joint sealants and fillers at pavement terminations.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review methods and procedures related to hot-mix asphalt paving including, but not limited to, the following:

a. Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt.
b. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.

1.4 ACTION SUBMITTALS

A. Product Data: Include technical data and tested physical and performance properties.

1. Herbicide.
2. Paving geotextile.

3. Joint sealant.

B. Hot-Mix Asphalt Designs:

1. Certification, by authorities having jurisdiction, of approval of each hot-mix asphalt design proposed for the Work.
2. For each hot-mix asphalt design proposed for the Work.

C. Samples for Verification: For the following product, in manufacturer's standard sizes unless otherwise indicated:

1. Paving Geotextile: 12 by 12 inches minimum.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For paving-mix manufacturer.

B. Material Certificates:

1. Aggregates.
2. Asphalt binder.
3. Asphalt cement.
4. Cutback prime coat.
5. Emulsified asphalt prime coat.
6. Tack coat.
7. Fog seal.
8. Undersealing asphalt.

C. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by NCDOT.

B. Testing Agency Qualifications: Qualified in accordance with ASTM D3666 for testing indicated.

C. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of NCDOT for asphalt paving work.

1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

1.7 FIELD CONDITIONS

A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:

1. Prime Coat: Minimum surface temperature of 60 deg F.
2. Tack Coat: Minimum surface temperature of 60 deg F.
3. Slurry Coat: Comply with weather limitations in ASTM D3910.

4. Asphalt Base Course and Binder Course: Minimum surface temperature of 40 deg F and rising at time of placement.
5. Asphalt Surface Course: Minimum surface temperature of 60 deg F at time of placement.

PART 2 - PRODUCTS

2.1 AGGREGATES

A. General: Use materials and gradations that have performed satisfactorily in previous installations.

B. Coarse Aggregate: ASTM D692/D692M, sound; angular crushed stone, crushed gravel, or cured, crushed blast-furnace slag.

C. Fine Aggregate: AASHTO M 29, sharp-edged natural sand or sand prepared from stone, gravel, cured blast-furnace slag, or combinations thereof.

1. For hot-mix asphalt, limit natural sand to a maximum of 20 percent by weight of the total aggregate mass.

D. Mineral Filler: AASHTO M 17, rock or slag dust, hydraulic cement, or other inert material.

2.2 ASPHALT MATERIALS

A. Asphalt Binder: AASHTO M 320 binder designation .

B. Asphalt Cement: ASTM D3381/D3381M for viscosity-graded material.

C. Cutback Prime Coat: ASTM D2027/D2027M, medium-curing cutback asphalt, MC-30 .

D. Emulsified Asphalt Prime Coat: AASHTO M 140 emulsified asphalt, or AASHTO M 208 cationic emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.

E. Tack Coat: AASHTO M 140 emulsified asphalt, or AASHTO M 208 cationic emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.

F. Fog Seal: AASHTO M 140 emulsified asphalt, or AASHTO M 208 cationic emulsified asphalt, slow setting, factory diluted in water, of suitable grade and consistency for application.

G. Water: Potable.

H. Undersealing Asphalt: ASTM D3141/D3141M; pumping consistency.

2.3 AUXILIARY MATERIALS

A. Recycled Materials for Hot-Mix Asphalt Mixes: Reclaimed asphalt pavement; reclaimed, unbound-aggregate base material; and recycled tires asphalt shingles or glass from sources and gradations that have performed satisfactorily in previous installations, equal to performance of required hot-mix asphalt paving produced from all new materials.

B. Herbicide: Commercial chemical for weed control, registered by the EPA, and not classified as "restricted use" for locations and conditions of application. Provide in granular, liquid, or wettable powder form.

C. Sand: AASHTO M 29, Grade No. 2 or No. 3.

D. Paving Geotextile: AASHTO M 288 paving fabric; nonwoven polypropylene; resistant to chemical attack, rot, and mildew; and specifically designed for paving applications.

E. Joint Sealant: ASTM D6690, Type I, hot-applied, single-component, polymer-modified bituminous sealant.

2.4 MIXES

A. Hot-Mix Asphalt: Dense-graded, hot-laid, hot-mix asphalt plant mixes NCDOT ; designed in accordance with procedures in AI MS-2, "Asphalt Mix Design Methods"; and complying with the following requirements:

1. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
2. Base Course: indicated on Drawings
3. Binder Course: indicated on Drawings
4. Surface Course: indicated on Drawing

B. Emulsified-Asphalt Slurry: ASTM D3910, Type 1.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that subgrade is dry and in suitable condition to begin paving.

B. Proceed with paving only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Protection: Provide protective materials, procedures, and worker training to prevent asphalt materials from spilling, coating, or building up on curbs, driveway aprons, manholes, and other surfaces adjacent to the Work.

B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.
2. Proof-roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.

3.3 COLD MILLING

A. Clean existing pavement surface of loose and deleterious material immediately before cold milling. Remove existing asphalt pavement by cold milling to grades and cross sections indicated.

1. Mill to a depth of 1-1/2 inches.
2. Mill to a uniform finished surface free of excessive gouges, grooves, and ridges.
3. Control rate of milling to prevent tearing of existing asphalt course.
4. Repair or replace curbs, driveway aprons, manholes, and other construction damaged during cold milling.
5. Excavate and trim unbound-aggregate base course, if encountered, and keep material separate from milled hot-mix asphalt.
6. Patch surface depressions deeper than 1 inch after milling, before wearing course is laid.
7. Handle milled asphalt material in accordance with approved waste management plan required in Section 017419 "Construction Waste Management and Disposal."
8. Keep milled pavement surface free of loose material and dust.
9. Do not allow milled materials to accumulate on-site.

3.4 PATCHING

A. Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 12 inches into perimeter of adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade.

B. Portland Cement Concrete Pavement: Break cracked slabs and roll as required to reseat concrete pieces firmly.

1. Undersealing: Pump hot undersealing asphalt under rocking slab until slab is stabilized or, if necessary, crack slab into pieces and roll to reseat pieces firmly.
2. Remove disintegrated or badly cracked pavement. Excavate rectangular or trapezoidal patches, extending into perimeter of adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Recompact existing unbound-aggregate base course to form new subgrade.

C. Tack Coat: Before placing patch material, apply tack coat uniformly to vertical asphalt surfaces abutting the patch. Apply at a rate of 0.05 to 0.15 gal./sq. yd. .

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

D. Placing Single-Course Patch Material: Fill excavated pavement areas with hot-mix asphalt base mix for full thickness of patch and, while still hot, compact flush with adjacent surface.

E. Placing Two-Course Patch Material: Partially fill excavated pavements with hot-mix asphalt base course mix and, while still hot, compact. Cover asphalt base course with compacted layer of hot-mix asphalt surface course, finished flush with adjacent surfaces.

3.5 REPAIRS

A. Leveling Course: Install and compact leveling course consisting of hot-mix asphalt surface course to level sags and fill depressions deeper than 1 inch in existing pavements.

1. Install leveling wedges in compacted lifts not exceeding 3 inches thick.

B. Crack and Joint Filling: Remove existing joint filler material from cracks or joints to a depth of 1/4 inch .

1. Clean cracks and joints in existing hot-mix asphalt pavement.

2. Use emulsified-asphalt slurry to seal cracks and joints less than 1/4 inch wide. Fill flush with surface of existing pavement and remove excess.
3. Use hot-applied joint sealant to seal cracks and joints more than 1/4 inch wide. Fill flush with surface of existing pavement and remove excess.

3.6 SURFACE PREPARATION

A. Ensure that prepared subgrade has been proof-rolled and is ready to receive paving. Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces.

B. Herbicide Treatment: Apply herbicide in accordance with manufacturer's recommended rates and written application instructions. Apply to dry, prepared subgrade or surface of compacted-aggregate base before applying paving materials.

1. Mix herbicide with prime coat if formulated by manufacturer for that purpose.

C. Cutback Prime Coat: Apply uniformly over surface of compacted unbound-aggregate base course at a rate of 0.15 to 0.50 gal./sq. yd. . Apply enough material to penetrate and seal, but not flood, surface. Allow prime coat to cure.

1. If prime coat is not entirely absorbed within 24 hours after application, spread sand over surface to blot excess asphalt. Use enough sand to prevent pickup under traffic. Remove loose sand by sweeping before pavement is placed and after volatiles have evaporated.
2. Protect primed substrate from damage until ready to receive paving.

D. Emulsified Asphalt Prime Coat: Apply uniformly over surface of compacted unbound-aggregate base course at a rate of 0.10 to 0.30 gal./sq. yd. per inch depth . Apply enough material to penetrate and seal, but not flood, surface. Allow prime coat to cure.

1. If prime coat is not entirely absorbed within 24 hours after application, spread sand over surface to blot excess asphalt. Use enough sand to prevent pickup under traffic. Remove loose sand by sweeping before pavement is placed and after volatiles have evaporated.
2. Protect primed substrate from damage until ready to receive paving.

E. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd. .

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.7 INSTALLATION OF PAVING GEOTEXTILE

A. Apply tack coat, asphalt binder, or asphalt cement uniformly to existing pavement surfaces at a rate of 0.20 to 0.30 gal./sq. yd. .

B. Place paving geotextile promptly in accordance with manufacturer's written instructions. Broom or roll geotextile smooth and free of wrinkles and folds. Overlap longitudinal joints 4 inches and transverse joints 6 inches .

C. Protect paving geotextile from traffic and other damage, and place hot-mix asphalt overlay the same day.

3.8 HOT-MIX ASPHALT PLACEMENT

A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand in areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.

1. Place hot-mix asphalt base course and binder course in number of lifts and thicknesses indicated.
2. Place hot-mix asphalt surface course in single lift.
3. Spread mix at a minimum temperature of 250 deg F .
4. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes unless otherwise indicated.
5. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.

B. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.

1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Overlap mix placement about 1 to 1-1/2 inches from strip to strip to ensure proper compaction of mix along longitudinal joints.
2. Complete a section of asphalt base course and binder course before placing asphalt surface course.

C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.9 JOINTS

A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.

1. Clean contact surfaces and apply tack coat to joints.
2. Offset longitudinal joints, in successive courses, a minimum of 6 inches .
3. Offset transverse joints, in successive courses, a minimum of 24 inches .
4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method in accordance with AI MS-22, for both "Ending a Lane" and "Resumption of Paving Operations."
5. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
6. Compact asphalt at joints to a density within 2 percent of specified course density.

3.10 COMPACTION

A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.

1. Complete compaction before mix temperature cools to 185 deg F.

B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.

C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:

1. Average Density, Marshall Test Method: 96 percent of reference laboratory density in accordance with AASHTO T 245, but not less than 94 percent or greater than 100 percent.
2. Average Density, Rice Test Method: 92 percent of reference maximum theoretical density in accordance with ASTM D2041/D2041M, but not less than 90 percent or greater than 96 percent.

D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.

E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.

F. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.

G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.11 ASPHALT CURBS

A. Construct hot-mix asphalt curbs over compacted pavement surfaces. Apply a light tack coat unless pavement surface is still tacky and free from dust. Spread hot-mix asphalt at a minimum temperature of 250 deg F .

1. Hot-Mix Asphalt: Same as pavement surface-course mix.

B. Place hot-mix asphalt to curb cross section indicated or, if not indicated, to local standard shapes, by machine or by hand in wood or metal forms. Tamp hand-placed materials and screed to smooth finish. Remove forms after hot-mix asphalt has cooled.

3.12 INSTALLATION TOLERANCES

A. Pavement Thickness: Compact each course to produce thickness indicated within the following tolerances:

1. Base Course and Binder Course: Plus or minus 1/2 inch .
2. Surface Course: Plus 1/4 inch , no minus.

B. Pavement Surface Smoothness: Compact each course to produce surface smoothness within the following tolerances as determined by using a 10-foot) straightedge applied transversely or longitudinally to paved areas:

1. Base Course and Binder Course: 1/4 inch .
2. Surface Course: 1/8 inch .
3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch .

C.

3.13 SURFACE TREATMENTS

A. Fog Seals: Apply fog seal at a rate of 0.10 to 0.15 gal./sq. yd. to existing asphalt pavement and allow to cure. With fine sand, lightly dust areas receiving excess fog seal.

B. Slurry Seals: Apply slurry coat in a uniform thickness in accordance with ASTM D3910 and allow to cure.

1. Roll slurry seal to remove ridges and provide a uniform, smooth surface.

3.14 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined in accordance with ASTM D3549/D3549M.

C. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.

D. Asphalt Traffic-Calming Devices: Finished height of traffic-calming devices above pavement will be measured for compliance with tolerances.

E. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement in accordance with AASHTO T 168.

1. Reference maximum theoretical density will be determined by averaging results from four samples of hot-mix asphalt-paving mixture delivered daily to site, prepared in accordance with ASTM D2041/D2041M, and compacted in accordance with job-mix specifications.
2. In-place density of compacted pavement will be determined by testing core samples in accordance with ASTM D1188 or ASTM D2726/D2726M.

a. One core sample will be taken for every 1000 sq. yd. or less of installed pavement, with no fewer than three cores taken.
b. Field density of in-place compacted pavement may also be determined by nuclear method in accordance with ASTM D2950/D2950M and coordinated with ASTM D1188 or ASTM D2726/D2726M.

F. Replace and compact hot-mix asphalt where core tests were taken.

G. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

3.15 WASTE HANDLING

A. General: Handle asphalt-paving waste in accordance with approved waste management plan required in Section 017419 "Construction Waste Management and Disposal."

END OF SECTION 321216

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SECTION 321313 - CONCRETE PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes Concrete Paving, including the following:

1. Driveways.
2. Roadways.
3. Parking lots.
4. Curbs and gutters.
5. Walks.

B. Related Requirements:

1. Section 033000 "Cast-in-Place Concrete" for general building applications of concrete.
2. Section 321373 "Concrete Paving Joint Sealants" for joint sealants in expansion and contraction joints within concrete paving and in joints between concrete paving and asphalt paving or adjacent construction.
3. Section 321713 "Parking Bumpers."
4. Section 321723 "Pavement Markings."
5. Section 321726 "Tactile Warning Surfacing" for detectable warning tiles, mats, and pavers.

1.3 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash, slag cement, and other pozzolans.

B. W/C Ratio: The ratio by weight of water to cementitious materials.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review methods and procedures related to concrete paving, including but not limited to, the following:

a. Concrete mixture design.
b. Quality control of concrete materials and concrete paving construction practices.
c. Concrete pouring and finishing plan.

2. Require representatives of each entity directly concerned with concrete paving to attend, including the following:

a. Contractor's superintendent.
b. Independent testing agency responsible for concrete design mixtures.
c. Ready-mix concrete manufacturer.
d. Concrete paving Subcontractor.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1.6 INFORMATIONAL SUBMITTALS

A. Material Certificates: For the following, from manufacturer:

1. Cementitious materials.
2. Steel reinforcement and reinforcement accessories.
3. Admixtures.
4. Curing compounds.
5. Applied finish materials.
6. Bonding agent or epoxy adhesive.
7. Joint fillers.

B. Material Test Reports: For each of the following:

1. Aggregates: Include service-record data indicating absence of deleterious expansion of concrete due to alkali-aggregate reactivity.

C. Field quality-control reports.

1.7 QUALITY ASSURANCE

A. Stamped Detectable Warning Installer Qualifications: An employer of workers trained and approved by manufacturer of stamped concrete paving systems.

B. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C94/C94M requirements for production facilities and equipment.

1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities" (Quality Control Manual - Section 3, "Plant Certification Checklist").

C. Testing Agency Qualifications: Qualified according to ASTM C1077 and ASTM E329 for testing indicated.

1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.

1.8 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified independent testing agency to perform preconstruction testing on concrete paving mixtures.

1.9 FIELD CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

B. Cold-Weather Concrete Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:

1. When air temperature has fallen to or is expected to fall below 40 deg F , uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F and not more than 80 deg F at point of placement.
2. Do not use frozen materials or materials containing ice or snow.
3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in design mixtures.

C. Hot-Weather Concrete Placement: Comply with ACI 301 and as follows when hot-weather conditions exist:

1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
2. Cover steel reinforcement with water-soaked burlap, so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

A. ACI Publications: Comply with ACI 301 unless otherwise indicated.

2.2 FORMS

A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.

1. Use flexible or uniformly curved forms for curves with a radius of 100 feet or less. Do not use notched and bent forms.

B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

2.3 STEEL REINFORCEMENT

A. Plain-Steel Welded-Wire Reinforcement: ASTM A1064/A1064M, fabricated from as-drawn steel wire into flat sheets.

B. Deformed-Steel Welded-Wire Reinforcement: ASTM A1064/A1064M, flat sheet.

C. Epoxy-Coated Welded-Wire Reinforcement: ASTM A884/A884M, Class A, plain steel.

D. Reinforcing Bars: ASTM A615/A615M, Grade 60 ; deformed.

E. Galvanized Reinforcing Bars: ASTM A767/A767M, Class II zinc coated, hot-dip galvanized after fabrication and bending; with ASTM A615/A615M, Grade 60 deformed bars.

F. Epoxy-Coated Reinforcing Bars: ASTM A775/A775M or ASTM A934/A934M; with ASTM A615/A615M, Grade 60 deformed bars.

G. Steel Bar Mats: ASTM A184/A184M; with ASTM A615/A615M, Grade 60 deformed bars; assembled with clips.

H. Plain-Steel Wire: ASTM A1064/A1064M, as drawn.

I. Deformed-Steel Wire: ASTM A1064/A1064M.

J. Epoxy-Coated-Steel Wire: ASTM A884/A884M, Class A; coated, plain.

K. Joint Dowel Bars: ASTM A615/A615M, Grade 60 plain-steel bars galvanized after fabrication according to ASTM A767/A767M, Class I coating. Cut bars true to length with ends square and free of burrs.

L. Epoxy-Coated, Joint Dowel Bars: ASTM A775/A775M; with ASTM A615/A615M, Grade 60 plain-steel bars.

M. Tie Bars: ASTM A615/A615M, Grade 60 ; deformed.

N. Hook Bolts: ASTM A307, Grade A , internally and externally threaded. Design hook-bolt joint assembly to hold coupling against paving form and in position during concreting operations, and to permit removal without damage to concrete or hook bolt.

O. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded-wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete specified, and as follows:

1. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.
2. For epoxy-coated reinforcement, use epoxy-coated or other dielectric-polymer-coated wire bar supports.

P. Epoxy Repair Coating: Liquid, two-part, epoxy repair coating, compatible with epoxy coating on reinforcement.

Q. Zinc Repair Material: ASTM A780/A780M.

2.4 CONCRETE MATERIALS

A. Cementitious Materials: Use the following cementitious materials, of same type, brand, and source throughout Project:

1. Portland Cement: ASTM C150/C150M, gray portland cement Type I.
2. Fly Ash: ASTM C618, Class C.
3. Slag Cement: ASTM C989/C989M, Grade 100 or 120.
4. Blended Hydraulic Cement: ASTM C595/C595M, Type IS, portland blast-furnace slag cement.

B. Normal-Weight Aggregates: ASTM C33/C33M, Class 4S, uniformly graded. Provide aggregates from a single source with documented service-record data of at least 10 years' satisfactory service in similar paving applications and service conditions using similar aggregates and cementitious materials.

1. Maximum Coarse-Aggregate Size: 1-1/2 inches nominal.
2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
3.

C. Air-Entraining Admixture: ASTM C260/C260M.

D. Chemical Admixtures: Admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.

1. Water-Reducing Admixture: ASTM C494/C494M, Type A.
2. Retarding Admixture: ASTM C494/C494M, Type B.
3. Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type D.
4. High-Range, Water-Reducing Admixture: ASTM C494/C494M, Type F.
5. High-Range, Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type G.
6. Plasticizing and Retarding Admixture: ASTM C1017/C1017M, Type II.

E. Water: Potable and complying with ASTM C94/C94M.

2.5 CURING MATERIALS

A. Absorptive Cover: AASHTO M 182, Class 3, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd..

B. Moisture-Retaining Cover: ASTM C171, polyethylene film or white burlap-polyethylene sheet.

C. Water: Potable.

D. Evaporation Retarder: Waterborne, monomolecular, film forming, manufactured for application to fresh concrete.

E. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C309, Type 1, Class B, dissipating.

F. White, Waterborne, Membrane-Forming Curing Compound: ASTM C309, Type 2, Class B, dissipating.

2.6 RELATED MATERIALS

A. Joint Fillers: ASTM D1751, asphalt-saturated cellulosic fiber in preformed strips.

B. Slip-Resistive Aggregate Finish: Factory-graded, packaged, rustproof, nonglazing, abrasive aggregate of fused aluminum-oxide granules or crushed emery aggregate containing not less than 50 percent aluminum oxide and not less than 20 percent ferric oxide; unaffected by freezing, moisture, and cleaning materials.

C. Bonding Agent: ASTM C1059/C1059M, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

D. Epoxy-Bonding Adhesive: ASTM C881/C881M, two-component epoxy resin capable of humid curing and bonding to damp surfaces; of class suitable for application temperature, of grade complying with requirements, and of the following types:

1. Types I and II, nonload bearing, for bonding hardened or freshly mixed concrete to hardened concrete.

E. Chemical Surface Retarder: Water-soluble, liquid, set retarder with color dye, for horizontal concrete surface application, capable of temporarily delaying final hardening of concrete to a depth of 1/8 to 1/4 inch .

2.7 CONCRETE MIXTURES

A. Prepare design mixtures, proportioned according to ACI 301 for each type and strength of normal-weight concrete, and as determined by either laboratory trial mixtures or field experience.

1. Use a qualified independent testing agency for preparing and reporting proposed concrete design mixtures for the trial batch method.
2. When automatic machine placement is used, determine design mixtures and obtain laboratory test results that comply with or exceed requirements.

B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:

1. Fly Ash or Pozzolan: 25 percent.
2. Slag Cement: 50 percent.
3. Combined Fly Ash or Pozzolan, and Slag Cement: 50 percent, with fly ash or pozzolan not exceeding 25 percent.

C. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:

1. Air Content, 1-1/2-inch Nominal Maximum Aggregate Size: 5-1/2 percent plus or minus 1-1/2 percent.

D. Limit water-soluble, chloride-ion content in hardened concrete to 0.15percent by weight of cement.

E. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.

1. Use water-reducing admixture in concrete as required for placement and workability.
2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

2.8 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C94/C94M and ASTM C1116/C1116M. Furnish batch certificates for each batch discharged and used in the Work.

1. When air temperature is between 85 and 90 deg F , reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F , reduce mixing and delivery time to 60 minutes.

B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C94/C94M. Mix concrete materials in appropriate drum-type batch machine mixer.

1. For concrete batches of 1 cu. yd. or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
2. For concrete batches larger than 1 cu. yd. , increase mixing time by 15 seconds for each additional 1 cu. yd..
3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixing time, quantity, and amount of water added.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

B. Proof-roll prepared subbase surface below concrete paving to identify soft pockets and areas of excess yielding.

1. Completely proof-roll subbase in one direction. Limit vehicle speed to 3 mph .
2. Proof-roll with a pneumatic-tired and loaded, 10-wheel, tandem-axle dump truck weighing not less than 15 tons .
3. Correct subbase with soft spots and areas of pumping or rutting exceeding depth of 1/2 inch according to requirements in Section 312000 "Earth Moving."

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Remove loose material from compacted subbase surface immediately before placing concrete.

3.3 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.4 INSTALLATION OF STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.

C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.

D. Install welded-wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.

E. Zinc-Coated Reinforcement: Use galvanized-steel wire ties to fasten zinc-coated reinforcement. Repair cut and damaged zinc coatings with zinc repair material.

F. Epoxy-Coated Reinforcement: Use epoxy-coated steel wire ties to fasten epoxy-coated reinforcement. Repair cut and damaged epoxy coatings with epoxy repair coating according to ASTM D3963/D3963M.

G. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities, or replace units as required before placement. Set mats for a minimum 2-inch overlap of adjacent mats.

3.5 JOINTS

A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.

1. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.

1. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.
2. Provide tie bars at sides of paving strips where indicated.
3. Butt Joints: Use bonding agent at joint locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
4. Keyed Joints: Provide preformed keyway-section forms or bulkhead forms with keys unless otherwise indicated. Embed keys at least 1-1/2 inches into concrete.
5. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.

C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.

1. Locate expansion joints at intervals of 50 feet unless otherwise indicated.
2. Extend joint fillers full width and depth of joint.
3. Terminate joint filler not less than 1/2 inch or more than 1 inch below finished surface if joint sealant is indicated.
4. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.

5. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
6. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.

D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows, to match jointing of existing adjacent concrete paving:

1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a 1/4-inch radius. Repeat grooving of contraction joints after applying surface finishes.

    a. Tolerance: Ensure that grooved joints are within 3 inches either way from centers of dowels.

2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.

    a. Tolerance: Ensure that sawed joints are within 3 inches (75 mm) either way from centers of dowels.

3. Doweled Contraction Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.

E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a 1/4-inch radius. Repeat tooling of edges after applying surface finishes.

3.6 CONCRETE PLACEMENT

A. Before placing concrete, inspect and complete formwork installation steel reinforcement, and items to be embedded or cast-in.

B. Remove snow, ice, or frost from subbase surface and steel reinforcement before placing concrete. Do not place concrete on frozen surfaces.

C. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.

D. Comply with ACI 301 requirements for measuring, mixing, transporting, and placing concrete.

E. Do not add water to concrete during delivery or at Project site. Do not add water to fresh concrete after testing.

F. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

G. Consolidate concrete according to ACI 301 by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.

1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-

faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating dowels joint devices.

H. Screed paving surface with a straightedge and strike off.

I. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleedwater appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

J. Curbs and Gutters: Use design mixture for automatic machine placement. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing.

K. Slip-Form Paving: Use design mixture for automatic machine placement. Produce paving to required thickness, lines, grades, finish, and jointing.

1. Compact subbase and prepare subgrade of sufficient width to prevent displacement of slip-form paving machine during operations.

3.7 FLOAT FINISHING

A. General: Do not add water to concrete surfaces during finishing operations.

B. Float Finish: Begin the second floating operation when bleedwater sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.

1. Burlap Finish: Drag a seamless strip of damp burlap across float-finished concrete, perpendicular to line of traffic, to provide a uniform, gritty texture.
2. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface, perpendicular to line of traffic, to provide a uniform, fine-line texture.
3. Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface 1/16 to 1/8 inch deep with a stiff-bristled broom, perpendicular to line of traffic.

3.8 INSTALLATION OF DETECTABLE WARNINGS

A. Blockouts: Form blockouts in concrete for installation of detectable paving units specified in Section 321726 "Tactile Warning Surfacing."

1. Tolerance for Opening Size: Plus 1/4 inch, no minus.

B. Cast-in-Place Detectable Warning Tiles: Form blockouts in concrete for installation of tiles specified in Section 321726 "Tactile Warning Surfacing." Screed surface of concrete where tiles are to be installed to elevation, so that edges of installed tiles will be flush with surrounding concrete paving. Embed tiles in fresh concrete to comply with Section 321726 "Tactile Warning Surfacing" immediately after screeding concrete surface.

3.9 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306.1 for cold-weather protection.

C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.

D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

E. Curing Methods: Cure concrete by moisture curing moisture-retaining-cover curing curing compound or a combination of these as follows:

1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:

   a. Water.
   b. Continuous water-fog spray.
   c. Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12-inchlap over adjacent absorptive covers.

2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover, placed in widest practicable width, with sides and ends lapped at least 12 inches , and sealed by waterproof tape or adhesive. Immediately repair any holes or tears occurring during installation or curing period, using cover material and waterproof tape.
3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating, and repair damage during curing period.

3.10 PAVING TOLERANCES

A. Comply with tolerances in ACI 117 and as follows:

1. Elevation: 3/4 inch .
2. Thickness: Plus 3/8 inch , minus 1/4 inch .
3. Surface: Gap below 10-feet-) long; unleveled straightedge not to exceed 1/2 inch .
4. Alignment of Tie-Bar End Relative to Line Perpendicular to Paving Edge: 1/2 inch per 12 inches of tie bar.
5. Lateral Alignment and Spacing of Dowels: 1 inch.
6. Vertical Alignment of Dowels: 1/4 inch (6 mm).
7. Alignment of Dowel-Bar End Relative to Line Perpendicular to Paving Edge: 1/4 inch per 12 inches of dowel.
8. Joint Spacing: 3 inches .
9. Contraction Joint Depth: Plus 1/4 inch , no minus.
10. Joint Width: Plus 1/8 inch (, no minus.

3.11 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Services: Testing and inspecting of composite samples of fresh concrete obtained according to ASTM C172/C172M shall be performed according to the following requirements:

1. Testing Frequency: Obtain at least one composite sample for each 100 cu. yd. or fraction thereof of each concrete mixture placed each day.

a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.

2. Slump: ASTM C143/C143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
3. Air Content: ASTM C231/C231M, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
4. Concrete Temperature: ASTM C1064/C1064M; one test hourly when air temperature is 40 deg F and below and when it is 80 deg F and above, and one test for each composite sample.
5. Compression Test Specimens: ASTM C31/C31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
6. Compressive-Strength Tests: ASTM C39/C39M; test one specimen at seven days and two specimens at 28 days.

a. A compressive-strength test shall be the average compressive strength from two specimens obtained from same composite sample and tested at 28 days.

C. Strength of each concrete mixture will be satisfactory if average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.

D. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

E. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.

F. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.

G. Concrete paving will be considered defective if it does not pass tests and inspections.

H. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

I. Prepare test and inspection reports.

3.12 REPAIR AND PROTECTION

A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.

B. Drill test cores, where directed by Architect, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory paving areas with portland cement concrete bonded to paving with epoxy adhesive.

C. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

D. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION 321313

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SECTION 321373 - CONCRETE PAVING JOINT SEALANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cold-applied joint sealants.
2. Hot-applied joint sealants.
3. Cold-applied, fuel-resistant joint sealants.
4. Hot-applied, fuel-resistant joint sealants.
5. Joint-sealant backer materials.
6. Primers.

B. Related Requirements:

1. Section 079200 "Joint Sealants" for sealing nontraffic and traffic joints in locations not specified in this Section.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Concrete pavement joint sealants.
2. Joint-sealant backer materials.

B. Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors for each type of joint sealant.

C. Paving-Joint-Sealant Schedule: Include the following information:

1. Joint-sealant application, joint location, and designation.
2. Joint-sealant manufacturer and product name.
3. Joint-sealant formulation.
4. Joint-sealant color.

1.3 PRECONSTRUCTION TESTING

A. Preconstruction Testing: Performed by a qualified testing agency.

1.4 FIELD CONDITIONS

A. Do not proceed with installation of joint sealants under the following conditions:

1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 deg F .
2. When joint substrates are wet.

3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain joint sealants from single manufacturer.

2.2 JOINT SEALANTS, GENERAL

A. Compatibility: Provide joint sealants, backer materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.

2.3 COLD-APPLIED JOINT SEALANTS

A. Single-Component, Self-Leveling, Silicone Joint Sealant: ASTM D5893/D5893M, Type SL.

2.4 HOT-APPLIED JOINT SEALANTS

A. Hot-Applied, Single-Component Joint Sealant, Type I: ASTM D6690.

2.5 JOINT-SEALANT BACKER MATERIALS

A. Joint-Sealant Backer Materials: Nonstaining; compatible with joint substrates, sealants, primers, and other joint fillers; and approved for applications indicated by joint-sealant manufacturer, based on field experience and laboratory testing.

B. Round Backer Rods for Cold- and Hot-Applied Joint Sealants: ASTM D5249, Type 1, of diameter and density required to control sealant depth and prevent bottom-side adhesion of sealant.

2.6 PRIMERS

A. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine joints to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Cleaning of Joints: Before installing joint sealants, clean out joints immediately to comply with joint-sealant manufacturer's written instructions.

1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.

B. Joint Priming: Prime joint substrates where indicated or where recommended in writing by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

3.3 INSTALLATION OF JOINT SEALANTS

A. Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated unless more stringent requirements apply.

B. Joint-Sealant Installation Standard: Comply with recommendations in ASTM C1193 for use of joint sealants as applicable to materials, applications, and conditions.

C. Install joint-sealant backers to support joint sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.

1. Do not leave gaps between ends of joint-sealant backer materials.
2. Do not stretch, twist, puncture, or tear joint-sealant backer materials.
3. Remove absorbent joint-sealant backer materials that have become wet before sealant application and replace them with dry materials.

D. Install joint sealants immediately following backer material installation, using proven techniques that comply with the following:

1. Place joint sealants so they fully contact joint substrates.
2. Completely fill recesses in each joint configuration.
3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

E. Provide joint configuration to comply with joint-sealant manufacturer's written instructions unless otherwise indicated.

3.4 CLEANING AND PROTECTION

A. Clean off excess joint sealant as the Work progresses, by methods and with cleaning materials approved in writing by joint-sealant manufacturers.

B. Protect joint sealants, during and after curing period, from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs,

cut out and remove damaged or deteriorated joint sealants immediately and replace with joint sealant so installations in repaired areas are indistinguishable from the original work.

3.5 PAVING-JOINT-SEALANT SCHEDULE

A. Joints within concrete paving :

1. Joint Location:

   a. Expansion and isolation joints in concrete paving.
   b. Contraction joints in concrete paving.
   c. Other joints as indicated.

2. Joint Sealant: Single-component, self-leveling, silicone joint sealant, Hot-applied, single-component joint sealant.
3. Joint-Sealant Color: Manufacturer's standard

B. Joints within concrete paving and between concrete and asphalt paving:

1. Joint Location:

   a. Joints between concrete and asphalt paving.
   b. Joints between concrete curbs and asphalt paving.
   c. Other joints as indicated.

2. Joint Sealant: Hot-applied, single-component joint sealant.
3. Joint-Sealant Color: Manufacturer's standard.

END OF SECTION 321373

SECTION 321713 - PARKING BUMPERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Precast concrete wheel stops.
2. Resilient wheel stops.
3. Resilient-shell, concrete-filled wheel stops.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Precast concrete wheel stops.

PART 2 - PRODUCTS

2.1 PARKING BUMPERS

A. Precast Concrete Wheel Stops: Precast, steel-reinforced, air-entrained concrete; 4000-psi minimum compressive strength; manufacturer's standard height and width by 72 inches long. Provide chamfered corners, transverse drainage slots on underside, and a minimum of two factory-formed or -drilled vertical holes through wheel stop for anchoring to substrate.

1. Source Limitations: Obtain wheel stops from single source from single manufacturer.
2. Surface Appearance: Smooth, free of pockets, sand streaks, honeycombs, and other obvious defects. Corners shall be uniform, straight, and sharp.
3. Mounting Hardware: Galvanized-steel spike or dowel, 1/2-inch diameter, 14-inch minimum length.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that pavement is in suitable condition to begin installation in accordance with manufacturer's written instructions.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wheel stops in accordance with manufacturer's written instructions unless otherwise indicated.

B. Securely anchor wheel stops to substrate with hardware in each preformed vertical hole in wheel stop as recommended in writing by manufacturer. Recess head of hardware beneath top of wheel stop.

END OF SECTION 321713

SECTION 321723 - PAVEMENT MARKINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Painted markings applied to asphalt paving.
2. Painted markings applied to concrete surfaces.

1.3 PREINSTALLATION MEETINGS

1.4 ACTION SUBMITTALS

A. Product Data: Include technical data and tested physical and performance properties.

1. Pavement-marking paint, alkyd.
2. Pavement-marking paint, thermoplastic.

B. Shop Drawings:

1. Indicate pavement markings, colors, lane separations, defined parking spaces, and dimensions to adjacent work.
2. Indicate, with international symbol of accessibility, spaces allocated for people with disabilities.

1.5 QUALITY ASSURANCE

1.6 FIELD CONDITIONS

A. Environmental Limitations: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 40 deg F for alkyd materials, and not exceeding 95 deg F.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. PPG Paints, McCormick Paints, Sherwin Williams Company, Transpo Industries, or approved equal.

B. Source Limitations: Obtain pavement-marking paints from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Accessibility Standard: Comply with applicable provisions in the USDOJ's "2010 ADA Standards for Accessible Design.

2.3 PAVEMENT-MARKING PAINT

A. All stop bars, directional arrows and crosswalk pavement marking to be thermoplastic paint complying with AASTO M249.
   1. Color: White

B. All parking striping Pavement-Marking Paint, Alkyd: Alkyd-resin type, lead and chromate free, ready mixed, complying with AASHTO M 248, Type N; colors complying with FS TT-P-1952F.

   1. Color: as indicated on Drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that pavement-marking substrate is dry and in suitable condition to begin pavement marking in accordance with manufacturer's written instructions.

B. Proceed with pavement marking only after unsatisfactory conditions have been corrected.

3.2 PAVEMENT MARKING

A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Architect.

B. Allow asphalt paving or concrete surfaces to age for a minimum of 30 days before starting pavement marking.

C. Sweep and clean surface to eliminate loose material and dust.

D. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 .

   1. Laser-cut stencils, firmly secured to asphalt paving or concrete surface. Mask an extended area beyond edges of each stencil to prevent paint application beyond stencil. Apply paint so that it cannot run beneath stencil.

3.3 PROTECTING AND CLEANING

A. Protect pavement markings from damage and wear during remainder of construction period.

B. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION 321723

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SECTION 321726 - TACTILE WARNING SURFACING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cast-in-place detectable warning tiles.
2. Cast-in-place detectable warning tiles.
3. Detectable warning mats applied to existing concrete paving.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples for each type of exposed finish requiring color selection.

PART 2 - PRODUCTS

2.1 TACTILE WARNING SURFACING, GENERAL

A. Accessibility Requirements: Comply with applicable provisions in the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines for Buildings and Facilities and ICC A117.1 for tactile warning surfaces.

1. For tactile warning surfaces composed of multiple units, provide units that when installed provide consistent side-to-side and end-to-end dome spacing that complies with requirements.

2.2 DETECTABLE WARNING TILES

A. Cast-in-Place Detectable Warning Tiles: Accessible truncated-dome detectable warning tiles with replaceable surface configured for setting flush in new concrete walkway surfaces, with slip-resistant surface treatment on domes and field of tile.
1. Material: Cast-fiber-reinforced polymer concrete tile.
2. Color: As selected by Architect from manufacturer's full line.
3. Shapes and Sizes:

a. Rectangular panel, 12 by 12 inches
b. Radius panel, nominal 24 inches deep by 6-foot outside radius.

4. Dome Spacing and Configuration Manufacturer's standard compliant spacing, in manufacturer's standard pattern.
5. Mounting:

a. Permanently embedded detectable warning tile wet-set into freshly poured concrete.
b. Detectable warning tile set into formed recess in concrete and adhered with mortar.

c. Replaceable detectable warning tile wet-set into freshly poured concrete and surface-fastened to permanently embedded anchors.

B. Surface-Applied Detectable Warning Tiles: Accessible truncated-dome detectable warning concrete tiles configured for surface application on existing concrete walkway surfaces, with slip-resistant surface treatment on domes, field of tile, and beveled outside edges.
1. Material: Cast-fiber-reinforced polymer concrete tile.
2. Color: As selected by Architect from manufacturer's full line.
3. Shapes and Sizes:

a. Rectangular panel, 12 by 12 inches
b. Radius panel, nominal 24 inches deep by 6-foot outside radius.

4. Dome Spacing and Configuration: Manufacturer's standard compliant spacing manufacturer's standard pattern.
5. Mounting: Adhered and fastened to existing concrete walkway.

2.3 ACCESSORIES

A. Fasteners and Anchors: Manufacturer's standard as required for secure anchorage of tactile warning surfaces, noncorrosive and compatible with each material joined, and complying with the following:

1. Furnish Type 304 stainless-steel fasteners for exterior use.
2. Fastener Heads: For nonstructural connections, use flathead or oval countersunk screws and bolts with tamper-resistant heads, colored to match tile.

B. Adhesive: As recommended by manufacturer for adhering tactile warning surfacing unit to pavement.

C. Sealant: As recommended by manufacturer for sealing perimeter of tactile warning surfacing unit.

PART 3 - EXECUTION

3.1 INSTALLATION OF TACTILE WARNING SURFACING

A. General: Prepare substrate and install tactile warning surfacing according to manufacturer's written instructions unless otherwise indicated.

B. Place tactile warning surfacing units in dimensions and orientation indicated. Comply with location requirements of AASHTO MP 12.

C. Cast-in-Place Detectable Warning Tiles: Set each detectable warning tile accurately and firmly in place and completely seat tile back and embedments in wet concrete by tamping or vibrating. Set surface of tile flush with surrounding concrete and adjacent tiles. Remove concrete from tile surfaces and clean using methods recommended in writing by manufacturer.

D. Removable Cast-in-Place Detectable Warning Tiles: Set each detectable warning tile accurately and firmly in place with embedding anchors and fasteners attached, and firmly seat tile back in wet concrete by tamping or vibrating. Set surface of tile flush with surrounding concrete and adjacent tiles. Remove concrete from tile surfaces and clean tiles using methods recommended in writing by manufacturer.

E. Surface-Applied Detectable Warning Tiles: Prepare existing paving surface by grinding and cleaning as recommended by manufacturer. Apply adhesive to back of tiles in amounts and pattern recommended by

manufacturer, and set tiles in place. Install anchor devices through face of tiles and into pavement using anchors located as recommended by manufacturer. Apply sealant in continuous bead around perimeter of installation.

F. Surface-Applied Detectable Warning Mats: Prepare existing paving surface by grinding and cleaning as recommended by manufacturer. Apply adhesive to back of mat and set mat in place. Firmly seat mat in adhesive bed. Install anchor devices through face of mat and into pavement using anchors located as recommended by manufacturer. Set heads of anchors flush with mat surface. Apply sealant in continuous bead around perimeter of mat.

G. Remove and replace tactile warning surfacing that is broken or damaged or does not comply with requirements in this Section. Remove in complete sections from joint to joint unless otherwise approved by Architect. Replace using tactile warning surfacing installation methods acceptable to Architect.

H. Protect tactile warning surfacing from damage and maintain free of stains, discoloration, dirt, and other foreign material.

END OF SECTION 321726

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SECTION 321813 - SYNTHETIC GRASS SURFACING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Synthetic grass surfacing for landscaping.

B. Related Requirements:

1. Section 312000 "Earth Moving" for preparation, compaction, and grading of granular base.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Synthetic grass surfacing.

B. Shop Drawings: For synthetic grass surfacing.

1. Include sections and details.
2. Show locations of seams and method of seaming.

C. Samples: For each type of synthetic grass surfacing indicated.

1. Turf Fabric: 12 inches square.
2. Infill Material: 4 oz. of each type.
3. Impact-Attenuation Pad: 12 inches square.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Product Test Reports: For each synthetic grass surfacing assembly.

C. Field quality-control reports.

D. Sample Warranties: For special warranties.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For synthetic grass surfacing, including maintenance cleaning instructions, to include in maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Turf Fabric: Minimum of 300 sq. ft. for each type indicated.
2. Infill: Minimum of two bags of each type.
3. Seaming Tape and Adhesive: One roll of seaming tape and one gallon of adhesive.
4. One new set of maintenance tools, of type recommended by synthetic grass surfacing manufacturer for installation.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store materials in location and manner to allow installation of synthetic grass surfacing without excess disturbance of granular base.

1.9 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace synthetic grass surfacing that fails in materials within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Deterioration and excessive wear.
b. Deterioration from UV light.

2. Warranty Period: 12 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Provide components and materials specified in this Section from single manufacturer for a complete and compatible assembly.

2.2 PERFORMANCE REQUIREMENTS

A. Turf Fabric: Turf fabric tested in accordance with the following methods, with additional test method conditions for each method in accordance with ASTM F1551, ASTM D7968, EN71-3, and EPA-537-A.

1. Tuft Bind: Not less than 8 lbf in accordance with ASTM D1335.
2. Breaking Strength: Minimum 200 lbf in warp direction and minimum 200 lbf perpendicular to warp direction, in accordance with ASTM D5034.

B. Synthetic Turf Playing Surfaces: Assembly tested in accordance with the following methods, with additional test method conditions for each method in accordance with ASTM F1551, and ADA Compliance ASTM F1951.

1. Impact Attenuation: in accordance with ASTM F1292.
2. Abrasiveness Index: in accordance with ASTM F1015.

C. Permeability: shall meet or exceed 10 inches/h of rainfall capacity in accordance with ASTM F1551.

D. Exterior Fire Test Exposure: Class A for application indicated in accordance with ASTM D2859. Identify products with appropriate markings to applicable testing agency.

2.3 SYNTHETIC GRASS SURFACING

A. Synthetic Grass Surfacing for Landscaping: Complete surfacing system, consisting of synthetic yarns bound to water-permeable backing and infill indicated, suitable for playgrounds.

1. Basis-of-Design Product: Subject to compliance with requirements, provide SYNLawn; Play Platinum or comparable product by one of the following:

    a. AstroTurf; a SportGroup company.
    b. Advanced Polymer Technology.
    c. ForeverLawn
    d. Sprinturf; Specialty Surfaces International.

2. Yarn Fiber: Monofilament polyethylene
3. Lead Content of Yarn Fiber: Maximum of 100 ppm in accordance with ASTM F2765.
4. Pile Weight: 100 oz./sq. yd. in accordance with ASTM D5848.
5. Pile Height: 1-1/2 inches in accordance with ASTM D5823.

B. Backing: Manufacturer's standard polypropylene polyester primary backing with urethane-coated secondary backing; provide perforations or drainage channels sufficient to meet permeability indicated.

C. Infill: Manufacturer's standard infill.

1. Infill Proportions: Manufacturer's standard proportions.

D. Seaming Method: Adhesive.

2.4 MATERIALS

A. Sand Infill: Uniformly sized latex-coated silica sand free of silts, clays, and contaminants, and of subangular or rounder shape in accordance with ASTM F1632; mesh size as recommended by synthetic grass surfacing manufacturer.

B. Organic Fiber Infill: Coconut or cork fiber granules free of contaminants, and as recommended by synthetic grass surfacing manufacturer.

C. Seam Adhesive: One- or two-part urethane, recommended or approved by synthetic grass surfacing manufacturer, and suitable for ambient conditions at time of installation.

D. Seam Tape: Synthetic grass manufacturer's recommended seam tape, minimum 12 inches wide.

E. Impact-Attenuation Pad: Manufacturer's standard impact-attenuation pad with permeability sufficient to meet synthetic grass surfacing assembly permeability indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine base and other conditions, with Installer present, for compliance with requirements for installation tolerances, permeability, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF SYNTHETIC GRASS SURFACING

A. Avoid disturbance of base during installation of impact-attenuation pad and turf fabric.

B. Impact-Attenuation Pad Installation: Roll out pad and allow to relax a minimum of six hours prior to final fit and trim. Stagger head seams between adjacent rows. Fit seams snugly without stretching or forcing.

C. Roll out turf fabric and allow to relax at least four hours prior to seaming.

D. Provide seams flat and snug, with no gaps or fraying. Remove yarns that are trapped within seams. Attach turf fabric to perimeter restraint system as recommended by the manufacturer.

E. Repair loose seams and bubbles formed due to expansion of turf fabric prior to installation of infill.

F. Evenly broadcast and groom infill by machine in proportions and depth after settling as recommended by the manufacturer, and to meet indicated performance requirements. Rake fibers trapped by infill to surface.

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections:

1. Permeability: Shall meet or exceed 10 inches/h of rainfall capacity in accordance with ASTM F1551.
2. Impact Attenuation: in accordance with ASTM F1292.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel in proper maintenance procedures for synthetic grass surfacing.

END OF SECTION 321813

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SECTION 323113 - CHAIN LINK FENCES AND GATES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Chain-link fences and gates.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:

a. Fence and gate posts, rails, and fittings.
b. Chain-link fabric, reinforcements, and attachments.
c. Gates and hardware.

B. Shop Drawings: For each type of fence and gate assembly.

1. Include plans, elevations, sections, details, and attachments to other work.
2. Include accessories, hardware, gate operation, and operational clearances.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Product Certificates: For each type of chain-link fence and gate.

C. Product Test Reports: For framework strength according to ASTM F1043, for tests performed by manufacturer and witnessed by a qualified testing agency or a qualified testing agency.

D. Field quality-control reports.

E. Sample Warranty: For special warranty.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: For testing fence grounding; member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

B. Emergency Access Requirements: According to requirements of authorities having jurisdiction for gates with automatic gate operators serving as a required means of access.

C. Mockups: Build mockups to set quality standards for fabrication and installation.

1. Build mockup for typical chain-link fence and gate, including accessories.

a. Size: 10-foot length of fence.

1.7 FIELD CONDITIONS

A. Field Measurements: Verify layout information for chain-link fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

B. Report any discrepancies to the Landscape Architect and Owner Representative.

1.8 WARRANTY

A. Special Warranty: Installer agrees to repair or replace components of chain-link fences and gates that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Failure to comply with performance requirements.
b. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
c. Faulty operation of gate operators and controls.

2. Warranty Period: 15 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Structural Performance: Chain-link fence and gate frameworks shall withstand the design wind loads and stresses for fence height(s) and under exposure conditions indicated according to ASCE/SEI 7.

1. Design Wind Load: 105 mph

a. Minimum Post Size: Determine according to ASTM F1043 for post spacing not to exceed 10 feet for Material Group IA, ASTM F1043, Schedule 40 steel pipe.
b. Minimum Post Size and Maximum Spacing: Determine according to CLFMI WLG 2445, based on mesh size and pattern specified.

B. Lightning Protection System: Maximum resistance-to-ground value of 25 ohms at each grounding location along fence under normal dry conditions.

2.3 CHAIN-LINK FENCE FABRIC

A. General: Provide fabric in one-piece heights measured between top and bottom of outer edge of selvage knuckle or twist according to "CLFMI Product Manual" and requirements indicated below:

1. Fabric Height: As indicated on Drawings.
2. Steel Wire for Fabric: Wire diameter of 0.148 inch

    a. Mesh Size: 2 inches
    b. Polymer-Coated Fabric: ASTM F668, Class 2b over aluminum coated steel wire.

        1) Color: Black, according to ASTM F934.

3. Selvage: Knuckled at both selvages

2.4 FENCE FRAMEWORK

A. Posts and Rails: ASTM F1043 for framework, including rails, braces, and line; terminal; and corner posts. Provide members with minimum dimensions and wall thickness according to ASTM F1043 or ASTM F1083 based on the following:

1. Fence Height: As indicated on Drawings.

2. Heavy-Industrial-Strength Material: Group IA, round steel pipe, Schedule 40

    a. Line Post: 2.375 inches
    b. End, Corner, and Pull Posts: 2.875 inches

3. Horizontal Framework Members: Intermediate, top, and bottom rails according to ASTM F1043.

    a. Top Rail: 1.66 inches

4. Brace Rails: ASTM F1043.
5. Metallic Coating for Steel Framework:
    a. Type B: Zinc with organic overcoat, consisting of a minimum of 0.9 oz./sq. ft. of zinc after welding, a chromate conversion coating, and a clear, verifiable polymer film.

6. Polymer coating over metallic coating.

    a. Color: Black according to ASTM F934.

2.5 SWING GATES

A. General: ASTM F900 for gate posts and single and double swing gate types.

1. Gate Leaf Width: As indicated.
2. Framework Member Sizes and Strength: Based on gate fabric height as indicated.

B. Pipe and Tubing:

1. Zinc-Coated Steel: ASTM F1043 and ASTM F1083; protective coating and finish to match fence framework
2. Gate Posts: Round tubular steel
3. Gate Frames and Bracing: Round tubular steel

C. Frame Corner Construction: Welded or assembled with corner fittings.

D. Hardware:

1. Hinges: 180-degree inward swing.
2. Latch: Permitting operation from both sides of gate with provision for padlocking accessible from both sides of gate.
3. Lock: Manufacturer's standard internal device.
4. Closer: Manufacturer's standard

2.6 FITTINGS

A. Provide fittings according to ASTM F626.

B. Post Caps: Provide for each post.

1. Provide line post caps with loop to receive tension wire or top rail.

C. Rail and Brace Ends: For each gate, corner, pull, and end post.

D. Rail Fittings: Provide the following:

1. Top Rail Sleeves: Pressed-steel or round-steel tubing not less than 6 inches long.
2. Rail Clamps: Line and corner boulevard clamps for connecting intermediate and bottom rails to posts.

E. Tension and Brace Bands: Pressed steel

F. Tension Bars: Steel, length not less than 2 inches shorter than full height of chain-link fabric. Provide one bar for each gate and end post, and two for each corner and pull post, unless fabric is integrally woven into post.

G. Truss Rod Assemblies: Steel, hot-dip galvanized after threading rod and turnbuckle or other means of adjustment.

H. Tie Wires, Clips, and Fasteners: According to ASTM F626.

1. Standard Round Wire Ties: For attaching chain-link fabric to posts, rails, and frames, according to the following:
   a. Aluminum: ASTM B211 Alloy 1350-H19; [0.148-inch diameter, mill-finished wire.

I. Finish:

1. Metallic Coating for Pressed Steel or Cast Iron: Not less than 1.2 oz./sq. ft. of zinc.

   a. Polymer coating over metallic coating.

2. Aluminum: Mill finish.

2.7 GROUT AND ANCHORING CEMENT

A. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M. Provide grout, recommended in writing by manufacturer, for exterior applications.

B. Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with water at Project site to create pourable anchoring, patching, and grouting compound. Provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating, and that is recommended in writing by manufacturer for exterior applications.

2.8 GROUNDING MATERIALS

A. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connectors and Grounding Rods: Listed and labeled for complying with UL 467.

1. Connectors for Below-Grade Use: Exothermic welded type.
2. Grounding Rods: Copper-clad steel, 5/8 by 96 inches

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for a certified survey of property lines and legal boundaries, site clearing, earthwork, pavement work, and other conditions affecting performance of the Work.

1. Do not begin installation before final grading is completed unless otherwise permitted by Architect.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

3.3 CHAIN-LINK FENCE INSTALLATION

A. Install chain-link fencing according to ASTM F567 and more stringent requirements specified.

B. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.

C. Post Setting: Set posts in concrete at indicated spacing into firm, undisturbed soil.

1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
2. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.
    a. Concealed Concrete: Place top of concrete 2 inches below grade as indicated on Drawings to allow covering with surface material.

D. Terminal Posts: Install terminal end, corner, and gate posts according to ASTM F567 and terminal pull posts at changes in horizontal or vertical alignment of as indicated on Drawings. For runs exceeding 500 feet, space pull posts an equal distance between corner or end posts.

E. Line Posts: Space line posts uniformly at 10 feet o.c.

F. Post Bracing and Intermediate Rails: Install according to ASTM F567, maintaining plumb position and alignment of fence posts. Diagonally brace terminal posts to adjacent line posts with truss rods and turnbuckles. Install braces at end and gate posts and at both sides of corner and pull posts.

1. Locate horizontal braces at midheight of fabric 72 inches or higher, on fences with top rail, and at two-third fabric height on fences without top rail. Install so posts are plumb when diagonal rod is under proper tension.

G. Top Rail: Install according to ASTM F567, maintaining plumb position and alignment of fence posts. Run rail continuously through line post caps, bending to radius for curved runs and terminating into rail end attached to posts or post caps fabricated to receive rail at terminal posts. Provide expansion couplings as recommended in writing by fencing manufacturer.

H. Intermediate and Bottom Rails: Secure to posts with fittings.

I. Chain-Link Fabric: Apply fabric to inside of enclosing framework. Leave 2-inch bottom clearance between finish grade or surface and bottom selvage unless otherwise indicated. Pull fabric taut and tie to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.

J. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts, with tension bands spaced not more than 15 inches o.c.

K. Tie Wires: Use wire of proper length to firmly secure fabric to line posts and rails. Attach wire at one end to chain-link fabric, wrap wire around post a minimum of 180 degrees, and attach other end to chain-link fabric according to ASTM F626. Bend ends of wire to minimize hazard to individuals and clothing.

1. Maximum Spacing: Tie fabric to line posts at 12 inches (300 mm) o.c. and to braces at 24 inches (610 mm) o.c.

L. Fasteners: Install nuts for tension bands and carriage bolts on the side of fence opposite the fabric side.

3.4 GATE INSTALLATION

A. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach fabric as for fencing. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation.

3.5 GROUNDING AND BONDING

A. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Fence and Gate Grounding:

1. Ground for fence and fence posts shall be a separate system from ground for gate and gate posts.
2. Install ground rods and connections at maximum intervals of 1500 feet.
3. Fences within 100 Feet of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of 750 feet.
4. Ground fence on each side of gates and other fence openings.

    a. Bond metal gates to gate posts.

C. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a ground rod located a maximum distance of 150 feet on each side of crossing.

D. Fences Enclosing Electrical Power Distribution Equipment: Ground according to IEEE C2 unless otherwise indicated.

E. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.

1. Make grounding connections to each barbed wire strand with wire-to-wire connectors designed for this purpose.
2. Make grounding connections to each barbed tape coil with connectors designed for this purpose.

F. Connections:

1. Make connections with clean, bare metal at points of contact.
2. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
3. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
4. Make above-grade ground connections with mechanical fasteners.
5. Make below-grade ground connections with exothermic welds.
6. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

G. Bonding to Lightning Protection System: Ground fence and bond fence grounding conductor to lightning protection down conductor or lightning protection grounding conductor according to NFPA 780.

H. Comply with requirements in Section 264113 "Lightning Protection for Structures."

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests.

B. Grounding Tests: Comply with requirements in Section 264113 "Lightning Protection for Structures."

C. Prepare test reports.

3.7 ADJUSTING

A. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

B. Lubricate hardware and other moving parts.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain chain-link fences and gates.

END OF SECTION 323113

SECTION 323119 - DECORATIVE METAL FENCES AND GATES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Decorative aluminum fences.
   2. Swing gates.

B. Related Sections:

   1. Section 033000 "Cast-in-Place Concrete" for concrete bases for posts.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For fencing and gates.

   1. Include plans, elevations, sections, gate locations, post spacing, mounting, attachment, and grounding details.

C. Samples: For each fence material and for each color specified.

   1. Provide Samples 12 inches in length for linear materials.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Product Test Reports: For decorative metallic-coated-steel tubular picket fences, including finish, indicating compliance with referenced standard[**and other specified requirements**].

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Fabricator of products.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For gate operators to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Wind Loading:

1. Fence Height: 0 to 15 feet.
2. Wind Exposure Category: B.
3. Design Wind Speed: 105 mph.

B. Lightning-Protection System: Maximum grounding-resistance value of 25 ohms under normal dry conditions.

2.2 DECORATIVE ALUMINUM FENCES

A. Decorative Aluminum Fences: Fences made from aluminum extrusions.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or approved equal:

a. Ameristar.
b. Alumi-Guard, Inc.
c. Elite Fence Products, Inc.
d. Master Halco.

B. Posts: Square extruded tubes.

1. Line Posts: 2-1/2 by 2-1/2 inches with min 0.100-inch wall thickness, or as specified by the manufacturer.
2. End and Corner Posts: 2-1/2 by 2-1/2 inches with min 0.100-inch wall thickness, or as specified by the manufacturer.
3. Swing Gate Posts: 2-1/2 by 2-1/2 inches with min 0.125-inch wall thickness, or as specified from the manufacturer.

C. Post Caps: Aluminum castings that cover entire top of posts.

D. Rails: Extruded-aluminum channels, 1-1/2 by 1-1/2 inches**,** with 0.100-inch thick sidewalls and 0.070-inch thick top, or specified by manufacturer.

E. Pickets: Extruded-aluminum tubes, 3/4 inch square, with 0.050-inch wall thickness or as specified by manufacturer.

1. Terminate tops of pickets at top of rail for flush top appearance.

2. Picket Spacing: 4 inches clear, maximum.

F. Fasteners: Manufacturer's standard tamperproof**,** corrosion-resistant, color-coated fasteners matching fence components.

G. Fabrication: Assemble fences into sections by fastening pickets to rails.

1. Pickets, rails, and posts shall be pre-cut to specified lengths. Rails shall be pre-punched to accept pickets. Grommets shall be inserted into the pre-punched holes in the rails and pickets shall be inserted through the grommets so that pre-drilled picket holes align with the rails. Panels to be preassembled by manufacturer.

H. Finish: Baked enamel or powder coating.

2.3 SWING GATES

A. Gate Configuration: As indicated.

B. Gate Frame Height: 72 inches or as indicated.

C. Gate Opening Width: as indicated.

D. Aluminum Frames and Bracing: Fabricate members from square extruded-aluminum tubes 2-1/2 by 2-1/2 inches with 0.125-inch wall thickness, or specified from the manufacturer.

E. Frame Corner Construction: Welded

F. Additional Rails: Provide as indicated, complying with requirements for fence rails.

G. Infill: Comply with requirements for adjacent fence.

H. Picket Size, Configuration, and Spacing: Comply with requirements for adjacent fence.

I. Hardware: Latches permitting operation from both sides of gate, hinges, and keepers for each gate leaf more than 5 feet wide. Locking Mechanism and keys integrated into pull knob assembly shall be selected.

J. Hinges: BHMA A156.1, Grade 1, suitable for exterior use. Self-closing feature to comply with NC Building Code suitable for child protection.

1. Function: 39 - Full surface, triple weight, antifriction bearing.
2. Material: Wrought steel, forged steel, cast steel, or malleable iron; galvanized.

K. Cane Bolts: Provide for inactive leaf of pairs of gates. Fabricated from 1/2-inch diameter, round steel bars, hot-dip galvanized after fabrication. Finish to match gates. Provide galvanized-steel pipe strikes to receive cane bolts in closed position.

L. Galvanizing: For items other than hardware that are indicated to be galvanized, hot-dip galvanize to comply with ASTM A 123/A 123M. For hardware items, hot-dip galvanize to comply with ASTM A 153/A 153M.

M. Finish exposed welds to comply with NOMMA Guideline 1, Finish #2 - completely sanded joint, some undercutting and pinholes okay.

N. Aluminum Finish: Baked enamel or powder coating.

2.4 ALUMINUM

A. Aluminum, General: Provide alloys and tempers with not less than the strength and durability properties of alloy and temper designated in paragraphs below for each aluminum form required.

B. Extrusions: ASTM B 221, Alloy 6063-T5.

C. Tubing: ASTM B 429/B 429M, Alloy 6063-T6.

D. Plate and Sheet: ASTM B209, Alloy 6061-T6.

E. Die and Hand Forgings: ASTM B247, Alloy 6061-T6.

F. Castings: ASTM B 26/B 26M, Alloy A356.0-T6.

2.5 MISCELLANEOUS MATERIALS

A. Concrete: Normal-weight, air-entrained, ready-mix concrete complying with requirements in Section 033000 "Cast-in-Place Concrete" with a minimum 28-day compressive strength of 3000 psi 3-inch slump, and 1-inch maximum aggregate size or dry, packaged, normal-weight concrete mix complying with ASTM C 387/C 387M mixed with potable water according to manufacturer's written instructions.

B. Nonshrink Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M and specifically recommended by manufacturer for exterior applications.

2.6 GROUNDING MATERIALS

A. Grounding Conductors: Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.

1. Material above Finished Grade: Aluminum.
2. Material on or below Finished Grade: Copper.

B. Grounding Connectors and Grounding Rods: Comply with UL 467.

2.7 ALUMINUM FINISHES

A. Baked-Enamel or Powder-Coat Finish: AAMA 2603 except with a minimum dry film thickness of 2 mils. Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.

1. Color and Gloss: As indicated by manufacturer's designations - black.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for site clearing, earthwork, pavement work, construction layout, and other conditions affecting performance of the Work.

B. Do not begin installation before final grading is completed unless otherwise permitted by Architect.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

1. Construction layout and field engineering are specified in Section 017300 "Execution."

3.3 DECORATIVE FENCE INSTALLATION

A. Install fences according to manufacturer's written instructions.

B. Install fences by setting posts as indicated and fastening rails to posts. Peen threads of bolts after assembly to prevent removal.

C. Post Excavation: Drill or hand-excavate holes for posts in firm, undisturbed soil. Excavate holes to a diameter of not less than 4 times post size and a depth of not less than 24 inches plus 3 inches for each foot or fraction of a foot that fence height exceeds 4 feet.

D. Post Setting: Set posts in concrete at indicated spacing into firm, undisturbed soil.

1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
2. Concrete Fill: Place concrete around posts and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.

a. Concealed Concrete: Top 2 inches below grade to allow covering with surface material. Slope top surface of concrete to drain water away from post.

3. Posts Set in Concrete: Extend post to within 6 inches of specified excavation depth, but not closer than 3 inches to bottom of concrete.
4. Space posts uniformly at 8 feet o.c.

3.4 GATE INSTALLATION

A. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.

3.5 GROUNDING AND BONDING

A. Fence Grounding: Install at maximum intervals of 1500 feet except as follows:

1. Fences within 100 Feet of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of 750 feet.

a. Gates and Other Fence Openings: Ground fence on each side of opening. Bond metal gates to gate posts.

B. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.

C. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.

D. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.

E. Bonding to Lightning-Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning-protection down conductor or lightning-protection grounding conductor, complying with NFPA 780.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

1. Grounding-Resistance Tests: Subject completed grounding system to a megger test at each grounding location. Measure grounding resistance not less than two full days after last trace of precipitation, without soil having been moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural grounding resistance. Perform tests by two-point method according to IEEE 81.

3.7 ADJUSTING

A. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

B. Lubricate hardware and other moving parts.

END OF SECTION 323119

SECTION 329115 - SOIL PREPARATION (PERFORMANCE SPECIFICATION)

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes planting soils specified according to performance requirements of the mixes.

B. Related Requirements:

1. Section 311000 "Site Clearing" for topsoil stripping and stockpiling.
2. Section 329300 "Plants" for placing planting soil for plantings.
3. Section 329200 “Turf and Grasses” for placing planting soil for turf and grasses.

1.2 DEFINITIONS

A. Aged Pine Bark Fines: Pine bark fines passing a ½” screen ages after screening volume measured after compressing.

B. Bioretention Media: Soil produced by blending sand, fines, and organic matter for application in bioretention stormwater control measures.

C. CEC: Cation exchange capacity.

D. Duff Layer: A surface layer of soil, typical of forested areas, that is composed of mostly decayed leaves, twigs, and detritus.

E. Expanded Slate ASTM C-330 Sand: A manufactured sand graded from the screenings of crushed expanded slate.

F. Expanded Slate Fines: For the purposes of this specification, expanded slate passing a #200 screen.

G. Finished grade: Elevation of finished surface of planting soil.

H. Imported Soil: Soil that is transported to Project site for use.

I. Manufactured Soil: Soil produced by blending soils, sand, stabilized organic soil amendments, and other materials to produce planting soil.

J. Organic Matter: The total of organic materials in soil exclusive of undecayed plant and animal tissues, their partial decomposition products, and the soil biomass; also called "humus" or "soil organic matter."

K. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified as specified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

L. RCRA Metals: Hazardous metals identified by the EPA under the Resource Conservation and Recovery Act.

M. SSSA: Soil Science Society of America.

N. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

O. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.

P. Surface Soil: Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil"; but in disturbed areas such as urban environments, the surface soil can be subsoil.

Q. USCC: U.S. Composting Council.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

1. Include recommendations for application and use.
2. Include test data substantiating that products comply with requirements.
3. Include sieve analyses for aggregate materials.
4. Material Certificates: For each type of imported soil and soil amendment and fertilizer before delivery to the site, according to the following:

    a. Manufacturer's qualified testing agency's certified analysis of standard products.
    b. Analysis of fertilizers, by a qualified testing agency, made according to AAPFCO methods for testing and labeling and according to AAPFCO's SUIP #25.
    c. Analysis of nonstandard materials, by a qualified testing agency, made according to SSSA methods, where applicable.

B. Samples: For each bulk-supplied material, 1-gal. volume of each in sealed containers labeled with content, source, and date obtained. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of composition, color, and texture.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For each testing agency.

B. Preconstruction Test Reports: For preconstruction soil analyses specified in "Preconstruction Testing" Article.

C. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent, state-operated, or university-operated laboratory; experienced in soil science, soil testing, and plant nutrition; with the experience and capability to conduct the testing indicated; and that specializes in types of tests to be performed.

1. Laboratories: Subject to compliance with requirements.

2. Multiple Laboratories: At Contractor's option, work may be divided among qualified testing laboratories specializing in physical testing, chemical testing, and fertility testing.

1.7 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction soil analyses on imported soil.

1. Notify Landscape Architect seven days in advance of the dates and times when laboratory samples will be taken.

B. Preconstruction Soil Analyses: For each unamended soil type, perform testing on soil samples and furnish soil analysis and a written report containing soil-amendment and fertilizer recommendations by a qualified testing agency performing the testing according to "Soil-Sampling Requirements" and "Testing Requirements" articles.

1. Have testing agency identify and label samples and test reports according to sample collection and labeling requirements.

1.8 SOIL-SAMPLING REQUIREMENTS

A. General: Extract soil samples according to requirements in this article.

B. Sample Collection and Labeling: Have samples taken and labeled by Contractor under the direction of the testing agency.

1. Number and Location of Samples: Minimum of five representative soil samples from varied locations for each soil to be used or amended for landscaping purposes.
2. Procedures and Depth of Samples: According to USDA-NRCS's "Field Book for Describing and Sampling Soils."
3. Division of Samples: Split each sample into two, equal parts. Send half to the testing agency and half to Owner for its records.
4. Labeling: Label each sample with the date, location keyed to a site plan or other location system, visible soil condition, and sampling depth.

1.9 TESTING REQUIREMENTS

A. General: Perform tests on soil samples according to requirements in this article.

B. Physical Testing:

1. Soil Texture: Soil-particle, size-distribution analysis by one of the following methods according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods":

a. Sieving Method: Report sand-gradation percentages for very coarse, coarse, medium, fine, and very fine sand; and fragment-gradation (gravel) percentages for fine, medium, and coarse fragments; according to USDA sand and fragment sizes.
b. Hydrometer Method: Report percentages of sand, silt, and clay.

2. Total Porosity: Calculate using particle density and bulk density according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods."

3. Water Retention: According to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods."
4. Saturated Hydraulic Conductivity: According to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods"; at 85% compaction according to ASTM D698 (Standard Proctor).

C. Chemical Testing:

1. CEC: Analysis by sodium saturation at pH 7 according to SSSA's "Methods of Soil Analysis - Part 3- Chemical Methods."
2. Clay Mineralogy: Analysis and estimated percentage of expandable clay minerals using CEC by ammonium saturation at pH 7 according to SSSA's "Methods of Soil Analysis - Part 1- Physical and Mineralogical Methods."
3. Metals Hazardous to Human Health: Test for presence and quantities of RCRA metals including aluminum, arsenic, barium, copper, cadmium, chromium, cobalt, lead, lithium, and vanadium. If RCRA metals are present, include recommendations for corrective action.
4. Phytotoxicity: Test for plant-available concentrations of phytotoxic minerals including aluminum, arsenic, barium, cadmium, chlorides, chromium, cobalt, copper, lead, lithium, mercury, nickel, selenium, silver, sodium, strontium, tin, titanium, vanadium, and zinc.

D. Fertility Testing: Soil-fertility analysis according to standard laboratory protocol including the following:

1. Percentage of organic matter.
2. CEC, calcium percent of CEC, and magnesium percent of CEC.
3. Soil reaction (acidity/alkalinity pH value).
4. Buffered acidity or alkalinity.
5. Nitrogen ppm.
6. Phosphorous ppm.
7. Potassium ppm.
8. Manganese ppm.
9. Manganese-availability ppm.
10. Zinc ppm.
11. Zinc availability ppm.
12. Copper ppm.
13. Sodium ppm and sodium absorption ratio.
14. Soluble-salts ppm.
15. Presence and quantities of problem materials including salts and metals cited in the Standard protocol. If such problem materials are present, provide additional recommendations for corrective action.
16. Other deleterious materials, including their characteristics and content of each.

E. Organic-Matter Content: Analysis using loss-by-ignition method according to SSSA's "Methods of Soil Analysis - Part 3- Chemical Methods."

F. Recommendations: Based on the test results, state recommendations for soil treatments and soil amendments to be incorporated to produce satisfactory planting soil suitable for healthy, viable plants indicated. Include, at a minimum, recommendations for nitrogen, phosphorous, and potassium fertilization, and for micronutrients.

1. Fertilizers and Soil Amendment Rates: State recommendations in weight per 1000 sq. ft. for 6-inch depth of soil.
2. Soil Reaction: State the recommended liming rates for raising pH or sulfur for lowering pH according to the buffered acidity or buffered alkalinity in weight per 1000 sq. ft. for 6-inch depth of soil.

1.10 DELIVERY, STORAGE, AND HANDLING:

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and compliance with state and Federal laws if applicable. In lieu of containers, fertilizer and soil amendments may be furnished in bulk, with a certificate indicating the above information accompanying each delivery.

B. Before and after delivery, fertilizer and soil amendments shall be kept in a dry storage area away from contaminants. Precautions shall be taken prior to use to prevent rupture of packaging and to prevent wetting, contamination, or deterioration.

C. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Do not move or handle materials when they are wet or frozen.
4. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.

D. When stockpiling finished bioretention media blend, place on a paved or protected base to prevent contamination.

E. Do not deliver or place soil in frozen, wet, or muddy conditions.

PART 2 - PRODUCTS

2.1 PLANTING SOILS SPECIFIED ACCORDING TO PERFORMANCE REQUIREMENTS

A. General: Soil amendments, fertilizers, and rates of application specified in this article are guidelines that may need revision based on testing laboratory's recommendations after preconstruction soil analyses are performed.

B. Topsoil: Native soil on site or natural soil harvested from another site that naturally has the texture and composition to meet the specification described below, and is free of noxious weed see, shall constitute an Acceptable Planting Media (APM).

C. Planting mix for Lawn, Turf or Seeding Areas: A planting mix may be developed that will be an Acceptable Planting Media by amending the existing soil or by removing the existing soil and replacing it with new planting mix. The planting mix shall have uniform composition throughout, with a mixture of subsoil. It shall be free of stones, lumps, live plants and their roots, sticks, and other extraneous matter. It shall contain no man-made materials unless otherwise specified. Planting mix shall not be used while in a frozen or muddy condition.

1. Unless there are unusual circumstances with project and unless otherwise specified in the contract documents and approved by the Grounds Superintendent and/or designee, the Acceptable Planting Media shall contain the following specified percentages of constituents:

a. CLAY Minimum 10%/Maximum 40%
b. SAND Minimum 20%/Maximum 50%
c. SILT Minimum 20%/Maximum 50%
d. ORGANIC MATTER Minimum 5%/Maximum 10%

2. Organic Matter is defined as compost/humus such as sawdust or leaf mold that has completed the decomposition process. Compost shall be well-composted, stable, and weed-free material bearing USCC's "Seal of Testing Assurance". Wood derivatives shall be shredded and composted, nitrogen-treated, of uniform texture and free of chips, stones, sticks, soil, or toxic materials. Percentage of organic matter shall be determined by loss on ignition of moisture free samples dried at 65 degrees.
3. APM shall have an acidity range of pH 6.5 to 7.0.

D. Planting mix for Tree and/or Bed/Shrub Planting Areas: A planting mix may be developed that will be an Acceptable Planting Media by amending the existing soil or by removing the existing soil and replacing it with new planting mix. The planting mix shall have uniform composition throughout, with a mixture of subsoil. It shall be free of stones, lumps, live plants and their roots, sticks, and other extraneous matter. It shall contain no man-made materials unless otherwise specified. Planting mix shall not be used while in a frozen or muddy condition.

1. Unless there are unusual circumstances with project and unless otherwise specified in the contract documents and approved by the Grounds Superintendent and/or designee, the Acceptable Planting Media shall contain the following specified percentages of constituents:

   a. CLAY Minimum 10%/Maximum 40%
   b. SAND Minimum 20%/Maximum 50%
   c. SILT Minimum 20%/Maximum 50%
   d. ORGANIC MATTER Minimum 15%/Maximum 20%

2. Organic Matter is defined as compost/humus such as sawdust or leaf mold that has completed the decomposition process. Compost shall be well-composted, stable, and weed-free material bearing USCC's "Seal of Testing Assurance". Wood derivatives shall be shredded and composted, nitrogen-treated, of uniform texture and free of chips, stones, sticks, soil, or toxic materials. Percentage of organic matter shall be determined by loss on ignition of moisture free samples dried at 65 degrees.
3. APM shall have an acidity range of pH 6.5 to 7.0.

E. Bioretention Media Mix: Provide a mixture to meet 15A NCAC 02H .1052 MDC FOR BIORETENTION CELLS

1. MEDIA MIX. The media shall be a homogeneous engineered media blend with approximate volumes of: (a) 75 to 85 percent medium to coarse washed expanded slate ASTM C330 sand; (b) 8 to 10 percent expanded slate fines passing a #200 screen; and (c) 5 to 10 percent organic matter by compressed volume (such as pine bark fines compressed volume).

2. MEDIA P-INDEX. The phosphorus index (P-index) for the media shall not exceed 30 in Nutrient Sensitive Waters (NSW) as defined in 15A NCAC 02B .0202 and shall not exceed 50 elsewhere.

3. Compaction: The media shall not be mechanically compacted after being placed by conveyance equipment. To avoid future settlement, where natural compaction has not yet occurred it is recommended to either water in place or use foot pressure until firm to meet final elevation.

4. Bioretention Media Components:
   a. **Expanded Slate Lightweight sand gradation**
      1) Unit Dry Weight loose: 53 lb./c.f. to 58 lb./c.f. (ASTM C29)
      2) ASTM 330 Gradation: MS16 Expanded Slate

Sieve Size	% Retained	% Passing
9.5 mm (3/8")	0 %	100%
4.57 mm **(#4)**	0-5 %	95-100 %
2.36 mm (#8)	0-20 %	80-100 %
1.18 mm (#16)	50-15 %	50-85 %
0.589 mm (#30)	40-75 %	25-60 %
0.295 mm (#50)	70-95 %	5-30 %
150 µm (#100)	90-100 %	0-10 %
75 µm (#200)	95-100 %	0-5 %

b. Fine Fraction

Sieve Size	% Retained	% Passing
75 µm (#200)	0%	100 %
0.05 mm	25-35%	65 -75%
0.002 mm	98-100%	0-2%

c. Organic Component
   1. Aged pine bark fines screened to minus ½"
   2. Compost shall not contain any manure products or municipal biosolids
   3. Compost shall be screened to minus 1/2"
   4. Organic component shall have total N of ≤ 2% of dry weight.
   5. Organic component shall have P (P2O5) of ≤ 1% of dry weight.
   6. Organic component salt content shall be < 10 millimho/cm at 25 ° C (ECe <10) on a saturated paste extract.
   7. Organic component metals and contaminants must fall within US EPA Standard

5. Bioretention Media Performance Standards
   a. Laboratory Testing:
      1) Phosphorus Index (PI) of the blended media shall fall between 10 and 30 (NCDA)
      2) Minimum infiltration rate of the blended media shall be 2.0 in/hr.

6. Aggregates Placed with Bioretention Media
   a. Washed #57 stone shall be placed on top of subgrade to encapsulate the underdrain (see section 334600).
   b. Washed #8 or #89 stone shall be placed on top of #57 stone.
   c. Washed sand per ASTM C33 shall be placed on top of #8 or #89 stone.
   d. Bioretention Media shall be placed on top of washed sand.
   e. Triple-Shredded Hardwood Mulch shall be placed on top of Bioretention Media (see section 329300)

F. Soils can be placed on a pre-approved list by the Grounds Superintendent and/or designee, after a vendor has proved that they have the ability to provide the soils as described and be consistent with the mixtures. The Grounds Department retest soils and recompiles this list annually. Other soils can be tested throughout the year and placed on the list, if approved, at the contractor's or vendor's request. Thirty calendar days for approval is required. Grounds Management will collect the samples and submit the first soil samples for laboratory testing. Any sample that requires resubmittal for approval will be the contractor's or vendor's responsibility and must be tested by a reputable soil testing lab.

2.2 ORGANIC SOIL AMENDMENTS

A. Compost: Well-composted, stable, and weed-free organic matter produced by composting feedstock, and bearing USCC's "Seal of Testing Assurance," and as follows:

1. Reaction: pH of 5.5 to 8.

2. Soluble-Salt Concentration: Less than 4 dS/m.
3. Moisture Content: 35 to 55 percent by weight.
4. Organic-Matter Content: 30 to 40 percent of dry weight.
5. Particle Size: Minimum of 98 percent passing through a 1/2-inch sieve.

B. Sphagnum Peat: Partially decomposed sphagnum peat moss, finely divided or of granular texture with 100 percent passing through a 1/2-inch sieve, a pH of 3.4 to 4.8, and a soluble-salt content measured by electrical conductivity of maximum 5 dS/m.

C. Muck Peat: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture with 100 percent passing through a 1/2-inch sieve, a pH of 6 to 7.5, a soluble-salt content measured by electrical conductivity of maximum 5 dS/m, having a water-absorbing capacity of 1100 to 2000 percent, and containing no sand.

D. Wood Derivatives: Shredded and composted, nitrogen-treated sawdust, ground bark, or wood waste; of uniform texture and free of chips, stones, sticks, soil, or toxic materials.

1. Partially Decomposed Wood Derivatives: In lieu of shredded and composted wood derivatives, mix shredded and partially decomposed wood derivatives with ammonium nitrate at a minimum rate of 0.15 lb/cu. ft. of loose sawdust or ground bark, or with ammonium sulfate at a minimum rate of 0.25 lb/cu. ft. of loose sawdust or ground bark.

E. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, debris, and material harmful to plant growth.

2.3 FERTILIZERS

A. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:

1. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified testing agency.

PART 3 - EXECUTION

3.1 GENERAL

A. Place planting soil and fertilizers according to requirements in other Specification Sections.

B. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in planting soil.

C. Proceed with placement only after unsatisfactory conditions have been corrected.

D. Product supplied must meet the specification above as determined by soil testing at an approved lab or be supplied from a vendor on the Grounds Department’s pre-approved list. Soil shall not be handled or spread when moisture content is excessively high.

E. Erosion Control

1. Always follow local water quality guidelines to prevent sediment accumulation in or around installation. Proper erosion control devices and groundcover must be in place before finalizing the installation of the bioretention areas.

F. Placing Bioretention Media:
1. Contain and protect the Bioretention Media to prevent contamination or segregation of components if stock piling on site before placement.
2. Do not place bioretention media until all drainage areas which drain to it are stabilized.
3. Refer to project drawings and specifications for minimum depth of bioretention media in occurrence with 15A NCAC 02H.1052 MDC.
4. Place the Bioretention Media in horizontal lifts not exceeding 12 inches depth.
5. The media shall not be mechanically compacted after being placed by conveyance equipment. To avoid future settlement, where natural compaction has not yet occurred, it is recommended to either water in place or use foot pressure until firm to meet final elevation.

3.2 PREPARATION OF UNAMENDED, ON-SITE SOIL BEFORE AMENDING

A. Excavation: Excavate soil from designated area(s) to a depth of 6 inches stockpile until amended.

B. Unacceptable Materials: Clean soil of concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth.

C. Unsuitable Materials: Clean soil to contain a combined maximum of 5 percent by dry weight of stones, roots, plants, sod, clay lumps, and pockets of coarse sand.

D. Screening: Pass unamended soil through a 2-inch sieve to remove large materials.

3.3 PLACING AND MIXING PLANTING SOIL OVER EXPOSED SUBGRADE

A. General: Apply and mix unamended soil with amendments on-site to produce required planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Subgrade Preparation: Till subgrade to a minimum depth of 18 inches**.** Remove stones larger than 1-1/2 inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

C. Mixing: Spread unamended soil to total depth of 6 inches but not less than required to meet finish grades after mixing with amendments and natural settlement. Do not spread if soil or subgrade is frozen, muddy, or excessively wet.

1. Amendments: Apply soil amendments, and fertilizer, if required, evenly on surface, and thoroughly blend them with unamended soil to produce planting soil.

a. Mix lime with dry soil before mixing fertilizer.
b. Mix fertilizer with planting soil no more than seven days before planting.

2. Lifts: Apply and mix unamended soil and amendments in lifts not exceeding 12 inches in loose depth for material compacted by compaction equipment, and not more than 6 inches in loose depth for material compacted by hand-operated tampers.

D. Compaction: Compact each blended lift of planting soil to 75 percent of maximum Standard Proctor density according to ASTM D 698 and tested in place.

E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.4 PLACING MANUFACTURED PLANTING SOIL OVER EXPOSED SUBGRADE

A. General: Apply manufactured soil on-site in its final, blended condition. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Subgrade Preparation: Till subgrade to a minimum depth of 18 inches. Remove stones larger than 1-1/2 inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

1. Apply approximately half the thickness of planting soil over prepared, loosened subgrade. Mix thoroughly into top 4 inches of subgrade. Spread remainder of planting soil.

C. Application: Spread planting soil to total depth of 6 inches but not less than required to meet finish grades after natural settlement. Do not spread if soil or subgrade is frozen, muddy, or excessively wet.

1. Lifts: Apply planting soil in lifts not exceeding 12 inches in loose depth for material compacted by compaction equipment, and not more than 6 inches in loose depth for material compacted by hand-operated tampers.

A. Compaction: Compact each lift of planting soil to 75 percent of maximum Standard Proctor density according to ASTM D698.

B. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.5 BLENDING PLANTING SOIL IN PLACE

A. General: Mix amendments with in-place, unamended soil to produce required planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Preparation: Till unamended, existing soil in planting areas to a minimum depth of 18 inches. Remove stones larger than 1-1/2 inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

A. Mixing: Apply soil amendments and fertilizer, if required, evenly on surface, and thoroughly blend them into full depth of unamended, in-place soil to produce planting soil.

1. Mix lime and potassium with dry soil before mixing fertilizer.
2. Mix fertilizer with planting soil no more than seven days before planting.

A. Compaction: Compact blended planting soil to 75 percent of maximum Standard Proctor density according to ASTM D698.

B. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.6 APPLYING COMPOST TO SURFACE OF PLANTING SOIL

A. Application: Apply compost component of planting-soil mix 4 inches of compost to surface of in-place planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Finish Grading: Grade surface to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests:

1. Compaction: Test planting-soil compaction after placing each lift and at completion using a densitometer or soil-compaction meter calibrated to a reference test value based on laboratory testing according to ASTM D698. Space tests at no less than one for each 1000 sq. ft. of in-place soil or part thereof.

2. Infiltration: Perform at least one infiltration test on the bioretention media in each bioretention cell after it is installed to ensure that a rate exceeding 2 in/hr of infiltration is met by the installed bioretention media.

C. Soil will be considered defective if it does not pass tests.

D. Prepare test reports.

E. Label each sample and test report with the date, location keyed to a site plan or other location system, visible conditions when and where sample was taken, and sampling depth.

3.8 PROTECTION AND CLEANING

A. Protection Zone: Identify protection zones according to Section 015639 "Temporary Tree and Plant Protection."

B. Protect areas of in-place soil from additional compaction, disturbance, and contamination. Prohibit the following practices within these areas except as required to perform planting operations:

1. Storage of construction materials, debris, or excavated material.
2. Parking vehicles or equipment.
3. Vehicle traffic.
4. Foot traffic.
5. Erection of sheds or structures.
6. Impoundment of water.
7. Excavation or other digging unless otherwise indicated.

C. If planting soil or subgrade is overcompacted, disturbed, or contaminated by foreign or deleterious materials or liquids, remove the planting soil and contamination; restore the subgrade as directed by Architect and replace contaminated planting soil with new planting soil.

D. For Bioretention Media, broom clean paved areas and cover stockpiled material after each day’s operation.

E. Do not allow any traffic or storage of other materials placed on stored bioretention media nor allow excess landscape materials including soil to be placed in bioretention area except as is expressly a constituent of the media itself.

3.9 CLEANING

A. Protect areas adjacent to planting-soil preparation and placement areas from contamination. Keep adjacent paving and construction clean and work area in an orderly condition.

B. Remove surplus soil and waste material including excess subsoil, unsuitable materials, trash, and debris and legally dispose of them off Owner's property unless otherwise indicated.

1. Dispose of excess subsoil and unsuitable materials on-site where directed by Owner.

END OF SECTION 329115

SECTION 329200 - TURF AND GRASSES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Seeding.
2. Sodding.

1.2 DEFINITIONS

A. Finish Grade: Elevation of finished surface of planting soil.

B. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

C. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

D. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See Section 329113 "Soil Preparation" and drawing designations for planting soils.

E. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For landscape Installer.

B. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture, stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.

C. Certification of Sod: Certification of each seed mixture for turfgrass sod. Include identification of source and name and telephone number of supplier.

D. Product Certificates: For fertilizers, from manufacturer.

E. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to Project.

F. Soil Analysis: Submit complete results of analysis, identifying required soil amendments, and amendment rates and procedures.

G. Planting Schedule: Submit proposed planting schedule, indicating dates for installation and completion of lawn work. Once accepted, revise schedule only as approved in writing by the Owner's Representative, after documentation of reasons for delays.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Instructions: Prior to expiration of Contractor's Maintenance Period, submit instructions recommending procedures to be followed by OWNER for maintenance of lawns for one full year following expiration of Contractor's Maintenance Period. Meet with the OWNER and/or their representatives, to review instructions and to assure adequate understanding for OWNER to carry out instructions.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful turf establishment.

1. Professional Membership: Installer shall be a member in good standing of either the National Association of Landscape Professionals or AmericanHort.
2. Experience: Five years' experience in turf installation in addition to requirements in Section 014000 "Quality Requirements."
3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
4. Personnel Certifications: Installer's field supervisor shall have certification in one of the following categories from the National Association of Landscape Professionals:

    a. Landscape Industry Certified Technician - Exterior.
    b. Landscape Industry Certified Lawn Care Manager.
    c. Landscape Industry Certified Lawn Care Technician.

5. Pesticide Applicator: State licensed, commercial.

B. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work in this section.

C. Comply with all regulations applicable to landscape materials.

D. Soil Analysis: Provide and pay for the services of an approved, independent testing agency to perform an analysis of soil to be used. Analysis shall include a comprehensive description of soil, and a listing of types and quantities of soil amendments required for the establishment, growth and health of lawns. The number of samples required shall be a minimum of two samples per acre of lawn area, unless additional samples are recommended by testing agency.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws, as applicable.

B. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" sections in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver sod within 24 hours of harvesting and in time for planting promptly. Protect sod from breakage and drying.

C. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Accompany each delivery of bulk materials with appropriate certificates.

1.8 FIELD CONDITIONS

A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of Substantial Completion.

1. Spring Planting: April 15th – May 30th.
2. Fall Planting: September 23rd – December 30th.

B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

C. Utilities: Locate and avoid damage to all underground utilities; perform work in a manner which will avoid damage. Utilities not necessarily shown on Drawings.

D. Maintain grade stakes set by others until removal is mutually agreed upon by parties concerned.

E. When conditions detrimental to lawn establishment, growth and maintenance are encountered, such as rubble, adverse drainage conditions, or obstructions, notify Owner’s Representative for directions before planting.

F. Sodding shall only be permitted after irrigation system is installed and operating properly.

PART 2 - PRODUCTS

2.1 SEED

A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Rules for Testing Seeds" for purity and germination tolerances.

B. Seed Species:

1. Quality, State Certified: State-certified seed of grass species as listed below for solar exposure.
2. Full Sun, Warm-Season Grass: Bermudagrass (Cynodon dactylon).

2.2 TURFGRASS SOD

A. Turfgrass Sod: Certified Number 1 Quality/Premium, including limitations on thatch, weeds, diseases, nematodes, and insects, complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture that is strongly rooted and capable of vigorous growth and development when planted.

B. Sod shall be delivered machine cut to a uniform thickness of ¾" to 1½", excluding top growth and thatch. Length and width shall be the supplier's standard, with a maximum allowable deviation of 5%. Torn, uneven, or desiccated pads or edges shall not be acceptable.

C. Standard size sections of sod shall be capable of supporting their own weight and shape when suspended vertically.

D. Turfgrass Species, Warm-Season Grass: TifTuf Bermudagrass (Cynodon dactylon x transvaalensis 'DT-1')

E. Provide sod composed of species specified, free of weeds and other extraneous grass types.

2.3 FERTILIZERS

A. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:

1. Composition: 1 lb/1000 sq. ft. of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.

B. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:

1. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.

2.4 MULCHES

A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.

B. Sphagnum Peat Mulch: Partially decomposed sphagnum peat moss, finely divided or of granular texture, and with a pH range of 3.4 to 4.8.

C. Muck Peat Mulch: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture, with a pH range of 6 to 7.5, and having a water-absorbing capacity of 1100 to 2000 percent, and containing no sand.

D. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1-inch sieve; soluble salt content of 2 to 5 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:

1. Organic Matter Content: 50 to 60 percent of dry weight.
2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.

E. Fiber Mulch: Biodegradable, dyed-wood, cellulose-fiber mulch; nontoxic and free of plant-growth or germination inhibitors; with a maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.

F. Nonasphaltic Tackifier: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application; nontoxic and free of plant-growth or germination inhibitors.

G. Asphalt Emulsion: ASTM D977, Grade SS-1; nontoxic and free of plant-growth or germination inhibitors.

2.5 PESTICIDES

A. General: Pesticide, registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

B. Pre-Emergent Herbicide (Selective and Nonselective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.

C. Post-Emergent Herbicide (Selective and Nonselective): Effective for controlling weed growth that has already germinated.

PART 3 - EXECUTION

3.1 TURF AREA PREPARATION

A. General: Prepare planting area for soil placement and mix planting soil according to Section 329113 "Soil Preparation."

B. Placing Planting Soil: Place and mix planting soil in place over exposed subgrade.

1. Reduce elevation of planting soil to allow for soil thickness of sod.

C. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

D. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.2 SEEDING

A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph.

1. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
2. Do not use wet seed or seed that is moldy or otherwise damaged.
3. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.

B. Sow seed at a total rate of 2 lb/1000 sq. ft.

C. Rake seed lightly into top 1/8 inch of soil, roll lightly, and water with fine spray.

D. Protect seeded areas with slopes exceeding 1:4 with erosion-control blankets installed and stapled according to manufacturer's written instructions.

E. Protect seeded areas with erosion-control mats where indicated on Drawings; install and anchor according to manufacturer's written instructions.

F. Protect seeded areas with slopes not exceeding 1:6 by spreading straw mulch. Spread uniformly at a minimum rate of 2 tons/acre to form a continuous blanket 1-1/2 inches in loose thickness over seeded areas. Spread by hand, blower, or other suitable equipment.

1. Anchor straw mulch by crimping into soil with suitable mechanical equipment.
2. Bond straw mulch by spraying with asphalt emulsion at a rate of 10 to 13 gal./1000 sq. ft. Take precautions to prevent damage or staining of structures or other plantings adjacent to mulched areas. Immediately clean damaged or stained areas.

G. Protect seeded areas from hot, dry weather or drying winds by applying compost mulch within 24 hours after completing seeding operations. Soak areas, scatter mulch uniformly to a thickness of 3/16 inch and roll surface smooth.

3.3 SODDING

A. Sodding shall not be done when the ground is frozen, snow covered, saturated, excessively dry, or in any other condition which would make establishment and survival of sod reasonably unlikely.

B. Prior to sod bed preparation, soil shall be in a loose, smooth, friable condition, free from stones over 1-½" in any dimension, sticks, roots, construction debris, and other extraneous matter. If soil has become crusty, hardened or eroded since being spread, it shall be a part of this work to restore the soil to the loose, smooth condition described above.

C. Prior to preparation of previously undistributed areas, completely remove existing vegetation and debris, and dispose of such material off-site; do not turn under vegetation into soil being prepared for sod bed. Loosen existing grade to a depth of 4"; remove all debris which surfaces.

D. Spread fertilizer at the rate of 16 lbs per 1000 sq. ft. or as otherwise recommended by the soil test report for the specified turf species. Add pH balancing agents at rate recommended by soil test report to achieve a pH of 5.5 to 6.5 for Centipede grass, 6.5 to 7.0 for Bermuda grass, 6.5 to 7.5 for St. Augustine grass and 6.0 to 7.0 for Zoysia grass. Add peat and other additives as recommended by the soil test report. Blend additives thoroughly into upper 4" of soil. Remove any rock or other debris which may surface. Till areas until soil is loose and friable and all soil amendments are uniformly distributed.

E. Work areas to a smooth even surface free from surface irregularities, ridges or depressions. Prepared areas shall meet required finish grade elevations allowing for sod thickness, and shall have positive drainage.

F. Moisten prepared areas if soil is dry. Water thoroughly, and then allow surface moisture to evaporate. Do not create muddy soil conditions; do not saturate soil.

G. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.

H. The first row of sod shall be laid in a straight line with subsequent rows placed parallel to and butting tightly against each other. Stagger strips to offset joints in adjacent courses. Care shall be taken to ensure that sod is not stretched or overlapped and that all joints are butted tight. On slopes, sod shall be laid parallel to the contour.

I. Avoid damage to soil or sod during installation. Tamp and roll lightly to ensure contact with soil, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.

1. Lay sod across slopes exceeding 1:3.
2. Anchor sod on slopes exceeding 1:6 with wood pegs or steel staples spaced as recommended by sod manufacturer but not less than two anchors per sod strip to prevent slippage.

J. Immediately after laying and firming the sod, irrigate to a depth of 4 inches below the underside of the strips.

K. During the first seven days after installation, maintain a continuous moist soil depth of at least 4 inches. After that period, water as necessary to maintain moist root zone.

3.4 TURF MAINTENANCE

A. General: Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.

1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
3. Apply treatments as required to keep turf and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.

B. Watering: Install and maintain temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep turf uniformly moist to a depth of 4 inches.

1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
2. Water turf with fine spray at a minimum rate of 1 inch per week unless rainfall precipitation is adequate.

C. Mow turf as soon as top growth is tall enough to cut. For sod, the first mowing shall not be attempted until the sod is firmly rooted. Repeat mowing to maintain specified height without cutting more than one-third of grass height. Remove no more than one-third of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:

1. Mow bermudagrass to a height of 1/2 to 1 inch.
2. Prior to cutting secured areas, drive peds flush with grade.

D. Turf Postfertilization: Apply slow-release fertilizer after initial mowing and when grass is dry.

1. Use fertilizer that provides actual nitrogen of at least 1 lb/1000 sq. ft. to turf area.

3.5 SATISFACTORY TURF

A. Turf installations shall meet the following criteria as determined by Architect:

1. Satisfactory Seeded Turf: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. and bare spots not exceeding 5 by 5 inches.
2. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.

B. Use specified materials to reestablish turf that does not comply with requirements, and continue maintenance until turf is satisfactory.

3.6 PESTICIDE APPLICATION

A. Apply pesticides and other chemical products and biological control agents according to requirements of authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

B. Post-Emergent Herbicides (Selective and Nonselective): Apply only as necessary to treat already-germinated weeds and according to manufacturer's written recommendations.

3.7 CLEANUP AND PROTECTION

A. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off Owner's property.

C. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.

D. Remove nondegradable erosion-control measures after grass establishment period.

3.8 MAINTENANCE SERVICE

A. Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in "Turf Maintenance" Article. Begin maintenance immediately after each area is planted and continue until acceptable turf is established, but for not less than the following periods:

1. Seeded Turf: 60 days from date of Substantial Completion.

    a. When initial maintenance period has not elapsed before end of planting season, or if turf is not fully established, continue maintenance during next planting season.

2. Sodded Turf: 30 days from date of Substantial Completion.

END OF SECTION 329200

SECTION 329300 - PLANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Plants.
2. Tree-watering devices.
3. Landscape edgings.

1.2 DEFINITIONS

A. Backfill: The earth used to replace or the act of replacing earth in an excavation.

B. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant. Some sources classify herbicides separately from pesticides.

C. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See Section 329115 "Soil Preparation (Performance Specification)" for drawing designations for planting soils.

D. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Plant materials Include quantities, sizes, quality, and sources for plant materials.
   2. Plant Photographs: Include color photographs in digital format of each required species and size of plant material as it will be furnished to project. Take photographs from an angle depicting true size and condition of the typical plant to be furnished. Include a scale rod or other measuring device in each photograph. For species where more than 20 plants are required, include a minimum of three photographs showing the average plant, best quality plant, and worst quality plant to be furnished. Identify each photograph with fill scientific name of the plant, plant size, and growing nursery.

B. Samples for verification: for each of the following:
   1. Trees and shrubs: Three samples of each variety and size delivered to site for review. Maintain approved samples on-site as standard comparison.
   2. Organic Mulch: 1-quart volume of each organic mulch required; in sealed plastic bags labeled with composition of materials by percentage of weight and source of mulch. Each sample shall be

typical of the lot of material to be furnished; provide an accurate representation of color, texture, and organic makeup.

3. Proprietary Root-Ball-Stabilization Device: One Unit.
4. Slow-release, tree watering device: one unit of each size required.

1.5 INFORMATIONAL SUBMITTALS

A. Product certificates: For each type of manufactured product, from manufacturer, and complying with the following:
   1. Manufacturer's certified analysis of standard mulch products.
   2. Analysis of other materials by a recognized laboratory made according to the methods established by the association of Official Analytical Chemists, where applicable.

B. Qualification Data: For landscape installer: Include list of similar projects completed by installer demonstrating installer's capabilities and experience. Include project names, addresses, and year completed, and include names and addresses of owners' contact persons.

C. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to project.

D. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of plants during a calendar year.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful establishment of plants
   1. Professional membership: Installer shall be a member in good standing with the National Association of Landscape Professionals.
   2. Experience: Five years' Experience in landscape installation in addition to requirements in section 014000 "Quality Requirements."
   3. Installers field supervision: Require installer to maintain an experienced full-time supervisor on project site when work is in progress.
   4. Personal Certifications: Installer's field supervisor, personnel assigned to the work shall have certification in one of the following categories from the National Association of Landscape Professionals:
      a. Landscape Industry Certified Technician – Exterior.
      b. Landscape Industry Certified Horticultural Technician.
   5. Pesticide Applicator: State licensed, commercial.

B. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.
   1. Selection of plants purchased under allowances is made my Landscape Architect, who tags plants at their place of growth before they are prepared for transplanting.

C. Measurements: Measure according to ANSI Z60.1. Do not prune to obtain required sizes.

   1. Trees and Shrubs: Measure with branches and trunks or canes in their normal position. Take height measurements from or near the top of the root flare for field-grown stock and container-

grown stock. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip to tip. Take caliper measurements 6 inches the root flare for trees up to 4-inch caliper size, and 12 inches above the root flare for larger sizes.

2. Other Plants: Measure with stems, petioles, and foliage in their normal position.

D. Plant Material Observation: Landscape Architect may observe plant material either at place of growth or at site before planting for compliance with requirements for genus, species, variety, cultivar, size, and quality. Landscape Architect may also observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and may reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.

1. Notify Landscape Architect of sources of planting materials seven days in advance of delivery to site.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws if applicable.

B. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Accompany each delivery of bulk materials with appropriate certificates.

C. Deliver bare-root stock plants within 24 hours of digging. Immediately after digging up bare-root stock, pack root system in wet straw, hay, or other suitable material to keep root system moist until planting. Transport in covered, temperature-controlled vehicles, and keep plants cool and protected from sun and wind at all times.

D. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.

E. Handle planting stock by root ball.

F. Store bulbs, corms, and tubers in a dry place at 60 to 65 deg F until planting.

G. Wrap trees and shrubs with burlap fabric over trunks, branches, stems, twigs, and foliage to protect from wind and other damage during digging, handling, and transportation.

H. Deliver plants after preparations for planting have been completed, and install immediately. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.

1. Heel-in bare-root stock. Soak roots that are in less than moist condition in water for two hours. Reject plants with dry roots.
2. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
3. Do not remove container-grown stock from containers before time of planting.

4. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly wet condition.

1.9 FIELD CONDITIONS

A. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.

B. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion.

1. Spring Planting: April 15th – May 30th.
2. Fall Planting: September 23rd – December 30th.

C. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.

1.10 WARRANTY

A. Special Warranty: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by Owner.
b. Structural failures including plantings falling or blowing over.
c. Faulty performance of tree stabilization
d. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

2. Warranty Periods: From date of Substantial Completion.

a. Trees, Shrubs, Vines, and Ornamental Grasses: 12 months.
b. Ground Covers, Biennials, Perennials, and Other Plants: 12 months.
c. Annuals: Three months.

3. Include the following remedial actions as a minimum:

a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
c. A limit of one replacement of each plant is required except for losses or replacements due to failure to comply with requirements.
d. Provide extended warranty for period equal to original warranty period, for replaced plant material.

PART 2 - PRODUCTS

2.1 PLANT MATERIAL

A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant List, Plant Schedule, or Plant Legend indicated on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.

1. Trees with damaged, crooked, or multiple leaders; tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); crossing trunks; cut-off limbs more than 3/4 inch in diameter; or with stem girdling roots are unacceptable.
2. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.

B. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required. Plants of a larger size may be used if acceptable to Landscape Architect, with a proportionate increase in size of roots or balls.

C. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which begins at root flare according to ANSI Z60.1. Root flare shall be visible before planting.

D. Labeling: Label each plant of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for the plant.

E. If formal arrangements or consecutive order of plants is indicated on Drawings, select stock for uniform height and spread, and number the labels to assure symmetry in planting.

F. Annuals and Biennials: Provide healthy, disease-free plants of species and variety shown or listed, with well-established root systems reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. Provide only plants that are acclimated to outdoor conditions before delivery and that are in bud but not yet in bloom.

2.2 FERTILIZERS

A. Planting Tablets: Tightly compressed chip-type, long-lasting, slow-release, commercial-grade planting fertilizer in tablet form. Tablets shall break down with soil bacteria, converting nutrients into a form that can be absorbed by plant roots.

1. Size: 5-gram tablets.
2. Nutrient Composition: 20 percent nitrogen, 10 percent phosphorous, and 5 percent potassium, by weight plus micronutrients.

2.3 MULCHES

A. Organic Mulch: Triple shredded hardwood.

1. Size Range: 3 inches maximum, 1/2 inch minimum.
2. Color: Natural. NO DYED MULCH PRODUCTS.

2.4 PESTICIDES

A. General: Pesticide registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

B. Pre-Emergent Herbicide (Selective and Nonselective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.

C. Post-Emergent Herbicide (Selective and Nonselective): Effective for controlling weed growth that has already germinated.

2.5 TREE-STABILIZATION MATERIALS

A. Trunk-Stabilization Materials:

1. Guy Stakes: Rough-sawn, sound, new hardwood, free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal by length indicated, pointed at one end.
2. Wood Deadmen: Timbers measuring 8 inches in diameter and 48 inches long, treated with specified wood pressure-preservative treatment.
3. Flexible Ties: Wide rubber or elastic bands or straps of length required to reach stakes or turnbuckles.
4. Guys and Tie Wires: Are NOT permitted.
5. Tree-Tie Webbing: UV-resistant polypropylene or nylon webbing with brass grommets.
6. Guy Cables: Are NOT permitted.
7. Flags: Standard surveyor's plastic flagging tape, white, 6 inches long.
8. Proprietary Staking-and-Guying Devices: Proprietary stake or anchor and adjustable tie systems to secure each new planting by plant stem; sized as indicated and according to manufacturer's written recommendations.

2.6 TREE-WATERING DEVICES

A. Slow-Release Watering Device: Standard product manufactured for drip irrigation of plants and emptying its water contents over an extended time period; manufactured from UV-light-stabilized nylon-reinforced polyethylene sheet, PVC, or HDPE plastic.

1. Color: As selected by Landscape Architect from manufacturer's full range.

2.7 MISCELLANEOUS PRODUCTS

A. Wood Pressure-Preservative Treatment: AWPA U1, Use Category UC4a; acceptable to authorities having jurisdiction, and containing no arsenic or chromium.

B. Antidesiccant: Water-insoluble emulsion, permeable moisture retarder, film forming, for trees and shrubs. Deliver in original, sealed, and fully labeled containers and mix according to manufacturer's written instructions.

C. Burlap: Non-synthetic, biodegradable.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive plants, with Installer present, for compliance with requirements and conditions affecting installation and performance of the Work.

1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
2. Verify that plants and vehicles loaded with plants can travel to planting locations with adequate overhead clearance.
3. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
4. Uniformly moisten excessively dry soil that is not workable or which is dusty.

B. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Landscape Architect and replace with new planting soil.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

C. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Landscape Architect's acceptance of layout before excavating or planting. Make minor adjustments as required.

D. Lay out plants at locations directed by Landscape Architect. Stake locations of individual trees and shrubs and outline areas for multiple plantings.

3.3 PLANTING AREA ESTABLISHMENT

A. General: Prepare planting area for soil placement and mix planting soil according to Section 329115 "Soil Preparation (Performance Specification).

B. Placing Planting Soil: Place and mix planting soil in-place over exposed subgrade

C. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

D. Application of Mycorrhizal Fungi: At time directed by Landscape Architect, broadcast dry product uniformly over prepared soil at application rate according to manufacturer's written recommendations.

3.4 EXCAVATION FOR TREES AND SHRUBS

A. Planting Pits and Trenches: Excavate circular planting pits.

1. Excavate planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are unacceptable. Trim perimeter of bottom leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Do not further disturb base. Ensure that root ball will sit on undisturbed base soil to prevent settling. Scarify sides of planting pit smeared or smoothed during excavation.
2. Excavate approximately three times as wide as ball diameter.
3. Excavate at least 12 inches wider than root spread and deep enough to accommodate vertical roots for bare-root stock.
4. Do not excavate deeper than depth of the root ball, measured from the root flare to the bottom of the root ball.
5. If area under the plant was initially dug too deep, add soil to raise it to the correct level and thoroughly tamp the added soil to prevent settling.
6. Maintain angles of repose of adjacent materials to ensure stability. Do not excavate subgrades of adjacent paving, structures, hardscapes, or other new or existing improvements.
7. Maintain supervision of excavations during working hours.
8. Keep excavations covered or otherwise protected when unattended by Installer's personnel.

B. Backfill Soil: Subsoil and topsoil removed from excavations may be used as backfill soil unless otherwise indicated.

C. Obstructions: Notify Landscape Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.

D. Drainage: Notify Landscape Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub planting pits.

E. Fill excavations with water and allow to percolate away before positioning trees and shrubs.

3.5 TREE, SHRUB, AND VINE PLANTING

A. Inspection: At time of planting, verify that root flare is visible at top of root ball according to ANSI Z60.1. If root flare is not visible, remove soil in a level manner from the root ball to where the top-most root emerges from the trunk. After soil removal to expose the root flare, verify that root ball still meets size requirements.

B. Roots: Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.

C. Balled and Burlapped Stock: Set each plant plumb and in center of planting pit or trench with root flare 1 inch above adjacent finish grades.

1. Backfill: use planting soil for backfill. For trees, use excavated soil for backfill.
2. After placing some backfill around root ball to stabilize plant, carefully cut and remove burlap, rope, and wire baskets from tops of root balls and from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
4. Place planting tablets equally distributed around each planting pit when pit is approximately one-half filled. Place tablets beside the root ball about 1 inch from root tips; do not place tablets in bottom of the hole.

    a. Quantity: Two per plant or three for each caliper inch of tree.

5. Continue backfilling process. Water again after placing and tamping final layer of soil.

D. Balled and Potted and Container-Grown Stock: Set each plant plumb and in center of planting pit or trench with root flare 1 inch above adjacent finish grades.

1. Backfill: use planting soil for backfill. For trees, use excavated soil for backfill.
2. Carefully remove root ball from container without damaging root ball or plant.
3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
4. Place planting tablets equally distributed around each planting pit when pit is approximately one-half filled. Place tablets beside the root ball about 1 inch from root tips; do not place tablets in bottom of the hole.

    a. Quantity: Two per plant or three for each caliper inch of tree.

5. Continue backfilling process. Water again after placing and tamping final layer of soil.

E. Slopes: When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.

3.6 TREE, SHRUB, AND VINE PRUNING

A. Remove only dead, dying, or broken branches. Do not prune for shape.

B. Prune, thin, and shape trees, shrubs, and vines as directed by Architect.

C. Prune, thin, and shape trees, shrubs, and vines according to standard professional horticultural and arboricultural practices. Unless otherwise indicated by Architect, do not cut tree leaders; remove only injured, dying, or dead branches from trees and shrubs; and prune to retain natural character.

D. Do not apply pruning paint to wounds.

3.7 TREE STABILIZATION

A. Trunk Stabilization by Staking and Guying: Install trunk stabilization as follows unless otherwise indicated on Drawings. Stake and guy trees more than 14 feet in height and more than 3 inches in caliper unless otherwise indicated. NO WIRES TO STABILIZE TREES, USE FIBROUS OR WEBB GUYING MATERIAL.

1. Site-Fabricated, Staking-and-Guying Method: Install no fewer than three guys spaced equally around tree.

    a. Securely attach guys to stakes 30 inches long, driven to grade. Adjust spacing to avoid penetrating root balls or root masses.
    b. For trees more than 6 inches, anchor guys to wood deadmen buried at least 36 inches below grade.
    c. Support trees with bands of flexible ties at contact points with tree trunk and reaching to turnbuckle. Allow enough slack to avoid rigid restraint of tree.
    d. Support trees with fabric or webbing, connected to the brass grommets of tree-tie webbing at contact points with tree trunk and reaching to turnbuckle. Allow enough slack to avoid rigid restraint of tree.
    e. Attach flags to each guy wire, 30 inches above finish grade.
    f. Paint turnbuckles with luminescent white paint.

2. Proprietary Staking and Guying Device: Install staking and guying system sized and positioned as recommended by manufacturer unless otherwise indicated and according to manufacturer's written instructions.

3.8 GROUND COVER AND PLANT PLANTING

A. Set out and space ground cover and plants other than trees, shrubs, and vines as indicated on Drawings in even rows with triangular spacing.

B. Use planting soil for backfill.

C. Dig holes large enough to allow spreading of roots.

D. For rooted cutting plants supplied in flats, plant each in a manner that minimally disturbs the root system but to a depth not less than two nodes.

E. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.

F. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.

G. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

3.9 PLANTING AREA MULCHING

A. Install weed-control barriers before mulching according to manufacturer's written instructions. Completely cover area to be mulched, overlapping edges a minimum of 6 inches (150 mm) and secure seams with galvanized pins.

B. Mulch backfilled surfaces of planting areas and other areas indicated.

1. Trees and Treelike Shrubs in Turf Areas: Apply organic mulch ring of 3-inch average thickness, to cover the planting pit or trench. Do not place mulch within 3 inches of trunks or stems.
2. Organic Mulch in Planting Areas and Bioretention Areas: Apply 3-inch average thickness of organic mulch extending 12 inches beyond edge of individual planting pit or trench and over whole surface of planting area, and finish level with adjacent finish grades. Do not place mulch within 3 inches of trunks or stems.

3.10 EDGING INSTALLATION

A. Shovel-Cut Edging: Separate mulched areas from turf areas**,** curbs, and paving with a 45-degree, 4- to 6-inch deep, shovel-cut edge as indicated on Drawings.

3.11 INSTALLING SLOW-RELEASE WATERING DEVICE

A. Provide one device for each tree.

B. Place device on top of the mulch at base of tree stem and fill with water according to manufacturer's written instructions.

3.12 PLANT MAINTENANCE

A. Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings.

B. Fill in, as necessary, soil subsidence that may occur because of settling or other processes. Replace mulch materials damaged or lost in areas of subsidence.

C. Apply treatments as required to keep plant materials, planted areas, and soils free of pests and pathogens or disease. Use integrated pest management practices when possible to minimize use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.

D. Apply pesticides and other chemical products and biological control agents according to authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

E. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.

F. At time of Substantial Completion, verify that tree-watering devices are in good working order and leave them in place. Replace improperly functioning devices.

3.13 REPAIR AND REPLACEMENT

A. General: Repair or replace existing or new trees and other plants that are damaged by construction operations, in a manner approved by Landscape Architect.

1. Submit details of proposed pruning and repairs.
2. Perform repairs of damaged trunks, branches, and roots within 24 hours, if approved.
3. Replace trees and other plants that cannot be repaired and restored to full-growth status, as determined by Landscape Architect.

B. Remove and replace trees that are more than 25 percent dead or in an unhealthy condition before the end of the corrections period or are damaged during construction operations that Landscape Architect determines are incapable of restoring to normal growth pattern.

1. Provide new trees of same size as those being replaced for each tree of 6 inches or smaller in caliper size.
2. Provide one new tree of 6-inch caliper size for each tree being replaced that measures more than 6 inches in caliper size.
3. Species of Replacement Trees: Same species being replaced.

3.14 CLEANING AND PROTECTION

A. During planting, keep adjacent paving and construction clean and work area in an orderly condition. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.

C. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.

D. After installation and before Substantial Completion remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and Project site.

E. At time of Substantial Completion, verify that tree-watering devices are in good working order and leave them in place. Replace improperly functioning devices.

3.15 MAINTENANCE SERVICE

A. Maintenance Service: Provide maintenance by skilled employees of landscape Installer. Maintain as required in "Plant Maintenance" Article. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established, but for not less than maintenance period below:

1. Maintenance Period for Trees and Shrubs: 12 months from date of Substantial Completion
2. Maintenance Period for Ground Cover and Other Plants: Six months from date of Substantial Completion

B. For Bioretention Areas: Follow state guidelines for maintenance practices, including by not limited to pest management, watering newly planted plant materials, pruning, erosion and sediment control, raking and replacing mulch, debris clean up, weeding and periodic soil testing. Even the most porous soil can clog from accumulated debris and sediment.

END OF SECTION 329300

SECTION 6000
WATER DISTRIBUTION SYSTEM

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6010 WATER DISTRIBUTION PIPE

A. DESIGN

1. The following Standard Specifications and associated Detail Drawings shall apply to all water system extensions and development of the Cary municipal water system. The Standard Specifications and Detail Drawings included herein shall apply to all aspects of the Cary water system that extend into Morrisville, RTP, Wake County, Chatham County, and any other areas outside the corporate limits in which the water system is otherwise owned, operated and maintained by Cary.

   All utility extension permits must be obtained prior to construction. Refer to General Provisions in Section 2000 for further requirements.

2. Location: Water transmission lines shall be located and sized in accordance with the current "Water System Master Plan" or as directed by Cary and shall extend to the adjacent properties to provide an adequate network. All public water mains shall be located under the roadway within dedicated right of way or dedicated easements with a minimum width of 20 feet. Dedicated easements for water mains and appurtenances shall be recorded as "Cary Utility and Pipeline Easement." Cary utility and pipeline easements shall contain only Cary utilities unless otherwise approved by an approved development plan or encroachment agreement. See Section 2100 for allowable landscape plantings within a Cary easement.

3. Easement Areas: No permanent structures, equipment, retaining walls, embankments, impoundments, or other elements that would inhibit maintenance operations shall be constructed within a utility and pipeline easement. Fences may be allowed across easements provided that appropriate access gates have been installed to allow utility maintenance. Fill or cut slopes greater than 5:1 are not allowed to extend into easements

4. Sizing: Major transmission lines shall be sized in accordance with the "Water System Master Plan" or as directed by Cary. Six (6) inch mains may be used on a case-by-case basis when Cary has determined that a good grid exists and the existing network supports using six (6) inch mains. The total maximum length of 6 inch and 8-inch lines, without connecting to a larger main, is 1200 feet and 2000 feet, respectively. Four (4) inch water mains are permitted on residential cul-de-sacs less than 400 feet long. Where the existing network is lacking connectivity, lines shall be upsized to provide adequate fire flow as directed by the Director of Utilities. All lines shall be designed in accordance with Policy Statement 129, Minimum Water Supply Pressure.

5. Second Connection Required: In support of Cary Standard Operating Procedure 008, a second connection to the distribution system is required for any development proposing 100 or more service connections.

6. . No service taps are allowed on a fire hydrant line.

7. Construction involving Existing Mains:

   a) The existing water main must remain active and protected during all phases of construction. The contractor must provide a plan for the structural protection of the existing water main.

   b) A proposed construction sequence must be submitted for any demolition of a portion of existing water main. The plan must be reviewed and approved by Utilities and Public Works.

8. Restraint:

   All valves and fittings shall be restrained. Pipe joints shall also be restrained an adequate length away from valves and fittings in accordance with AWWA manual M41 (or the latest edition of *Thrust Restraint Design for Ductile Iron Pipe* as published by the Ductile Iron Pipe Research Association). The standard joint restraint method shall be to use manufacturer provided restrained joint pipe and fittings. Pipe up to and including 12-inches in diameter may also utilize either mechanical joint pipe with approved wedge action retainer glands (for the specified distance) or reaction blocking at fittings as an alternative.

   a) 4" to 8" Diameter Pipe: For pipe 4-inches through 8-inches, the following table may be used to determine the required restrained length of pipe for single occurrences of valves or fittings within the pipe system. The table may not be used for combined bends or offsets where a series of fittings occur. In lieu of using the below table, a pipe restraint plan detailing all assumptions and calculations may be provided by the NC Professional Engineer sealing the plan drawings. In either case, the method of restraint to be used and the length of pipe to be restrained (if applicable) shall be clearly identified on the plans at all necessary locations.

Required Restrained Lengths for Single Fittings and Valves for Pipe 4-inches to 8-inches in Diameter (in Feet, Both Directions unless otherwise noted)

	4"	**6"**	**8"**
90° Horizontal	59'	84'	108'
90° Vertical Up	59'	84'	108'
90° Vertical Down	91'	130'	168'
45° Horizontal	24'	35'	45'
45° Vertical Up	24'	35'	45'
45° Vertical Down	38'	54'	70'
22½° Horizontal	12'	17'	21'
22½° Vertical Up	12'	17'	21'
22½° Vertical Down			

	18’	26’	33’
11¼° Horizontal **11¼° Vertical Up** **11¼° Vertical Down**	6’ 6’ 9’	8’ 8’ 13’	11’ 11’ 17’
	4”	**6”**	**8”**
Tee ***(Restrain the Branch)***	89’	*4” branch* – 88’ *6” branch* – 128’	*4” branch* – 87’ *6” branch* – 127’ *8” branch* – 166’
Reducer ***(Restrain Larger Pipe)***	N/A	67’	8” x 4” – 121’ 8” x 6” – 70’
Dead Ends (*Caps and Plugs*) & Inline Valves	91’	130’	168’

b) All pipe and fittings: **Projects with pipe diameters greater than 8-inches, polywrapped pipe, or combined bends must have a pipe restraint plan with the method of restraint to be used and the length of pipe to be restrained clearly identified on the plans at all necessary locations.** The pipe restraint plan must be calculated in accordance with AWWA manual M41 (or the latest edition of *Thrust Restraint Design for Ductile Iron Pipe* as published by the Ductile Iron Pipe Research Association). The plan must also account for the actual soil types that exist at the project site.

c) Valves: Inline valves, which are those valves greater than 10-feet from a waterline intersection, shall be restrained in a manner consistent with operation as a dead end. This includes restraining the valve to the pipe and restraining a sufficient number of pipe joints on both sides of the valve to accommodate dead end restraint. Valves located at waterline intersections (at tees and crosses) however shall only be restrained to the adjacent fitting. (*Note that the tee itself must still be restrained.)* In these cases, there shall be no joints between the valve and fitting. Restraint at intersections may be achieved by using stainless steel rods (through 16” diameter) or approved wedge action retainer glands (through 48” diameter).

d) Dead Ends: All MJ cap and plug fittings, including tapped caps, shall be restrained with approved wedge action retainer glands. The adjacent pipe shall be restrained the distances specified above (or on the sealed pipe restraint plan). Reaction blocking shall not be used to restrain caps and plugs.

Restraining systems not included within this Specification shall require written approval prior to utilization. All joint restraint products that include the means of restraint within the joint gasket shall be prohibited in Cary’s water system.

9. Depth of Installation:

All water mains shall have a minimum cover of 4 feet measured from the top of the pipe to the finished grade. When water lines are installed along a roadway they shall be installed at sufficient depth to maintain four (4) feet of cover to the subgrade of any future road improvements including potential vertical alignment changes.

10. Relation to Sanitary, Storm Sewers and Reclaimed Water Lines:

	Water	Storm water	Sewer (Gravity and Forcemain)	Reclaimed
Water	18-inches vertical	**Parallel Installations**: 10-feet horizontal **Crossings**: 18 inches vertical	**Parallel Installations:** 10 feet horizontally **Crossings:** 18-inches vertical separation water main over sewer	**Parallel Installations**: 10-feet horizontal and water line at least 18-inches above reclaimed **Crossings (water main over reclaimed water pipeline)**: Min. 18-in vertical separation
Storm water	**Parallel Installations**: 10-feet horizontal **Crossings**: 18 inches vertical		24-inches vertical	Min. 18-inches vertical.
Sewer (Gravity & Forcemain)	**Parallel Installations:** 10 feet horizontally **Crossings:** 18-inches vertical separation water main over sewer	24-inches vertical	7-feet horizontal separation, increasing with depth	**Parallel Installations:** 10-feet horizontal **Crossings (reclaimed water pipes over sewer pipes)**: 18-inches
Reclaimed	**Parallel Installations**: 10-feet horizontal and water line at least 18-inches above reclaimed **Crossings (water main over reclaimed water pipeline)**: Min. 18-in vertical separation	Min. 18-inches vertical.	**Parallel Installations:** 10-feet horizontal **Crossings (reclaimed water pipes over sewer pipes)**: 18-inches	18 inches vertical

a) Separation between Potable Water Mains and Sanitary Sewer Mains or Storm Sewers.

- Parallel Installations: 10-ft lateral separation (pipe edge to pipe edge) or minimum 5-ft lateral separation and water line at least 18-inches above

sanitary sewer line measured vertically from top of sewer pipeline to bottom edge of water main. In unique cases where the sanitary sewer and the water main are installed with at least 5-ft of lateral separation but less than 10-ft of horizontal separation, and less than 18-inches of vertical separation, both the water main and sanitary sewer shall be constructed of ductile iron pipe with joints in full compliance with water main standards.

- Crossings (Water Main over Sanitary or Storm Sewer): All water main crossings of sanitary sewer lines shall be constructed over the sewer or storm line in conformance with Cary Specifications. At a minimum, 18-inches of clearance shall be maintained between the bottom edge of the water main and the top edge of the sanitary or storm sewer main. If 18-inches of clearance is not maintained, the water main and sanitary sewer main shall both be constructed of ductile iron pipe with joints in conformance with water main construction standards. The sanitary sewer pipe shall be ductile iron the entire run from manhole to manhole. When the separation between pipelines is 18-inches or less, the void space between the pipes shall be filled with minimum 500-psi, quick setting, and non-excavatable flowable fill extending 3-ft on both sides of the crossing. Regardless of pipe material, at least 12-inches of vertical separation is required for both sanitary and/or storm sewer crossings of potable water mains.

- Crossings (Water Main under Sanitary Line): Allowed only as approved by Cary, when it is not possible to cross the water main above the sanitary line. At a minimum, 18-inches of separation shall be maintained, (measured from pipe edge to pipe edge) and both the water main and sanitary sewer shall be constructed of ductile iron in conformance with water main construction standards. The sanitary sewer pipe shall be ductile iron the entire run from manhole to manhole. If local conditions prevent providing 18-inches of clearance, then at least 12-inches of clearance shall be provided and the void space between the pipes shall be filled with minimum 500-psi, quick setting, and non-excavatable flowable fill extending at least 3-ft on both sides of the crossing.
- Crossings (Water Main under Storm Sewer Line): Allowed only as approved by Cary, when it is not possible to cross the water main above the storm sewer line. At a minimum, 18-inches of separation shall be maintained, (measured from pipe edge to pipe edge) and the water main shall be constructed of ductile iron in conformance with water main construction standards. If local conditions prevent providing 18-inches of clearance, then at least 12-inches of clearance shall be provided and the void space between the pipes shall be filled with minimum 500-psi, quick setting, and non-excavatable flowable fill extending at least 3-ft on both sides of the crossing.

b) Separation between Potable Water Mains and Reclaimed Water Mains

- Parallel Installations: Preferred 10-ft lateral separation (pipe edge to pipe edge) AND water line at least 18-inches above reclaimed water line measured vertically from top of reclaimed water pipeline to bottom edge of water main. Because all reclaimed water mains in Cary's municipal system are required to fully comply with water system testing and integrity standards as described by 15A NCAC 18C, when the 10-ft lateral separation standard cannot be met, a minimum of 3-ft lateral separation, shall be provided.

- Crossings (Water Main over Reclaimed Water Pipeline): All water main crossings of reclaimed water mains shall be constructed over the reclaimed water line in conformance with Cary Specifications. At a minimum, 18-inches of clearance shall be maintained between the bottom edge of the water main and the top edge of the reclaimed water main. When the minimum 18-inch clearance cannot be maintained, the reclaimed main shall be constructed of ductile iron pipe in conformance with water main construction standards extending at least 10-ft on both sides of the crossing. The void space between the pipes shall be filled with minimum 500-psi, quick setting, and non-excavatable flowable fill extending at least 3-ft on both sides of the crossing. Reclaimed water mains crossing more than 18-inches under potable water service lines may be constructed of either C900 or C905 PVC as typically required for reclaimed water pipeline construction.

- Crossings (Water Main under Reclaimed Water Pipeline): Allowed only on a case by case basis and design shall be approved by Cary prior to construction. At a minimum, 18-inches of separation shall be maintained and both potable water and reclaimed mains shall be constructed of ductile iron pipe in conformance with water main construction standards extending at least 10-ft on both sides of the crossing. If local conditions prevent 18-inches of clearance between the pipelines, the void space between the pipes shall be filled with minimum 500-psi, quick setting, and non-excavatable flowable fill extending at least 3-ft on both sides of the crossing.

B. MATERIALS

General: All water main distribution pipe shall be ductile iron and comply with NSF/ANSI/CAN 61-2021/NSF/ANSI/CAN 600-2021 Drinking water system components-Health Effects and latest revisions. Any newly installed ductile iron water mains larger than 12-inch in diameter shall be zinc-coated ductile iron pipe. The zinc-coated ductile iron pipe shall be sprayed with an arc-sprayed zinc per ISO 8179 zinc coating on the outside of the pipe and covered with an asphaltic topcoat. The mass of the zinc applied shall be 200 g/m2 of pipe surface area. A finishing layer topcoat shall be applied to the zinc. The coating system shall conform in every respect to ISO 8179-1 "Ductile iron pipes – External zinc-based coating – Part 1: Metallic zinc with finishing layer. Second edition 2004-06-01.

1. The Utilities Department maintains a list of approved manufacturers for all water distribution products. The zinc coated ductile iron pipe shall be manufactured by a manufacturer listed on Cary's Approved Products List. New manufacturers must submit requests for approval to the Utilities Department in accordance with Standard Procedure 120, Manufacturer Approval Guidelines.

2. Ductile Iron Pipe

   a) Ductile iron pipe shall be designed and manufactured in accordance with AWWA C150 and C151 and provided in nominal 18-ft or 20-ft lengths. The minimum required pressure ratings for ductile iron pipe and required laying conditions are tabulated below. For all other installations other than specified, the laying condition, bedding requirements or the minimum pressure class rating and/or thickness class shall be increased in accordance with AWWA C151. A pipe thickness design shall be submitted for external loading in all cases where the pipe depth exceeds the specified range of depths outlined in the following table.

Pressure Class, Max. Depth and Laying Condition for DI Water Mains

Pipe Diameter	AWWA C-150, Laying Condition	Pressure Class	Maximum Depth of Cover
4-8 -inch	type 1	350 psi	3-16 feet
4-8 -inch	type 4	350 psi	16-34 feet
10-12 -inch	type 1	350 psi	3-10 feet
10-12 -inch	type 4	350 psi	14-28 feet
10-12 -inch	type 5	350 psi	28-44 feet
14-20 -inch	type 4	250 psi	3-22 feet
14-20 -inch	type 5	250 psi	22-30 feet
14-20 -inch	type 5	350 psi	30-41 feet
24-30 -inch	type 4	250 psi	3-19 feet
24-30 -inch	type 5	300 psi	19-29 feet
24-30 -inch	type 5	350 psi	29-33 feet
36-42 -inch	type 4	300 psi	3-20 feet
36-42 -inch	type 5	350 psi	20-32 feet

Note: For cases not specified, a ductile iron pipe and bedding design certified by a Professional Engineer licensed in the State of North Carolina shall be required in compliance with AWWA C150 and the Ductile Iron Pipe Research Association.

   b) Pipe joints shall be mechanical joint or push-on type as per AWWA C111. Pipe lining shall be cement mortar in accordance with AWWA C104. All buried

ductile iron pipe shall have a bituminous exterior coating in accordance with AWWA C151.

3. Ductile Iron Fittings
   All ductile iron fittings shall be provided in conformance with AWWA C110 for standard ductile iron fittings and AWWA C153 for compact ductile iron fittings. All fittings shall be pressure rated for a minimum 350-psi through 24-inches in diameter and 250-psi for fittings greater than 24-inches in diameter. In cases where minimum pressure standards are less than the pipe specification, fittings shall always be pressured rated to meet or exceed the pressure ratings for the specified pipe. All fittings for potable water service shall be provided with cement mortar linings and asphaltic seal coats in accordance with AWWA C104. All ductile iron fittings shall have an asphaltic exterior coating in accordance with AWWA C151. All ductile iron fittings shall be provided with mechanical joint end connections or proprietary restrained joints from an approved manufacturer. Gaskets shall be provided in conformance with AWWA C111 with EPDM rubber gaskets preferred over SBR.

4. Restrained Joint Ductile Iron Pipe
   All restrained joint ductile iron pipe unless otherwise specified shall be of the boltless restrained joint type. For installations requiring welded locking rings, the rings shall be factory welded. The restrained joints shall provide a minimum of 4-degrees of deflection for pipe sizes, 4-inches through 12-inches in diameter.

   All proprietary pipe restraint systems shall be approved by Cary and provided in compliance with all standards for coatings, linings, pressure classes, etc. as required for ductile iron pipe. All restrained joint pipe shall be installed based on laying conditions, pressure class, etc. as required for typical ductile iron pipe.

C. INSTALLATION

1. Ductile iron pipe shall be installed in accordance with the requirements of AWWA C600 and the Ductile Iron Pipe Handbook published by the Ductile Iron Pipe Research Association. Materials at all times shall be handled with mechanical equipment or in such a manner to protect them from damage. At no time shall pipe and fittings be dropped or pushed into ditches.

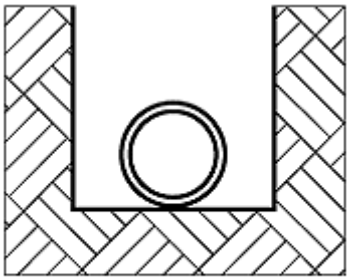
2. Pipe and fitting interiors shall be protected from foreign matter and shall be inspected for damage and defects prior to installation. In the event foreign matter is present in pipe and fittings, it shall be removed before installation. Open ends of pipe shall be plugged or capped when pipe laying is not in progress.

3. All pipe shall be constructed with at least 48 inches of cover below the finished surface grade. Pipe shall be laid on true lines as directed by the Engineer. Trenches shall be sufficiently wide to adjust the alignment. Bell holes shall be dug at each joint to permit proper joint assembly. The pipe shall be laid and adjusted

so that the alignment with the next succeeding joint will be centered in the joint and the entire pipeline will be in continuous alignment both horizontally and vertically. Pipe joints shall be fitted so that a thoroughly watertight joint will result. All joints will be made in conformance with the manufacturer's recommendations for the type of joint selected. All transition joints between different types of pipe shall be made with transition couplings approved on shop drawings showing the complete assembly to scale.

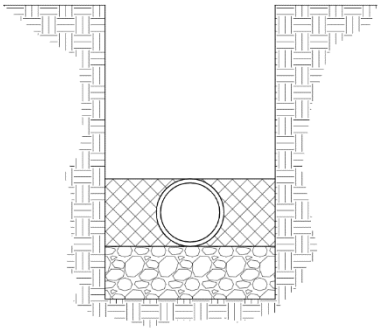
4. Pipe shall be installed at laying conditions as specified by the plans. Laying conditions for ductile iron pipe shall be as described in AWWA C151 and the Ductile Iron Pipe Research Association. Laying conditions shall be defined as follows:

   Type 1: Flat Bottom Trench with Pipe Resting on Stable Undisturbed Earth. Unstable conditions such as wet trench bottoms, intermediate rock layering, partially weathered rock, and other unsuitable soil conditions shall require utilizing more stringent laying conditions. At a minimum, Type 4 laying condition shall be utilized with a minimum of 4-inches of bedding to overcome unstable conditions. For severe unstable soil conditions, undercut excavation and an engineer designed foundation plan shall be provided prior to pipeline installation.



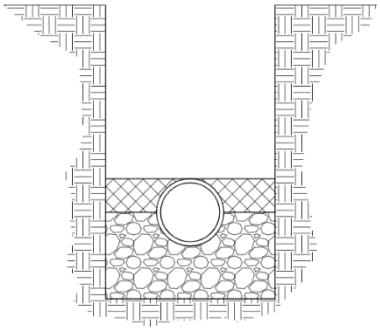
Type 1*

   Type 4: Pipe bedded in Class 1 material, No. 67 or No. 78 crushed stone to a depth of 1/8 pipe diameter or a minimum of 4-inches. Embedment material, consisting of Class 1, Class 2 or Class 3 materials, (as defined in Section 7000), shall be compacted greater than 95% Proctor to the top of the pipe. Careful attention must be allocated to compacting embedment material under the bottom edges of the pipe.



Type 4

Type 5: Pipe bedded in Class 1 material, No. 67 or No. 78 crushed stone to the center of the pipe and extending a minimum of 4-inches under the pipe. Granular or select embedment, consisting of Class 1 or Class 2 materials, compacted to greater than 95% Proctor installed to the top of the pipe.



Type 5

5. For installations below the water table, a single layer of engineering fabric shall be installed between the pipe and trench floor/trench wall. The fabric shall fully encapsulate the waterline, bedding, and embedment material with a minimum of 12-inch overlap at the top of the embedment material.

6. Prior to beginning construction, the Contractor shall contact local utility companies and verify the location of existing utilities. The Contractor shall be completely and solely responsible for locating all existing buried utilities inside the construction zone before beginning excavation. The Contractor shall be solely responsible for scheduling and coordinating the utility location work. When an existing utility is in conflict with construction, it shall be exposed prior to beginning construction to prevent damage to the existing utility.

7. All valves that are under the ownership and acceptance of Cary's municipal water system shall be operated only by trained personnel of Cary. Existing valves in

Cary's water system will not be operated without a minimum notice of 24 hours to the Engineer and the Public Works Department. Contractor's personnel shall only be responsible for operating valves within new construction areas that are not directly connected with the existing municipal water supply. At such time when the valves in new construction areas are connected with the municipal water supply, the valves shall only be operated by Cary personnel or in limited circumstances by Contractor's personnel after receiving authorization from the Operator in Responsible Charge of the water distribution system. For all other cases, the Contractor shall operate valves only in accordance with Cary Policy Statement No. 49, Water Valves, Control of Closing and Opening.

D. PIPE IDENTIFICATION AND MARKING

1. Marking Tape
   a) Installation: Marking tape shall be installed continuously and longitudinally along all water mains and water services for new construction and for any repair or retrofit construction using open trench methods. For service connections, the marking tape shall extend from the main line to the water meter. Marking tape shall be installed directly above the center of the pipe and at least 24-inches deep from final grade to a maximum depth of 36-inches below final grade.

   b) Specifications: The water main marking tape shall be an approved product identified in Cary's Approved Products List. The marking tape shall be made of polyethylene (or approved equivalent) material, 6-inches wide and a minimum of 6 millimeters thick. The marking tape shall have detectable markers embedded in the tape and spaced adequately to provide continuous detection along the tape from above the buried pipe at final grade. The tape shall be blue in color and shall be marked with words "CAUTION WATER LINE BURIED BELOW" (or an approved equivalent wording). The wording shall be repetitive along the full length of the tape.

2. Marker Balls
   a) Installation: Non-programmable marker balls are required at the ends of all casing pipe and at reducers. They shall also be installed along and directly above all water mains in conditions where marking tape cannot be installed due to restrictions or conflicts. In these conditions, non-programmable marker balls shall be placed, at all vertical and horizontal deflection points, at all tees and crosses and at a spacing along the main no greater than 100 feet apart. Each marker ball shall be installed directly above the center of the pipe and at least 24-inches deep from final grade to a maximum depth of 36-inches below final grade. Any sections where tape cannot be accurately placed at time of backfilling sufficient survey data shall be collected to reestablish location for tape installation.

   b) Specifications: The Marker Ball is a non-programmable ball and shall be an approved product identified in Cary's Approved Products List. The marker ball

shall be blue in color for potable water and conform to APWA standards. It shall have a minimum detectable depth of 5 feet.

6020 FIRE PROTECTION

A. FIRE HYDRANTS

1. Location

   a) All fire hydrants shall be installed on a minimum 6-inch public water line. New fire hydrants are not permitted on private water lines. Only one fire hydrant may be installed when the line is served by a 6-inch tap and is not looped to another main. There shall be at least one fire hydrant at each street intersection. The minimum acceptable flow for fire hydrants is 1000-gpm at minimum 20-psi residual in residential areas and 1500-gpm at minimum 20-psi residual in other districts. Hydrants at intersections shall be located in accordance with the Standard Details. Valves provided on the fire hydrant branch supply line shall be located within 5-ft of the main line.

   b) In residential districts the maximum distance between hydrants, measured along street centerlines, shall be 500 feet. When residential intersections are less than 700 feet apart, a hydrant is not required between the intersections.

   c) In business, office and institutional, and industrial zoning the maximum distance between hydrants, measured along street centerline, shall be 300 feet. When business, office and institutional, and industrial intersections are less than 450 feet apart, a hydrant is not required between intersections

   d) On thoroughfares and collector streets with access points only at street intersections, hydrants shall be located at each street intersection and at 1000-foot intervals along the street. Where these intersections are less than 1200 feet apart, no hydrant is required between the intersections. Fire hydrants shall be placed in a staggered arrangement on both sides of any roadway classified as a major or minor thoroughfare with the hydrant spacing as referenced above.

   e) Where sprinkler systems are used, a fire department connection shall be within 50 feet of an accessible fire hydrant except within the *Business Improvement District* where greater lengths may be permitted. See Section 6020 B for other sprinkler system requirements.

2. Specifications: Hydrants shall conform to AWWA C502 with a minimum valve opening of 4 1/2 inches. Hydrants shall be furnished with a 4 1/2-inch steamer* and double 2 1/2 inch hose connections with caps and chains, National Standard Threads, mechanical joint, 1 1/2 inch pentagon operating nut, open left, painted fire hydrant red, bronze to bronze seating, a minimum 4 foot bury depth with a

break away ground line flange and break away rod coupling. The hydrant bonnet will be designed with a sealed oil or grease reservoir with O-ring seals and a Teflon thrust bearing. Fire hydrant caps shall be attached to the body of the hydrant with a minimum 2/0 twist link, heavy duty, non-kinking, machine chain. All fire hydrants shall be designed and rated for a working pressure of 250-psi or greater.

***** For hydrants located within the Town of Morrisville only: Where Fire Department Connections are provided to buildings, the hydrant closest to the FDC shall be supplied with a 5-inch Storz connection in lieu of the 4 1/2 inch steamer connection. The Storz connection shall be by the hydrant manufacturer only and come as part of the hydrant assembly. No adapters for the Storz connection are allowed.

3. Installation: Hydrants shall be set plumb, properly located with the pumper nozzle facing the closest curb of a fire lane or street, but not a parking space. The back of the hydrant opposite the pipe connection shall be firmly blocked against the vertical face of the trench with 1/3 cubic yard of concrete. Double bridle rods and collars shall be connected from the tee to the hydrant. All joints between the tee and the hydrant shall be mechanical joints restrained with wedge action retainer glands. Stainless steel rods not less than 3/4 inch diameter may also be used to restrain the assembly. A minimum of 8 cubic feet of stone shall be placed around the drains. The backfill around the hydrants shall be thoroughly compacted and closely match the elevation on the approved plans. Hydrant extensions will not be allowed on new or retrofit installations. Hydrant installation shall be in accordance with Cary Standard Details. Hydrant tees may be used upon approval of the Utilities Department.

4. Depth of Bury:

   Typical 90-Degree Hydrant Shoe Installations:
   The maximum depth of bury for all new fire hydrants with 90-degree hydrant shoes shall be 5-ft from the breakaway flange connection. The breakaway flange or safety coupling shall be oriented vertically just above finished grading and bolted directly to the fire hydrant in compliance with manufacturer standards. The breakaway flange or safety coupling shall not be buried.

   Vertical Shoe Hydrant Installations:
   For installations requiring depth of bury greater than 5-ft, the fire hydrant shall be equipped with a vertical shoe arrangement that provides for full extension of the lower valve plate against a stopping mechanism located inside the vertical shoe to maximize hydraulic flow conditions through the hydrant. The vertical shoe shall be equipped with flanged connections. The maximum depth of bury for vertical shoe installations shall not exceed 4-ft measured from the breakaway flange to the bottom of the vertical hydrant shoe. The vertical shoe and all piping included in the hydrant supply line shall be restrained with blocking and rodding or blocking with wedge action retainer glands or standard Aquagrip connections.

In all cases where the vertical shoe is utilized, typical washed stone bedding extending at least 12-inches on all sides of the central axis and extending from the top of the vertical shoe downward to at least 12-inches below the vertical shoe shall be provided surrounding the vertical hydrant shoe assembly to assure positive drainage. In cases where Aqua-grip connections are not utilized, piping below the vertical shoe shall be provided in a flanged by plain end configuration and restrained with wedge action retainer glands to the lower mechanical joint fitting or the lower fitting shall be blocked and rodded to the vertical shoe connection. The entire assembly shall be restrained and support blocking shall be provided under the vertical bend assembly.

5. Hydrant Relocations: For installations where hydrants will be relocated, all hydrants with greater than 10-years of operational service, as indicated by the date of manufacture provided on the hydrant, shall be replaced with new fire hydrants. The existing fire hydrant shall be turned over to Cary's Public Works Department.

   For installations where the hydrant to be relocated has less than 10-years of operational service, the existing hydrant may be relocated. The existing hydrant shall still be disinfected, flushed and pressure tested.

B. AUTOMATIC FIRE SPRINKLER SYSTEMS

1. General: Working plans and calculations for all automatic fire sprinkler and standpipe systems shall be submitted to Cary's permitting department through the electronic plan review portal for review and approval before installation. If 20 sprinkler heads or more are modified or added to an existing sprinkler system, if any modifications occur in the hydraulically calculated remote area, or the hazard classification changes, a plan submittal including complete calculations and a permit will be required. All fire sprinkler systems shall be installed with an alarm check valve installed in each riser with all required appurtenances (example: retard chamber, water motor gong, pressure gauges, etc.). Exception: NFPA 13 D and 13 R residential sprinklers when approved by a fire official. All installations, minor repairs, or minor replacements shall be performed by a licensed fire sprinkler contractor. Contact the Inspections and Permits Department for a permit application.

2. Design: Approved working plans shall be in complete compliance with NFPA No. 13, 13D, 13R, 14, 16, 20, 22, 24 and Cary Specifications. An NFPA above ground material and test certificate and NFPA underground material and test certificate are required after completion of designated, approved work.

3. Hydraulic Design: If a system is hydraulically designed, the following design criteria must be followed:

a) Safety Margin: In all cases, a fixed minimum safety margin of at least 10-psi shall be applied to the design calculations. (Example: Demand = 70 psi, Supply ≥ 80 psi)

b) Hose Allowances: Both exterior and interior hose allowances shall comply with NFPA 13 requirements.

c) Water Supply Pressure: The sprinkler system designer shall be responsible for verifying system pressure. Refer to Cary Policy Statement 129 regarding Minimum Water Supply Pressure.

4. Backflow Prevention: When a fire protection system is proposed, with a Fire Dept. connection or as otherwise required by the Cross Connection Ordinance a reduced pressure principle detector assembly (RPDA) shall be installed on the supply side of the sprinkler fire protection line inside the riser room. These backflow prevention devices must be UL listed and/or listed by Factory Mutual Research Corporation. Reduced pressure principle detector assemblies shall not be arranged vertically. For all RPDA's, a relief valve fill cup piped outside the building shall be provided. The relief valve drain may be piped to the main building drain.

5. Post Indicator Valve (PIV): A post indicator valve shall be provided at the right of way or edge of easement no more than 40 feet from the building if space permits. Each connection into the building shall have a post indicator valve. The top of the PIV shall be 30-42 inches above finished grade and 36-inches of unobstructed access perimeter shall be maintained around the PIV. See Cary's Approved Backflow List at www.Townofcary.org.

   In urban settings, a wall mounted indicator valve may be used where there is no suitable location for a post mounted indicator valve. Wall mounted indicator valves shall be centered 30–42 inches above the finished grade. It shall be greater than 10-ft from any door, window, or other protected opening along the wall.

   All indicator valves regardless of type shall have an electronically controlled tamper switch. All PIVs shall be made of ductile iron construction and shall be UL listed and FM approved. The stand pipe of all PIV's shall be painted red. Cary shall maintain up to the post indicator valve. Where wall mounted indicator valves are used, Cary shall maintain up to a location 10 feet outside of the building or as designated on the approved plans.

6. Fire Department Connection: Where standpipe systems or combination sprinkler/standpipe systems are used, a fire department connection with 5-inch Storz connections shall be provided within 50-ft of an approved fire hydrant. All 5-inch Storz FDC's shall be installed in accordance with Cary Standard Detail 6000.35 or 6000.36.

a) Except, where buildings are only protected by automatic fire sprinkler systems, a 2.5-inch Siamese fire department connection with National Standard threads shall be provided within 50-ft of an approved fire hydrant, except for townhomes, apartment buildings, and within urban settings where greater lengths may be permitted. All 2.5" Siamese FDC's shall be installed in accordance with Cary Standard Detail 6000.28.

b) When a sprinkler system serves only part of a large structure, the fire department connection shall be labeled, with minimum 2-inch letters on a permanent sign, as to which section of the structure that sprinkler riser serves.

c) Automatic sprinkler systems and/or standpipe systems that require 150 psi and above, shall have a sign indicating the pressure required at the inlets to deliver the system demand at all Fire Department Connections.

7. Dedicated Riser Room: A dedicated sprinkler riser room is required providing an entry door to the room from the exterior of the building. All dedicated riser rooms shall be equipped with a floor drain sized appropriately to prevent flooding. The floor drain shall be piped to storm system or main building drain. The floor drain shall be provided with a circular raised ring/hub around the floor drain to prevent debris and/or chemicals from entering the drain during an emergency spill. The hub shall be fabricated of cast iron or other corrosion resistant material and extend at least 3-inches above floor elevation.

8. Alarm Communication: All sprinkler systems are to have alarm communication equipment to fully comply with NFPA 72. Equipment must be fully functional and reporting to a UL listed central receiving station before a Certificate of Occupancy is issued for the facility.

9. Access: All buildings which have an elevator, a fire alarm system monitored by a central receiving station, or a fire sprinkler protection system shall provide a "Knox Box" key entry system (Knox Co.). This "Knox Box" shall be mounted on the exterior entrance to the dedicated riser room or at the normal fire department entrance when no fire sprinkler system is provided and there is no dedicated riser room. Mount "Knox Box" on wall at 5 feet A.F.F. on door handle side of dedicated riser room door or entrance door. This "Knox Box" shall be ordered through the Cary Fire Department and shall be in place before a Certificate of Occupancy is issued. Keys to access the facility shall be provided to the Fire Department by the owner/manager.

10. Identification: The exterior door leading to the dedicated sprinkler riser room shall be labeled with minimum 2-inch lettering designating "SPRINKLER RISER ROOM" in a contrasting color. Durable vinyl lettering is suggested.

11. Fire Alarm Panel Location: When a building is protected by an automatic sprinkler system and has a fire alarm system, the fire alarm control panel or a remote annunciation of the fire alarm control panel shall be placed in the sprinkler riser room. This control panel shall have the capacity of silencing and resetting. Adjacent to the fire alarm control panel shall be a framed zone map. Nomenclature shall correspond with the zone map. All plans and specifications must be submitted to Cary's permitting department through the electronic plan review portal for approval prior to installation of equipment or wiring. When there is no sprinkler system in a building, the fire alarm control panel or remote annunciator shall be located at the normal fire department entrance.

C. FIRE PROTECTION DURING CONSTRUCTION

The fire protection water supply system, including fire hydrants, shall be installed and be in at least the functional status prior to placing combustible materials on the project site. In addition, functional status includes adequately installed and maintained access to the construction project, with the first layer of asphalt installed. If phased construction is planned, coordinated installation of the fire protection water system is permitted. Coordination of the water system will be done through the Utilities Department. Functional status would include meeting all standards set forth in Section 6060 "Testing and Inspections".

6030 VALVES AND APPURTENANCES

A. VALVES

1. General

a) Valves shall be installed on all branches from feeder mains and hydrants according to the following schedule: 4 valves at crosses; 3 valves at tees; one valve on each hydrant branch and elsewhere as directed by the Director of Utilities. When a loop section of water line is connected back into the feeder main within a distance of 200 feet or less, only one valve will be required in the feeder main. In all cases where new water mains are connected to an existing water distribution line, valves shall be located at all end points and at intermediate points throughout the new system extension to assure testing requirements can be met without interfering with the operation of the existing system.

b) Where no water line intersections are existing, a main line valve shall be installed at every 100 feet per 1 inch diameter main up to a maximum distance of 2000 feet between valves.

c) Valves shall be properly located, operable and at the correct elevation. The maximum depth of the valve nut shall be 6 feet without an extension kit. When valve extension kits are used, they must be manufactured by the same company which manufactured the valve.

2. Combination Air Valves

a) Combination air valves shall be provided to purge air from the system at startup, vent small pockets of air while the system is being pressurized and running, and prevent critical vacuum conditions during draining. Combination air valves rated for potable water use shall be installed at all high points of water lines 8 inches in diameter or larger and at other locations such as major changes in grade as directed by Cary. A high point shall be determined as any high location where the difference between the high elevation and adjacent low elevation exceeds 10-ft, unless otherwise determined by the Director of Utilities based on special circumstances.

   All combination air valves shall be provided in conformance with AWWA C-512. The water main shall be installed at a grade which will allow the air to migrate to a high point where the air can be released through an air valve. A minimum pipe slope of 1 foot in 500 feet should be maintained.

b) The combination air valve shall be sized by the Engineer and approved by Cary. Combination air valves shall be of the single housing style with Type 304 or 316 stainless steel body that combines the operation of both an air/vacuum and air release valve. The valve shall be rated for minimum 230 PSI working pressure. The combination air valve shall be provided with cylindrical shaped floats and anti-shock orifice made of high-density polyethylene. Combination air valves with spherical floats shall not be accepted. All combination air valves shall be installed in accordance with Cary Standard Details.

c) 2-inch combination air valves shall be installed in a standard 4-foot diameter eccentric manhole. The 2-inch valve shall have a 2-inch male NPT inlet. Connection to the main shall be with a saddle tap in the same sizing as the combination air valve assembly and isolated with a gate valve also of the same size. The isolation gate valve shall be provided with NPT threads and connected with “no lead” brass (meeting UNS C89833 as per ASTM B584) or bronze piping. Brass or bronze ball valves may be used in lieu of gate valves for 2-inch installations. The isolation valve shall be rated for 200-psi service or greater.

d) Combination air valves 3-inches and greater shall be installed in a flat top manhole sized according to the water main diameter. Mains less than or equal to 20” shall utilize a 5-foot diameter manhole and larger mains shall utilize a minimum 6-foot diameter manhole. All connections shall be by flange joints. Connection to the main shall be by an MJ x FLG tee with the branch diameter equal to at least half of the main diameter. If needed due to larger diameters, a flanged reducer shall be provided prior to the flanged gate valve sized equally to the flanged combination air valve.

e) Precast concrete manholes shall meet the requirements of section 7020. Manholes shall be provided without steps.

3. Gate Valves, less than 4-inches for Blowoff Assemblies

Gate valves for blowoff installations sized smaller than 4-inches, shall be resilient seated wedge type with a non-rising stem and a 2-inch operating nut in compliance with AWWA C509. The smaller diameter gate valves shall be provided with triple O-ring seals and threaded end connections in compliance with ANSI B2.1. Gate valves smaller than 2-inches shall be identified "no lead" and consist of brass components designated under UNS C89833 as per ASTM B584. The small diameter gate valves shall be rated for a minimum pressure rating of 200-psi.

4. Gate Valves, 4-inches to 12-inches

All valves for potable water applications, 12-inches in diameter and smaller shall be resilient seated wedge gate valves in conformance with the requirements of AWWA C509, (grey or ductile iron body) or AWWA C515, (reduced wall ductile iron body). All coating materials used in the construction of gate valves for potable water applications must comply with NSF 61 to assure lead free construction. All gate valves shall be designed for a working pressure of 250-psi with a minimum UL listing and FM approval rating of 200-psi. Gate valves shall be fusion bonded epoxy (FBE) coated both interior and exterior at a nominal thickness of 6-8-mils and the FBE coating shall be provided in conformance with AWWA C550. All gate valves shall be assembled with stainless steel bolts.

All gate valves 12-inches in diameter and smaller shall be installed in the vertical position and shall be provided with mechanical joint fittings. Gate valves shall be restrained by wedge action retainer glands or other approved manufacturer provided restraining systems. All gate valves shall open left with a non-rising stem (NRS) and be provided with a 2-inch square operating nut. All gate valves shall be constructed with triple O-ring seals in which 2 O-rings are located above the thrust collar and 1 O-ring is located below the thrust collar. The two upper O-rings shall be replaceable with the valve fully open and subjected to full rated working pressure.

The gate valve wedge shall be fully encapsulated in rubber. All valves shall be rated for bi-directional flow. All sealing gaskets shall be made of EPDM rubber materials.

5. Gate Valves, 14-inches through 48-inches

Gate valves 14-inches through 48-inches shall be resilient seated wedge gate valves in conformance with the requirements of AWWA C515, (reduced wall ductile iron body) and shall comply with all Specifications outlined for gate valves 4 through 12 inches. Gate valves installed vertically shall be provided with a

minimum of 2-ft of overhead clearance between the top of the operator nut and the finished grade. All gate valves 18-inches and greater shall be provided with a geared actuator. Vertical gate valve installations shall have spur gear actuators and horizontal installations shall have bevel gears.

Gate valves 18 inches in diameter shall be provided with a gear operator at a minimum 2:1 ratio and larger valves through 24-inches shall be provided with a gear operator at a minimum 3:1 ratio.

Gate valves installed in a horizontal position shall only be provided as permitted by the Director of Utilities for special circumstances where vertical alignment is not possible. All horizontal gate valves shall meet or exceed the Specifications outlined herein for vertical gate valves including the 250-psi pressure rating. All horizontal gate valves shall be equipped with bevel gears resulting in a minimum 4:1 turn ratio for valves 30 through 48-inches in diameter.

6. Insertion Valves, 12-inches and under: Insertion valves shall only be used as permitted by the Utilities Department. Insertion valves shall meet the requirements of AWWA C515, seat on the valve body and be rated for a working pressure of 250-psi or greater. All insertion valves shall be made of ductile iron in conformance with ASTM A-536 Grade 65-45-12 and epoxy coated at a minimum of 10-mils. Insertion valves under this section are available for pipe sizes through 12-inches in diameter. Larger insertion valves shall meet requirements for Insertion Valves, 16-inches through 24-inches, below. In cases where insertion valves are being installed to shut down water to a work zone area, the insertion valve shall be located a minimum of 100-ft from the work zone or greater as determined by the Engineer of Record to assure the insertion valve can safely operate as a dead end without dislodging from the pipeline or otherwise causing the existing pipeline to shift.

7. Insertion Valves, 16-inches through 24-inches: Insertion valves shall only be used as permitted by the Utilities Department.

8. Valve boxes

   a) Valve Boxes shall be cast iron, screw type, with a 5-inch opening, and "water" stamped on the cover. The cover shall be 6-inches in depth. All valve box assemblies and covers shall be cast from Class 35 gray iron and domestically made and manufactured in the USA.

   b) Valve box ring adjustments will not be allowed. The valve box shall be centered over the wrench nut and seated on compacted backfill without touching the valve assembly. All valve boxes in pavement shall be flush with the top of the pavement or flush with the finished grade. Outside of paved areas precast concrete valve box encasements or a trowel finished 2' x 2' x 6" pad of 3000-psi concrete may be used for valve box encasement provided the assembly is

buried flush with the surface grade and compacted properly to prevent movement of the precast encasement.

9. Actuators: All valves shall be provided with standard 2-inch operating nuts. Unless otherwise specified, the direction of rotation to open the valves shall be to the left, (counterclockwise), when viewed from the top. Each valve body or actuator shall have cast thereon the word "OPEN" and an arrow indicating the direction to open.

B. APPURTENANCES

1. Blowoffs:

   a) Blowoffs shall be a minimum of 2 inches and installed at the end of all dead-end water lines. Where there is not sufficient pressure or fire hydrants to thoroughly flush the system, a larger blowoff shall be required.

   b) Blowoff Assemblies shall be constructed as shown in Cary Standard Details. The valves shall be gate type with a non-rising stem and a 2-inch operating nut, O-ring seals and screwed ends. A full-size gate valve is required on water mains that are planned to be extended.

2. Reaction Blocking: Material for reaction blocking shall be 3000 psi concrete, poured in place. The reaction areas are shown in Cary Standard Details. A minimum 4 mil plastic shall cover the fitting to ensure that no concrete will interfere with removal of the fitting.

3. Rodding: All rodding shall be constructed with type 304 stainless steel rods at the number and sizing specified in the following table. Rod coupling shall not be allowed. All hardware shall also be stainless steel type 304.

   Stainless Steel Rod Requirements are as follows:

4-inch branch	2, ¾-inch stainless steel rods
6-inch branch	2, ¾-inch stainless steel rods
8-inch branch	4, ¾-inch stainless steel rods
12-inch branch	6, ¾-inch stainless steel rods
16-inch branch	8, ¾-inch stainless steel rods

4. Wedge Action Retainer Glands:
   All wedge action retainer glands shall be manufactured as a one-piece retainer gland for use with mechanical joints and shall be rated to provide restraint up to 350-psi pressure rating for sizes through 16-inches. For sizing above 16-inches, the wedge action retainer gland shall be rated to provide restraint up to 250-psi. Approved wedge action retainer glands shall be made of ductile iron, coated with a manufacturer applied epoxy coating or polyester powder coating.

In cases where wedge action retainer glands are approved for pipe restraint of fire hydrant supply lines or other applications, the entire hydrant supply line shall be restrained.

Wedge action retainer gland connections to push on pipe are not approved.

5. Sampling Stations:
   Sampling Stations shall be provided at all new residential and commercial development areas at the rate of 1 sampling station per development complex consisting of at least 200-homes or 1- per 10 acre or greater commercial complex or 1 per institutional facility with more than 100,000 square feet or as otherwise required by the Director of Utilities. Padlocks for sampling stations shall be provided by Cary's Public Works Dept. The sampling station requirement may be waived in cases where area sampling is already deemed sufficient by the Water System Operator.

Sampling stations shall be provided as a self-contained manufactured assembly with locking aluminum housing, stainless steel tube and unthreaded spigot.

6040 WATERMAIN TAPS AND SERVICES

A. DESIGN

1. Individual water services shall be provided from the main to each water meter for single family residences in accordance with the Details. All connections shall be made by wet taps. Service connections shall be made perpendicular to the main and shall run straight to the meter.

2. Individual taps to the main shall be provided for the domestic service, fireline service and hydrant lateral in accordance with the Standard Details.

3. All water service lines shall be installed with a minimum depth of cover of 24-inches or greater.

4. All water meter boxes and vaults shall be located at the edge of the serviced lot's right of way or easement. Water meter boxes shall not be placed in streets, sidewalks, parking areas or obstructed by fencing or buildings. A 10-foot clear zone shall be maintained behind meter boxes and vaults. In addition, within townhouse developments, water services shall be located within 4-feet of driveways in order to minimize conflicts between service lines and trees.

5. All meter boxes shall be protected during construction by installation of tree protection fencing or some other acceptable material. Material will be adequately maintained throughout the construction period to prevent damage and contamination of the sewer system.

6. Provisions for backflow prevention shall be in accordance with existing Cary policies and the NC Plumbing Code.

7. The water meter shall be sized based on water demand. All water service lines shall be minimum 1 inch diameter. Multiple branches up to a maximum of 2 potable water services per multiple branch assembly for a single residential use shall be sized by the Engineer of Record in accordance with AWWA M22 but shall not be less than 1.5-inches in diameter. Gang Service Boxes are prohibited.

8. Service taps 2 inches or less to existing water lines shall be made by Cary except if approved on development plans. Service taps greater than 2 inches to existing water lines shall be made by a Contractor of the Developer after obtaining applicable permits and paying applicable fees.

9. Service taps to new water lines shall be made by the Contractor in accordance with the Specifications after obtaining applicable permits and paying applicable fees.

10. All taps shall be in accordance with Policy Statement 95.

11. No taps shall be made within 3-feet of the bell or spigot end of the pipe.

B. MATERIALS

1. Full Body Tapping Sleeves: Mechanical Joint tapping sleeves shall be fabricated of ductile iron construction in a two-piece assembly with mechanical joint connections to the main line and flanged connection to the tapping valve. All MJ tapping sleeves shall be rated for a working pressure of 200-psi or greater and provided with a ¾-inch test plug for testing. All tapping sleeves shall be hydrostatically tested up to 200-psi before a tap is made. Tapping sleeves shall not be air tested.

   All mechanical joint tapping sleeves shall be manufacturer fabricated and approved for installation on the specific main line pipe material, whether ductile iron, plastic, cast iron or asbestos cement.

   Full body tapping sleeves must be used when the main line is greater than 24-inches. Tapping sleeves fabricated of carbon steel in a two-piece assembly with mechanical joint connections to the main line and flanged connection to the tapping valve will be considered for approval on a case-by-case basis for mains that are greater than 24-inches. Carbon steel sleeves should be rated for a working pressure of 250-psi or greater and be provided with a ¾-inch test plug. A fusion bonded epoxy coating shall be applied to all carbon steel sleeves.

2. Stainless Steel Tapping Sleeves, 6-inch through 12-inch main lines:

Stainless steel tapping sleeves may be used in lieu of mechanical joint tapping sleeves for ductile iron or asbestos cement water mains through 12-inches in diameter with branch sizing as shown in the following table. All stainless-steel tapping sleeves shall be manufactured in conformance with AWWA C223. All stainless-steel tapping sleeves shall have a stainless steel flange and be provided in a two piece assembly with a full circumferential gasket with tabbed gasket holding assembly and ¾-inch test plug. The back band shall be a minimum 14-gauge stainless steel and the front band (where the outlet is located) shall be a minimum 12-gauge stainless steel. The bolt bars shall be a minimum 7-gauge stainless steel. All stainless-steel tapping sleeves shall be manufacturer rated for a working pressure of 200-psi or greater and hydrostatically tested to 200-psi before a tap is made. Stainless steel tapping sleeves shall not be air tested.

Stainless Steel Tapping Sleeve Sizes Allowed

Nominal Main Size (inches)	Nominal Branch Size (inches)
6	4
8	4
10	4
10	6
12	4
12	6
12	8

3. Stainless Steel Tapping Sleeves, 14-inch through 24-inch main lines:
For larger diameter water mains, stainless steel tapping sleeves approved by Cary may be used in lieu of a mechanical joint tapping sleeve for cases where the branch line is 50% or less in diameter than the main line diameter. All the previous Specifications described for tapping sleeves from 6 to 12 inches shall be met for stainless steel tapping sleeves for larger diameter water mains. Additionally, the outlet band for stainless steel tapping sleeves 14-inches through 24-inches shall be a minimum 7-gauge stainless steel. The back half of the sleeve shall be a minimum 12-gauge stainless steel.

4. Tapping Saddles, 14-inch through 24-inch main lines:
Tapping Saddles may be used in lieu of mechanical joint tapping sleeves to tap mains 14 inches through 24-inches when the branch line is 50% or less in diameter than the main line diameter. Saddles shall be made of ductile iron providing a factor of safety of 2.5 with a working pressure of 250-psi. Saddles shall be equipped with an AWWA C110 flange connection on the branch. Sealing gaskets shall be O-ring type, high quality molded rubber having an approximate 70 durometer hardness, placed into a groove on the curved surface of the saddles. Straps shall be alloy steel. The minimum strap count for branch sizing from 4-12 inches is shown below.

Strap Requirements for Tapping Saddles

Nominal Saddle Outlet (inches)	Number of Straps
4	3
6	3
8	4
12	7

5. Service Line Taps: The maximum size of direct taps for ductile iron water mains 6-inches to 12-inches without a fitting, tapping sleeve or saddle shall be 1-inch. Any taps larger than 1-inch or any size tap on mains larger than 12-inches shall be provided with a saddle tap.

6. Corporation Stops:

   a) Corporation Stops shall be ball type, made of “no lead” brass (meeting UNS C89833 as per ASTM B584). Corp stops shall be complete with a compression coupling and AWWA Standard threads as per AWWA C800. Taps shall be located at 10:00 or 2:00 o'clock on the circumference of the pipe. Service taps shall be staggered alternating from one side of the water main to the other and at least 12 inches apart. The taps must be a minimum of 24 inches apart if they are on the same side of the pipe. All corporation stops shall be rated for a working pressure of 300-psi.

   b) No burned taps will be allowed and each corporation stop will be wrapped with Teflon tape for ductile iron pipe water mains. No taps are allowed on a fire hydrant line. No tapping shall be made where rodding is placed.

7. Service Saddles:
   Service Saddles shall be used for service taps larger than 1-inch on all ductile iron water mains 14-inches and greater, or when direct taps cannot be made. Service saddles shall also be used for all taps on existing water mains other than ductile iron, such as asbestos cement, PVC, etc. Service Saddles shall be provided with brass body and fasteners (85-5-5-5 waterworks brass or “no lead” brass meeting UNS C89833 as per ASTM B584) conforming to AWWA C800 and double straps made of silicon bronze (single strap for PVC mains) conforming to ASTM A98 and factory installed grade 60 rubber gaskets. Service saddles shall be provided with AWWA standard threads per AWWA C800.

8. Copper Service Tubing: Copper service tubing shall be type K soft copper tubing per ASTM B88. No union shall be used in the installation of the service connection of 100-feet or less. Service lines more than 100 feet shall use a three (3) piece compression coupling. Only one (1) compression coupling shall be used for each 100 feet or fraction thereof.

9. Meter boxes for 1-inch services: 1-inch meter boxes shall be cast iron per ASTM A48 Class 25 or ASTM A126 Class B. Meter boxes for 1-inch water services shall provide a cover opening of 8 X 18 1/8 inches and boxes shall measure at least 12.5 inches in depth. Lids shall also be cast iron and have the words “Water Meter” cast into them. They shall also be lockable. Lids shall be provided with a 2 inch (maximum) diameter hole to accommodate a transmitter. All meter boxes and lids shall be installed as shown in the Details and have a black E-coating.

   Meter boxes shall have 45-degree compression connections outside the box on the inlet side. There shall be a lockable ball valve inside the box on both the inlet and outlet which shall be permanently affixed to ensure proper spacing and alignment for the meter. Meter boxes shall also be provided with an ASSE 1024 approved inline, dual check valve located behind the meter. All fittings and connections shall be “no lead” brass conforming to UNS C89833 as per ASTM B584.

   A “no lead” brass curb stop with compression connections shall be installed within 2 feet of the inlet connection. The curb stop may be buried without a box above it.

   One 2 inch or 6-inch grade adjuster may be used when needed to meet final grade, however, no grade adjusters are permitted on new construction projects. Grade adjusters shall be cast iron. Grade adjuster and box shall be by the same manufacturer.

   In isolated cases and when approved by the Director of Utilities, meter boxes may be located in driveways, alleys and/or parking areas. In these cases, a street rated box capable of withstanding a 40,000-lbs proof load shall be specified.

10. 1 ½ and 2-inch Water Services: 1 1/2” and 2” meter boxes shall be light weight polymer concrete as indicated in the Standard Details. Meter boxes for 1 ½ and 2-inch water services shall provide a cover opening of 24 X 36 inches and boxes shall measure at least 30-inches in depth and provided in straight wall arrangement. Standard meter box covers shall bolt down to the box, and all polymer cement covers shall be provided in solid configuration with a 2-inch diameter transmitter hole, and with the words, “Water Meter” cast into the lid. The meter box covers shall be provided with 2 stainless steel bolts in penta head configuration for security. To ensure positive discharge, the box should be tied into the existing storm drain system or shall have an open bottom to allow drainage through a 12-inch stone base. All meter box covers for potable water service shall be provided in standard concrete gray or black color.

    Custom setter piping and fittings for 1 ½ and 2 inch water meters shall be constructed from “no lead” brass (meeting UNS C89833 as per ASTM B584) and copper tubing and shall be equipped with a lockable by-pass flanged ball valve and flanged angle meter ball valves. All applications shall have a separate above ground backflow preventer.

11. Water services greater than 2-inches: Water services greater than 2-inches shall have the meter and bypass line located within a precast concrete vault. All piping and valves shall have flanged connections. There shall be isolation gate valves on both sides of the meter as well as one on the bypass line. Gate valves within the vault shall meet the above requirements of AWWA C509 for non-rising stem gate valves but shall be provided with hand wheel operators. A standard buried gate valve with 2-inch nut shall be provided between the main and the vault. Link seals shall be used where the pipe enters and exits the vault.

12. Meter Vaults: Meter vaults and access doors shall meet HS-20 loading requirements and shall be located outside of travel areas. Pedestrian rated covers shall not be used regardless of where they are located. The access double doors shall be aluminum with a flush drop lift handle, stainless steel hinges and bolts, a stainless-steel slam lock, an automatic hold open arm, and compression springs to allow for easy opening. Vaults for 3- and 4-inch meters shall be approximately 8-feet by 10-feet in size. Six inch meter vaults shall be approximately 9-feet by 12-feet. To ensure positive drainage, the vault shall be tied into the existing storm drainage system. If positive drainage is unobtainable, a sump pump shall be located and operated in the vault.

6050 IRRIGATION SYSTEMS

A. All irrigation systems shall be provided with privately maintained reduced pressure principle backflow prevention installed in accordance with the NC Plumbing Code and the Foundation for Cross Connection Control and Hydraulic Research. Reduced pressure zone backflow preventers shall be installed above ground in an insulated box as shown by the details.

B. All irrigation systems within public street right of way require an encroachment agreement from Cary or NCDOT prior to installation. Plans designating the location, size, material, and depth shall be submitted with the agreement application to the Inspection & Permits Department. If there is an approved development plan, it shall be referenced with the encroachment submittal to Cary.

C. Pipe material for the mainline proposed to be used within the public right of way shall be Schedule 40 PVC or greater. A distance of at least 3-feet shall be provided from the back of curb or edge of asphalt in a ditch section. A minimum depth of 2-feet of cover shall be provided and all heads shall spray away from the street.

D. All street crossings of irrigation systems shall be encased in ductile iron or steel conduit. Irrigation systems installed in the medians of Cary maintained roadways must also have French drains installed behind the curb and gutter which are piped to a storm system.

6060 TESTING AND INSPECTIONS

A. GENERAL

1. All materials must be approved by the Infrastructure Field Technician prior to installation. Materials rejected by the Infrastructure Field Technician shall be immediately removed from the job site.

2. The Contractor shall furnish all materials, labor, and equipment to perform all testing and inspections to the satisfaction of the Infrastructure Field Technician or Water Quality representative. Cary shall provide water for testing purposes on water mains in accordance with Cary Standard Procedure 4, Control and Monitoring of Water System Flow Activity.

B. TESTING

1. Hydrostatic Testing

   a) No valve in the Cary water system shall be operated without authorization in accordance with Cary Policy Statement 49 "Water Valves, Control of Closing and Opening" A section of line that is to be hydrostatically tested, shall be slowly filled with water at a rate which will allow complete evacuation of air from the line. Hand pumps shall not be used for the pressure testing of water mains. Taps used for testing purposes shall be removed after testing and repaired using a "no lead" brass plug.

   b) When filling the pipeline, it is very important to fill the line slowly to avoid undue impacts associated with surge and to allow air to evacuate the pipeline. After all air has been expelled from the water main, the line shall be tested to a pressure of 200 psi as measured at the lowest elevation of the line for a duration of 2 hours. The testing period shall not commence until all air has been evacuated and the pressure has stabilized. The pressure gauge used in the hydrostatic test shall be calibrated in increments of 10-psi or less. The pressure gauge shall be liquid-filled and indexed for an operating range of 300-psi or less with a minimum dial size of 4 inches. At the end of the test period, the leakage shall be measured with an accurate water meter.

   c) Any measured leakage not within the allowable limits as specified in the following table shall require repair of the water main and additional testing until the standards are met. For pipe sizes other than those shown, the Contractor shall test within the allowable leakage amounts as specified by AWWA C600-99. All visible leaks shall be repaired regardless of the amount of leakage.

Maximum Leakage Allowed with Hydrostatic Testing

Pipe Size	Allowable Leakage at 200-psi
(Inches)	(Gal./Hr. per 1000 feet of pipe)
4	0.38
6	0.57

8	0.76
10	0.96
12	1.15
16	1.53
20	1.91
24	2.29
30	2.87
36	3.44
42	4.01

2. Disinfection

a) All additions or replacements to the water system shall be disinfected with chlorine in conformance with AWWA C651 before being placed in service under the supervision of the Cary's Infrastructure Field Technician in the following manner:

i. Taps shall be made at the control valve at the upstream end of the line and at all extremities of the line including valves.

ii. A solution of water containing 70% High Test Hypochlorite (HTH) available chlorine shall be introduced into the line by regulated pumping at the control-valve tap. The solution shall be of such a concentration that the line shall have a uniform concentration of not less than 50-ppm and not more than 100-ppm total chlorine immediately after chlorination. The chart below shows the required quantity of 70% HTH compound to be contained in solution in each 1000 feet section of line to produce the desired concentration from 50-ppm to 100 ppm.

Required Hypochlorite Concentration

Pipe Size (inches)	Pounds of High Test Hypochlorite (70%) to reach 50-ppm *per 1,000 feet of line*	Pounds High Test Hypochlorite (70%) to reach 100-ppm *per 1000 feet of line*
6	0.88	1.76
8	1.56	3.12
10	2.42	4.84
12	3.50	7.00
14	4.76	9.52
16	6.22	12.44
20	9.76	19.52
24	14.00	28.00
30	21.86	43.72

36	31.47	62.94
42	42.85	85.70

iii. The HTH Solution shall be circulated in the main by opening the control valve and systematically manipulating hydrants and taps at the line extremities. The HTH solution must be pumped in at a constant rate for each discharge rate so a uniform concentration will be produced in mains.

iv. HTH solution shall remain in lines for no less than 24 hours or as directed by Cary's Infrastructure Field Technician.

v. Extreme care shall be exercised at all times to prevent the HTH solution from entering existing mains.

vi. Free residual chlorine after 24 hours shall be at least 10 ppm or the Infrastructure Field Technician will require that the lines be re-chlorinated.

3. Flushing

i. Flushing of lines may only proceed after 24 hours of disinfection contact time and as directed by Cary staff, provided the free residual chlorine analysis is satisfactory.

ii. At the completion of disinfection, chlorinated water flushed from the water main shall be disposed of in conformance with all Federal, State and local regulations.

iii. In accordance with all applicable regulations, a neutralizing chemical shall be applied to minimize chlorine residual in the flushing water before discharging from the water main, unless an alternate plan is submitted in writing and approved by Cary.

iv. Water used for disinfection shall be flushed from the water main until the chlorine residual concentration is below 5-ppm before initiating sampling.

4. Bacteriological and Turbidity Sampling

a) Bacteriological sampling shall be utilized to verify disinfection prior to placing a newly constructed water main in operational service. Bacteriological sampling shall consist of 2 consecutive sets of acceptable samples taken at least 24-hours apart and collected from each 1,200-ft section of water main and all dead ends and branches as outlined by ANSI/AWWA C651.

b) For the first round of sampling, the requested laboratory analysis shall be specified as follows: "Bacteriological Test and Turbidity." For the second round

of testing, the laboratory analysis shall be specified as, “Bacteriological Test Only.”

c) Samples for laboratory analysis shall be witnessed by Cary’s Infrastructure Field Technician after flushing is completed. The Contractor shall furnish the sample bottles, the testing agency and shall secure these samples. The Contractor shall make arrangements with the laboratory that all test results be submitted directly to the Cary’s Infrastructure Field Technician or other designee approved by the Utilities Department. All costs for laboratory testing shall be borne by the Contractor.

d) The laboratory secured for testing shall be certified by the State Laboratory of Public Health. All sample bottles for bacteriological sampling provided by the laboratory shall be sterilized and treated with a dechlorinating agent, such as sodium thiosulfate. Samples for turbidity shall be taken in plain sterilized bottles from the lab, which are separate from the bottles provided for bacteriological testing. The sample bottles shall be provided with tamper proof seals that will be adhered to the bottles by the Cary’s Infrastructure Field Technician. The Infrastructure Field Technician shall provide a sample identification number, job title and an identification of Phase 1 or Phase 2 sampling that will be provided on the tamper proof custody seal. The bottles and tamper proof custody seals shall be accompanied by a chain of custody form provided by the certified laboratory conducting the testing. All sample identification numbers, job titles, and Phase 1 or Phase 2 testing identification from the custody seal shall be recorded on the chain of custody forms by the Infrastructure Field Technician.

e) All samples shall be collected in compliance with the sampling protocols provided by the certified laboratory. The samples shall be kept in a cooler provided by the Contractor at approximately 40-degrees Fahrenheit or 4-degrees Celsius and delivered to the certified lab for testing as soon as possible. The time at which the sample is taken shall be recorded on the chain of custody form by the Infrastructure Field Technician. Any samples processed at the laboratory more than 30-hours following collection shall be declared invalid, i.e. samples shall be submitted to the lab within 24-hours of collecting them.

f) All first-round samples shall be tested for bacteriological quality and turbidity in accordance with standards established by NCDENR and AWWA. If turbidity exceeds 1.0 NTU, the sample shall fail and the system shall be re-flushed before initiating a new round of testing.

g) If the phase 1 sample results for bacteriological quality and turbidity are acceptable, then a second set of samples can be collected at least 24-hours following the first sample collection. No additional flushing other than required

to obtain a representative sample will be allowed prior to collecting the second set of samples.

h) The second set of samples shall be tested for bacteriological quality only. All custody seals and chain of custody forms shall identify the second-round samples as “Phase 2” testing to notify the lab that the first set of samples have already been evaluated and received a satisfactory laboratory analysis.

i) At the completion of sampling, the total chlorine concentration shall be at least 2-mg/L and no higher than 4-mg/L before the system can be made operational.

j) If test results are unsatisfactory, the Contractor shall immediately re-chlorinate lines and proceed with such measures as are necessary to properly disinfect the lines.

k) The new water system shall be valved off from the existing system until a satisfactory bacteriological laboratory analysis has been obtained and the Infrastructure Field Technician has authorized the use of the new water system.

5. Marker Ball and Marker Tape Testing

Testing of the marker balls and tape shall be performed by the Contractor at the completion of the project to assure they are all working properly. It is the Contractor’s responsibility to provide the necessary equipment to test the markers. Any defective, missing, or otherwise non-locatable units shall be replaced.

6070 REPAIR AND REHABILITATION

B. Joint leaks of Ductile Iron Pipe shall be repaired by using a bell joint leak repair clamp approved by Cary or otherwise replacing the damaged pipe and reconnecting with a mechanical joint sleeve connection.

C. Line Breaks or Punctures shall be repaired by a full circle repair clamp as approved by Cary or otherwise replacing the damaged pipe and reconnecting with a mechanical joint sleeve connection.

D. Line Splits or Blow Outs shall be repaired by replacing the damaged section with ductile iron pipe with a restrained sleeve connection at each end.

E. Asbestos Cement Pipe to PVC or Ductile Iron Pipe transitions shall use coupling listed on Cary’s Approved Products List with different end diameters sized specifically for the pipe materials and pipe outside diameter at each end.

F. All water main point repairs shall be replaced with DIP in accordance with these Specifications and backfilled with crush and run stone compacted to 95% maximum dry density as specified elsewhere in the Standard Specifications.

G. Water Service Line Repairs

1. A water service line severed between the water main and the water meter shall be repaired using new type K copper tubing and bronze or “no lead” brass 3 piece compression unions.

2. A corporation stop pulled out of a PVC pipe water main shall have a new service saddle and a new “no lead” brass corporation stop installed on the water main.

3. A corporation stop pulled out of a ductile iron pipe shall have a full circle repair clamp placed over the old tap hole. A new tap shall be made and a new “no lead” brass corporation stop installed on the water main.

H. Abandonment: Water service laterals shall be abandoned at the main by locating, turning off, and capping the corporation stop.

END OF SECTION 6000

SECTION 331100 - WATER UTILITY DISTRIBUTION SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Materials, Installation, and Testing shall be in accordance with Town of Cary Standard Specifications. See Section 6000 Water Distribution System.

1. Please note the highlighted in the sections provided within this Project Manual are from the published Town of Cary Standard Specifications and are not indicative of any special requirements of the Project.
2. All references to pay items, allowances, and Contract language within the Town of Cary Standard Specifications are not applicable to this project and should be omitted from the bid.

B. Section 312317 Trenching

C. Section 312319 Dewatering

D. Section 312324 Flowable Fill

1.2 SUBMITTALS

A. Product Data: For each type of the following manufactured or supplied products required:

1. Pipe Materials
2. Fittings, gaskets, and other appurtenances

PART 2 - PRODUCTS

2.1 MATERIALS

A. All materials including but not inclusive of pipe, fittings, gaskets, etc. shall be provided in according to the material standards provided in the Water Distribution System section of the Town of Cary Standard Specifications

PART 3 - EXECUTION

3.1 EXAMINATION

A. Installation shall be coordinated with Engineer and Town of Cary inspectors for schedule inspections prior to being backfilled.

3.2 INSTALLATION

A. Installation per respective Town of Cary Standard Specifications section.

3.3 FIELD QUALITY CONTROL

A. All Chlorination, Hydrostatic, and Bacteriological preparation and testing shall be performed per the Town of Cary Standard Specifications Water Distribution System section.

B. Engineer shall be notified of testing schedule and results

C. No additional payments will be made for failed tests.

END OF SECTION 331100

SECTION 7000
WASTEWATER COLLECTION SYSTEMS

TABLE OF CONTENTS

7010 GRAVITY SEWER

A. DESIGN

1. Main Location

a) All public sanitary sewer mains shall be installed in dedicated street right of way or in dedicated utility easements. Mains installed in Cary right of way shall be located in the center of pavement. If the sewer main cannot practically be located in the center of the pavement it shall be located within the south or west side of the street. Mains within easements shall be centered within the easement. Mains located within NCDOT right of way shall be placed in accordance with NCDOT standards.

b) In preparing engineering design plans for sanitary sewer mains, all elevations shall be tied to NC grid system and the benchmark shall be described on the plans.

c) All private sewer collection mains inside Cary's Utility Service area that will connect or are planning to discharge into Cary's sewer system shall comply with all Cary design, siting and installation criteria outlined herein. The Owner of the private sewer collection system shall meet all State design requirements and obtain a State permit to operate the private system.

d) Gravity mains shall be installed in dedicated public right of way or in dedicated utility easements as follows:

Standard Easement Width for Sanitary Sewer Mains

Pipe Size (diameter)	Pipe Depth (feet)	Easement Width (feet)
8-inch to ≤12-inch	10-ft or less	20-ft
8-inch to ≤12-inch	10-ft – 12.5-ft	25-ft
8-inch to ≤12-inch	12.5-ft – 15-ft	30-ft
8-inch to ≤12-inch	15-ft to 17.5-ft	35-ft
8-inch to ≤12-inch	17.5-ft to 20-ft	40-ft
>12-inch to ≤24-inch	15-ft or less	30-ft
>12-inch to ≤24-inch	15-ft – 17.5-ft	35-ft
>12-inch to ≤24-inch	17.5-ft – 20-ft	40-ft
Greater than 24-inch	Any Depth	As Specified by the Utilities Department
Any Size	Deeper than 20-ft	

Dedicated easements for sewer mains and appurtenances shall be recorded as "Cary Utility and Pipeline Easement". Cary sewer

easements shall contain only Cary utilities unless otherwise approved by the development plan or an encroachment agreement.

Access easements to allow sufficient means of gaining entrance to proposed Utility and Pipeline Easements may be required by the Utilities Department where conventional access from the public right-of-way is limited or infeasible.

e) No permanent structures, equipment, retaining walls, embankments, impoundments, or other elements that would inhibit maintenance operations shall be constructed within a sewer main easement as outlined in Section 2000. Fences may be allowed across easements provided that appropriate access gates have been installed to allow utility maintenance. In all cases, Cary Operations Staff shall have access to secured access gates. Fill or cut slopes are not allowed to extend into easements without full development plan approval or an approved encroachment agreement from Cary, see Section 2000 for further information. All such pre-existing or planned conditions as noted herein that would impact operations and maintenance within the noted sewer main easement shall be noted and disclosed during the development plan approval process. Pre-existing conditions that are not disclosed during the development plan review may nullify the approval and require relocating the sewer easement where there are no existing conflicts.

f) Sewer line easements shall be graded smooth, free from rocks, boulders, roots, stumps, and other debris, and seeded and mulched upon the completion of construction. Easements across sloped areas shall be graded uniformly across the slope to no steeper than a 5 to 1 ratio.

g) Mains paralleling a creek shall be of sufficient depth to allow lateral connections below the stream bed elevation. The top of the sewer main and laterals shall be at least one foot below the stream bed. Steel encasement and ductile iron pipe shall be required when the cover between the top of the pipe and the stream bed is less than 3 feet.

h) Mains shall not be installed under any part of water impoundments.

i) The following minimum horizontal separations shall be maintained:

    i. 100 feet from any private or public water supply source, including wells, WS-1 waters or Class I or Class II impounded reservoirs used as a source of drinking water (except as noted below)

ii. 50 feet from wetlands and any waters (from normal high water) classified WS-II, WS-III, B, SA, ORW, HQW or SB (except as noted below)

iii. 10 feet from any other stream, lake, or impoundment (except as noted below)

iv. With approval directly from PERCS, the following separations may be acceptable when water main standards are implemented:

a) All appurtenances shall be outside the 100-foot radius of wells.

b) 25 feet from private wells (with no exceptions)

c) 50 feet from public water wells (with no exceptions)

Where the required minimum separations cannot be obtained, the following standards shall be used:

i. Sewer Pipe: Ductile Iron Pipe shall be used with joints equivalent to water main standards.

j) Sewer mains shall be extended to adjacent property lines.

k) Gravity sewer mains shall be deep enough to serve the adjoining property and allow for sufficient slope in lateral lines. Gravity sewer pipe shall have the following minimum covers:

i. 4 feet from the top of pipe to finished subgrade in roadways.

ii. 3 feet from the top of pipe to finished grade outside roadways.

- Material must be DIP if less than 4 feet of cover is provided.

l) Sewer mains over 20 feet deep require ductile iron for the entire run between manholes. Sewer mains 14 feet to 18 feet along or in roadways shall also require ductile iron pipe for the entire run between manholes. The maximum depth of sewer along or in roadways shall be 18 feet.

m) In all cases where fill material is added above existing sewer mains, the Engineer of Record shall prepare a structural analysis of the

existing pipeline and determine if it can support additional loading. If the additional fill material exceeds AWWA, DIPRA, UNIBELL and/or manufacturer standards for loading, the pipeline shall either be reinforced to adequately support the additional loading or replaced with a ductile iron pipe rated to support the added loading.

n) Separation Between Sanitary Sewer and Storm Water Pipes:

Sewer mains shall have a minimum vertical separation of 24 inches between storm pipes when the horizontal separation is 3 feet or less. Where sanitary and storm sewers cross with a vertical separation of less than 24 inches, the entire leg of sanitary sewer shall be made of standard ductile iron pipe with joints rated for water main service and the void space between the pipe crossing shall be backfilled with 3000-psi concrete or quick setting, minimum 500-psi, non-excavatable flowable fill that meets or exceeds NCDOT Specifications.

o) Separation Between Sanitary Sewer and Sewer Force Main:

There shall be a minimum 7-foot horizontal separation between parallel gravity and/or force mains when the depth of installation is 8-feet or less. In cases where the depth of installation is greater than 8-feet, the minimum horizontal separation between pipelines shall be 10-ft up to 10-ft depth of installation or a project specific design shall be implemented.

p) Separation Between Sanitary Sewer and Water Main

i. Parallel Installations: 10-ft lateral separation (pipe edge to pipe edge) or minimum 5-ft lateral separation, and water line at least 18-inches above sanitary sewer line measured vertically from top of sewer pipeline to bottom edge of water main. In unique cases where the sanitary sewer and the water main are installed with at least 5-ft of lateral separation but less than 10-ft of horizontal separation, and less than 18-inches of vertical separation, both the water main and sanitary sewer shall be constructed of ductile iron pipe with joints in full compliance with water main standards.

ii. Crossings (Water Main Over Sewer): All water main crossings of sewer lines shall be constructed over the sewer line in conformance with Cary Specifications. At a minimum, 18-inches of clearance shall be maintained between the bottom edge of the water main and the top edge of the sewer main. If 18-inches of clearance is not maintained, the water main and sanitary sewer main shall:

a. Both lines shall be constructed of ductile iron pipe with joints in conformance with water main construction standards.
b. The sanitary sewer pipe shall be ductile iron the entire run from manhole to manhole.
c. The void space between the pipes shall be filled with minimum 500-psi, quick setting non-excavatable flowable fill extending 3-ft on both sides of the crossing. Regardless of pipe material, at least 12-inches of vertical separation is required for sanitary sewer crossings of potable water mains.

iii. Crossings (Water Main Under Sewer Line): Allowed only as approved by Cary when it is not possible to cross the water main above the sewer line. At a minimum, 18-inches of separation shall be maintained, (measured from pipe edge to pipe edge) and the sanitary sewer shall be constructed of ductile iron in conformance with water main construction standards the entire run from manhole to manhole. If local conditions prevent providing 18-inches of clearance, then at least 12-inches of clearance shall be provided and the void space between the pipes shall be filled with minimum 500-psi, quick setting, non-excavatable flowable fill extending at least 3-ft on both sides of the crossing.

q) Separation Between Sanitary Sewer and Reclaimed Water

i. Sanitary sewer and reclaimed water mains shall be laid with at least 10 feet of horizontal separation, measured laterally edge to edge unless the elevation of the bottom of the reclaimed water main is at least 18 inches above the top edge of the sanitary sewer, with a horizontal separation of at least 3 feet.

ii. Where a reclaimed water main and a sanitary sewer main cross, the crossing shall be constructed at a 90-degree angle and the sanitary sewer main shall cross at least 18-inches below the reclaimed water line. Because all reclaimed water mains in Cary's municipal system are constructed to fully comply with water system testing and integrity standards as described by 15A NCAC 18C, when the minimum separation cannot be met, at least 12-inches of clearance shall be maintained, the sewer main shall be provided in ductile iron pipe in full compliance with water main standards, and the void space between the pipes shall be filled with minimum 500-psi, quick setting, non-

iii. excavatable flowable fill extending at least 3-ft on both sides of the crossing.

	Water	Storm water	Sewer (Gravity and Forcemain)	Reclaimed
Water	18-inches vertical	**Parallel Installations**: 10-feet horizontal **Crossings**: 18 inches vertical	**Parallel Installations:** 10 feet horizontally **Crossings:** 18-inches vertical separation water main over sewer	**Parallel Installations**: 10-feet horizontal and water line at least 18-inches above reclaimed **Crossings (water main over reclaimed water pipeline)**: Min. 18-in vertical separation
Storm water	**Parallel Installations**: 10-feet horizontal **Crossings**: 18 inches vertical		24-inches vertical	Min. 18-inches vertical.
Sewer (Gravity & Forcemain)	**Parallel Installations:** 10 feet horizontally **Crossings:** 18-inches vertical separation water main over sewer	24-inches vertical	7-feet horizontal separation, increasing with depth	**Parallel Installations:** 10-feet horizontal **Crossings (reclaimed water pipes over sewer pipes**): 18-inches
Reclaimed	**Parallel Installations**: 10-feet horizontal and water line at least 18-inches above reclaimed **Crossings (water main over reclaimed water pipeline)**: Min. 18-in vertical separation	Min. 18-inches vertical.	**Parallel Installations:** 10-feet horizontal **Crossings (reclaimed water pipes over sewer pipes**): 18-inches	18 inches vertical

iv. If the sanitary sewer crosses above the reclaimed water line, the clearance shall be at least 18-inches. Because all reclaimed water mains in Cary's municipal system are constructed to fully comply with water system testing and integrity standards as described by 15A NCAC 18C, when

the minimum separation cannot be met, at least 12-inches of clearance shall be maintained, the sewer main shall be provided in ductile iron pipe in full compliance with water main standards, and the void space between the pipes shall be filled with minimum 500-psi, quick setting non-excavatable flowable fill extending at least 3-ft on both sides of the crossing.

2. Main Size, Slope and Design Criteria

a) Public gravity mains shall be a minimum of 8 inches in diameter.

b) Major interceptors shall be sized in accordance with the most current "Cary Wastewater Collection System Master Plan". In areas not included in the master plan, interceptors shall be designed based on the proposed land use (according to Cary's Comprehensive Growth Plan), using the following flow factors. At a minimum, all gravity sewer mains shall be designed and sized to serve the ultimate tributary buildout of the drainage basin.

Residential flow rates:

Land Use	**Flow Factor**
Single Family Residential	280 gpd per dwelling unit
Multi-Family Residential	100 gpd per bedroom

Non-residential flow rates:

Use flow factors as required by the North Carolina Department of Environmental Quality (at the time of this Specification revision, these flow rates are contained in 15A NCAC 02T .0114).

For all other flow rates not listed in Section ii above, use:

Land Use	**Flow Factor**
Office and Institutional	0.09 gpd/sq.ft bldg. space
Commercial	0.12 gpd/sq.ft bldg. space
Industrial	0.20 gpd/sq.ft bldg. space

c) The ratio of peak to average daily flow shall be 3.3.

d) Sanitary sewers shall be designed to carry the projected peak flow at no more than 2/3 full. The minimum velocity for sanitary sewer lines shall be 3-fps.

e) Sanitary sewers shall be sized based on the Manning's Equation with Manning's roughness coefficient "n" = 0.013 or greater. Pipe diameter sizes used in the calculation of Manning's Equation shall be nominal pipe sizes.

f) The minimum grades for public sanitary sewers shall be as follows:

Minimum Slopes for Gravity Sewer Mains

Main Size *(diameter in inches)*	Minimum Slope V=3.0ft/s, depth 2/3 full *(feet per 100 feet)* *{standard required velocity}*
8	0.61
10	0.46
12	0.36
14	0.29
15	0.27
16	0.25
18	0.21
21	0.17
24	0.14
27	0.13
30	0.11
36	0.09

Note1: All minimum slopes based on Manning's Equation
Note2: Manning's coefficient n = 0.013 used for all computations

g) The minimum grade for the uppermost reach of a sanitary sewer line shall be 1% regardless of sewer line size.

h) The maximum grade for sanitary sewers is 10%. The maximum velocity in sanitary sewers is 15 ft/sec. These limits may only be exceeded with the approval of the Director of Utilities and the incorporation of the following provisions, which apply to all sewers either designed or installed at grades equal to or exceeding 10%:

i. All sewers with a grade of 10% or higher must have the downstream run of pipe installed with ductile iron pipe.

ii. High velocity manholes shall be used on all sewers with a grade of 10% or higher. High velocity lines cannot tie directly to an existing line and must proceed 180^{o} through the invert into the downstream line.

iii. Concrete thrust collars shall be installed on all sewers designed at grades of 10% or higher. The anchors shall be installed at the following spacing:

- Not over 36' center to center on grades from 10% to 25%
- Not over 24' center to center on grades from 25% to 40%
- Not over 16' center to center on grades exceeding 40%

iv. Cary reserves the right to require all high velocity requirements outlined herein for sewer lines either designed or installed at grades of 10% or greater, regardless of the flow velocity. In cases where the design grade established on the sewer design plan is exceeded during construction and the 10% threshold is exceeded, all high velocity requirements shall apply without waiver.

i) Sewer extensions shall be designed for projected flows, even when the diameter of the receiving sewer is less than the diameter of the proposed extension.

j) All pipe diameter changes shall occur only in manholes, with the invert of the larger pipe lowered sufficiently to maintain the same energy gradient. An approximate method of obtaining this result is to place the 0.8 depth point of both sewers at the same elevation. As an alternative, the crown of the incoming pipes may be designed for an elevation at or above the crown of the outgoing pipe.

k) All transitions of pipe material, pipe separations, grade changes and all angular deflection changes shall occur only at manholes.

l) Pipe trench excavation and backfilling shall be performed in accordance with Section 5000 of these Specifications.

m) <u>Construction Involving Existing Mains</u>

i. The existing sewer main must remain active and protected during all phases of construction. The contractor must provide a plan for the structural protection of the existing sewer main.

ii. A proposed construction sequence and bypass pumping plan must be submitted for any demolition of a portion of existing sewer main. The plan must be reviewed and approved by Utilities and Public Works.

B. <u>MATERIALS</u>

Materials specified herein are acceptable for sewer service as described.
See Standard Procedure 120 for instructions on requesting new product approval.

1. DUCTILE IRON PIPE

Material Specifications

Ductile Iron Pipe shall be designed and manufactured in accordance with AWWA C150 and C151 and provided in nominal 20-ft lengths. The minimum requirements for ductile iron pipe and required laying conditions are tabulated below. For all other installations other than specified, the laying condition, bedding requirements or the minimum pressure class rating and/or thickness class shall be increased in accordance with AWWA C151. A pipe thickness design shall be submitted for external loading in all cases where the pipe depth exceeds the specified range of depths outlined in the following table.

Pressure Class, Max. Depth and Laying Condition for DI Sewer Mains

Pipe Diameter	AWWA C-150, Laying Condition	Pressure Class	Maximum Depth of Cover
8 -inch	type 1	350 psi	3-16 feet
8 -inch	type 4	350 psi	16-34 feet
10-12 -inch	type 1	350 psi	3-10 feet
10-12 -inch	type 4	350 psi	10-28 feet
10-12 -inch	type 5	350 psi	28-44 feet
14-20 -inch	type 4	250 psi	3-22 feet
14-20 -inch	type 5	250 psi	22-30 feet
14-20 -inch	type 5	350 psi	30-38 feet
24-30 -inch	type 4	250 psi	3-19 feet
24-30 -inch	type 5	300 psi	19-29 feet
24-30 -inch	type 5	350 psi	29-33 feet
36-42 -inch	type 4	300 psi	3-20 feet
36-42 -inch	type 5	350 psi	20-32 feet

Note: For cases not specified, a ductile iron pipe and bedding design certified by a Professional Engineer licensed in the State of North Carolina shall be required in compliance with AWWA C150 and the Ductile Iron Pipe Research Association.

In cases where thickness class designation of ductile iron pipe is specified, the corresponding thickness class designations are as outlined in the table on the next page.

Ductile Iron Pipe Thickness Class

Pipe Diameter	Pressure Class	Nominal Thickness (inches)	Minimum Corresponding Thickness Class
4	350	0.25	51
6	350	0.25	50
8	350	0.25	50
10	350	0.26	50
12	350	0.28	50
14	250	0.28	50
16	250	0.30	50
18	250	0.31	50
20	250	0.33	50
24	250	0.37	50
24	300	0.40	51
30	250	0.42	51
30	300	0.45	52
36	300	0.51	52
36	350	0.56	53
42	300	0.57	52
42	350	0.63	53

Pipe joints shall be of the push-on type as per AWWA C111.

For 10-inch diameter and smaller gravity sewer mains, pipe lining shall be cement mortar with a seal coat of bituminous material, all in accordance with AWWA C104 except a minimum thickness of 1/8" shall be provided (double thickness).

For 12-inch diameter and larger gravity sewer mains, all ductile iron pipe and fittings for sewer construction shall receive an interior ceramic epoxy coating, consisting of an amine cured novalac epoxy containing at least 20% by volume of ceramic quartz pigment, from Cary approved manufacturer. The interior coating shall be applied at a nominal dry film interior thickness of 40-mils. All DIP bells and spigots shall be lined with 8-mils of approved joint compound listed on Cary's Approved Products List applied by brush to ensure full coverage. All pipe supplied with approved interior lining shall be provided free of holidays. Pipe installed with defects in the lining will be rejected and required to be replaced. Patching of coating defects after installation shall not be approved. Lined pipe must be installed by date required by lining manufacturer.

All buried DIP and fittings shall have bituminous coating on the exterior surface in accordance with AWWA C151. Pipe shall be supplied in minimum 20-ft lengths.

All ductile iron pipes shall be marked in conformance with ASTM A-746.

2. SOLID WALL PVC PIPE

Material Specifications

PVC Pipe shall be solid wall and made of PVC plastic having a cell classification of 12454 or 12364 (with minimum tensile modulus of 400,000 psi) as defined in Specification D1784. PVC pipe shall have integral wall bell and spigot joints for the conveyance of domestic sewage and shall be supplied in minimum 14 or 20 ft lengths. Fittings shall be made of PVC plastic having a cell classification of 12454-B, as defined in ASTM D1784.

All PVC gravity sewer pipe and PVC fittings up to 15-inches in diameter shall be manufactured in accordance with the latest version of ASTM D3034. All solid wall PVC pipe installed at diameters from 18-inches to 27-inches in diameter shall be manufactured in conformance with ASTM F679 and provided at minimum pipe stiffness of 115-psi. Fittings must be manufactured by pipe supplier or approved equal and have bell and/or spigot configurations compatible with that of the pipe. PVC pipe shall be installed in accordance with the requirements of this Specifications manual and ASTM D2321.

All PVC pipe up to and including 15 inches in diameter shall have a maximum Standard Dimension Ratio (SDR) of 35 for depth of installation no shallower than 4-ft of cover from the pipe crown and no deeper than 14-ft measured from the bottom of the pipe. All solid wall PVC pipe for depth of installation greater than 14-ft shall have a maximum Standard Dimension Ratio (SDR) of 26. Solid wall PVC pipe shall not be approved for depths of installation greater than 20-ft. All solid wall PVC pipe shall be marked and certified in conformance with ASTM D3034 or ASTM F679.

PVC Pipe Sizing and Minimum Wall Thickness

Nominal Pipe Diameter (inches)	Outside Diameter (inches)	Minimum Wall Thickness SDR 35 (inches)	Minimum Wall Thickness SDR 26 (inches)
8	8.400	0.240	0.323
10	10.500	0.300	0.404
12	12.500	0.360	0.481
15	15.300	0.437	0.588
18	18.701	-------	0.720
21	22.047	-------	0.849
24	24.803	-------	0.956
27	27.953	-------	1.077

Note: SDR 35 not approved for pipe diameters greater than 15-inches and for depths greater than 14-ft.

C. SEWER MAIN INSTALLATION

1. General Requirements

a) Pipe trench excavation and backfilling shall be performed in accordance with Section 5000 of these Specifications.

b) Transitions of pipe material, pipe separations, grade changes and all angular deflection changes shall occur only at manholes.

c) All sewer mains installed with less than 4 ft of cover or deeper than 20-ft shall be ductile iron pipe.

d) Pipe and fitting interiors shall be protected from foreign matter and shall be inspected for damage and defects prior to installation. In the event foreign matter is present in pipe and fittings, it shall be removed before installation. Open ends of pipe shall be covered and protected when pipe laying is not in progress to prevent debris from entering the pipe.

e) All sewer cleanouts shall be protected during construction by installation of tree protection fencing or Cary approved material. Material will be adequately maintained throughout the construction period to prevent damage and contamination of the sewer system.

f) All pipes shall be constructed with at least 48 inches of cover below the finished grade. Pipe shall be laid on true lines as directed by the Engineer. Trenches shall be sufficiently wide to adjust the alignment. Bell holes shall be dug at each joint to permit proper joint assembly.

The pipe shall be laid and adjusted so that the alignment with the next succeeding joint will be centered in the joint and the entire pipeline will be in continuous alignment both horizontally and vertically. Pipe joints shall be fitted so that a thoroughly watertight joint will result. All joints will be made in conformance with the manufacturer's recommendations for the type of joint selected.

g) Prior to beginning construction, the Contractor shall contact local utility companies and verify the location of existing utilities. The Contractor shall be completely and solely responsible for locating all existing buried utilities inside the construction zone before beginning excavation. The Contractor shall be solely responsible for scheduling and coordinating the utility location work. When an existing utility conflicts with construction, it shall be exposed prior to beginning construction to prevent damage to the existing utility.

2. Embedment Material

Bedding and embedment material classifications shall be defined as follows:

- CLASS I - Angular, (1/4 to 1-1/2 inch) graded stone, including a number of fill materials that have regional significance such as coral, slag, cinders, crushed stone, crushed gravel, and crushed shells.

- CLASS II - Coarse sands and gravels with maximum particle size of 1-1/2 inch, including variously graded sands and gravels containing small percentages of fines, generally granular and non-cohesive, either wet or dry. Soil types GW, GP, SW and SP are included in this class.

- CLASS III - Fine sand and clayey gravels, including fine sands, sand-clay mixtures, and gravel-clay mixtures, Soil Types Of GM, GC, SM, and SC are included in this class.

- CLASS IV - Silt, silty clays, and clays, including inorganic clays and silts of medium to high plasticity and liquid limits. Soil Types Of MH, ML, CH and CL are included in this class. These materials shall not be used for embedment.

Class I foundation material consisting of ¼-inch to 1½ -inch graded stone shall be required in addition to standard bedding and embedment for all sewer installations, regardless of pipe material, when the trench bottom is unstable due to water, rock, infiltration, or soil type.

All bedding, embedment and backfill materials shall be compacted to a minimum of 95% Standard Proctor density regardless of material. In instances where compliance with compaction requirements is questionable as determined by the Infrastructure Field Technician, testing shall be provided by the Contractor and a reputable licensed Geotechnical Engineer to verify compliance.

The minimum trench width shall be one pipe diameter plus 12 inches on each side of the pipe as described in Section 5000.

In any area where the pipe will be installed below existing or future ground water levels or where the trench could be subject to inundation, additional Class I material shall be used for bedding.

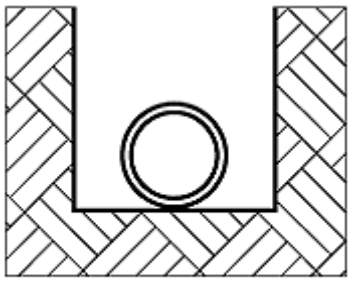
If hydraulic jack shoring is utilized for trench walls, it shall be restricted to the area just above the top of the pipe. This will ensure the embedment materials and pipe will not be disturbed when the shoring is removed.

3. DIP Specific Installation Requirements

Ductile iron pipe shall be installed in accordance with the requirements of AWWA C600 and the Ductile Iron Pipe Handbook published by the Ductile Iron Pipe Research Association. Materials at all times shall be handled with mechanical equipment or in such a manner to protect them from damage. At no time shall pipe and fittings be dropped or pushed into ditches.

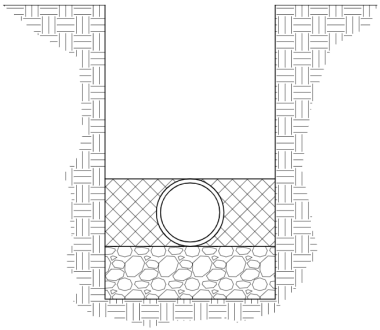
Pipe shall be installed at laying conditions as specified herein and identified by the plan drawings. Laying conditions for ductile iron pipe shall be as described in AWWA C151 and the Ductile Iron Pipe Research Association. Laying conditions shall be defined as follows:

Type 1: Flat Bottom Trench with Pipe Resting on Stable Undisturbed Earth. Unstable conditions such as wet trench bottoms, intermediate rock layering, partially weathered rock, and other unsuitable soil conditions shall require utilizing more stringent laying conditions. At a minimum, Type 4 laying condition shall be utilized with a minimum of 4-inches of bedding to overcome unstable conditions. For severe unstable soil conditions, undercut excavation and an engineer designed foundation plan shall be provided prior to pipeline installation.



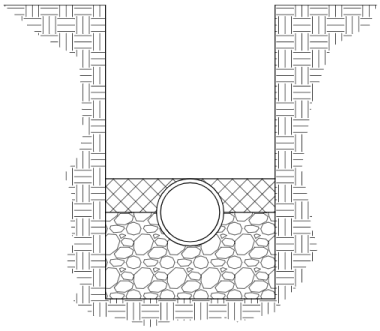
Type 1*

Type 4: Pipe bedded in Class 1 material, No. 67 or No. 78 crushed stone to a depth of 1/8 pipe diameter or a minimum of 4-inches. Embedment material consisting of Class 1, Class 2 or Class 3 materials shall be compacted to the top of the pipe greater than 95% Proctor. Careful attention must be allocated to compacting embedment material under the bottom edges of the pipe.



Type 4

Type 5: Pipe bedded in Class 1 material, No. 67 or No. 78 crushed stone to the center of the pipe and extending a minimum of 4-inches under the pipe. Granular or select embedment, consisting of Class 1 or Class 2 materials, compacted to greater than 95% Proctor installed to the top of the pipe.



Type 5

4. PVC Specific Installation Requirements

a) The installation of PVC Pipe shall satisfy the requirements of the manufacturer, and/or the following, whichever is more stringent:

b) For PVC pipe, the pipe shall be produced with bell and spigot end construction. Joining shall be accomplished by rubber gasket in accordance with manufacturer's recommendation. Flexible watertight elastomeric seals in accordance with ASTM D3212-1 may also be used. Each pipe length shall be clearly marked with information including pipe size, profile number and class number.

c) Installation of PVC pipe shall follow the recommendations of ASTM D-2321 "Underground Installation of Thermoplastic Pipe for Sewers and other Gravity-Flow Applications". For PVC pipe installation, bedding and embedment material shall be Class I, typically No. 67 or No. 78 washed stone. Bedding and embedment materials for PVC gravity sewers other than No. 67 or No. 78 washed stone shall be approved by prior to use.

d) Typical Bedding and Embedment for SDR35 PVC Gravity Sewers, 4-ft to 14-ft in Depth.

Bedding shall consist of minimum 4-inches of No. 67 or No. 78 stone installed under the pipe. Embedment shall extend to the top of the pipe. Bedding and embedment shall be compacted to 95% standard proctor density. Careful attention shall be placed on compacting embedment under the haunches of the pipe to prevent any potential voids.

e) Typical Bedding and Embedment for SDR26 PVC Gravity Sewers, 14-ft to 20-ft in Depth.

Bedding shall consist of minimum 6-inches of No. 67 or No. 78 stone installed under the pipe. The embedment, consisting of the same material, shall extend 6-inches above the crown of the pipe. Bedding and embedment shall be compacted to 95% standard proctor density. Careful attention shall be placed on compacting embedment under the haunches to prevent any potential voids.

f) The bedding and embedment materials shall be in accordance with ASTM D-2321. The embedment materials shall be installed from trench wall to trench wall.

g) The maximum allowable deflection after installation shall BE LESS THAN 5% for PVC pipe.

h) All PVC pipe shall be stored properly to prevent UV damage prior to installation. Any PVC pipe with visible fading caused by UV radiation from sunlight shall be rejected.

i) All PVC pipe shall be free from nicks, scratches and gouges at the time of installation. Such defects can impact the strength of PVC pipe and all pipes with visible gouges shall be rejected.

D. PIPE IDENTIFICATION AND MARKING

1. Marking Tape
   a) Installation: Marking tape shall be installed continuously and longitudinally along all sanitary sewer mains for new construction and for any repair or retrofit construction using open trench methods. For service connections, the marking tape shall extend from the main line to the cleanout at the right-of-way/easement. Marking tape shall be installed directly above the center of the pipe and at least 24-inches deep from final grade to a maximum depth of 36-inches below final grade.

   b) Specifications: The sanitary sewer main marking tape shall be an approved product identified in Cary's Approved Products List. The marking tape shall be made of polyethylene (or approved equivalent) material, 6-inches wide and a minimum of 6 millimeters thick. The marking tape shall have detectable markers embedded in the tape and spaced adequately to provide continuous detection along the tape from above the buried pipe at final grade. The tape shall be green in color and shall be marked with words "CAUTION SEWER LINE BURIED BELOW" (or an approved equivalent wording). The wording shall be repetitive along the full length of the tape.

7020 MANHOLES

A. DESIGN

1. Manhole Location, Siting and Design

a) Manholes shall be spaced at a maximum distance of 400 feet.

b) Manholes shall be installed at each deflection of line and/or grade. The flow channel through manholes shall have a uniform and smooth finish free of irregularities or obstructions. The invert channel shall conform to the shape and slope of the entering/exiting sewer line. Either pre-cast or brick and mortar inverts may be used.

c) When sewers of uniform slope pass through a manhole, the slope shall be maintained and the invert at the center of the manhole shall be provided. When sewers change slope at a manhole, the incoming and outgoing invert elevations will be given on the plan drawings.

d) The maximum flow deflection angle in a manhole shall be dependent upon pipe size as shown in the following table. Sufficient drop shall be provided in the manhole to compensate for energy loss caused by the change of alignment. A minimum drop of 0.1-ft is required for a change of alignment greater than 30-degrees.

Maximum Allowable Flow Deflection

Pipe Size (largest pipe controls)	Maximum Deflection Angle per Manhole
8-10 inch diameter	<90 degrees
12-20 inch diameter	75 degrees
>20-inch diameter	60 degrees

e) Free falls of wastewater flow into the manhole invert from incoming sewer mains shall not be allowed, except under limited circumstances.

f) In certain isolated circumstances standard free drops may be allowed, not exceeding 20-inches, when pipe diameter changes occur at a manhole. In these cases, the smaller diameter pipe crown shall be positioned no higher than the larger diameter pipe crown to limit the drop. When free drops are necessary due to pipe size changes, the Contractor shall take preventive measures to prevent free drops into the manhole invert, such as building a flume or trough up to the incoming invert or piping the flow to the primary invert flow channel.

g) Drop manholes are not allowed without the written approval of the Utilities Department. While certain physical constraints may dictate the

need for drop manholes, they may not be used merely to decrease trenching depth. Upstream slope changes shall be used to avoid the need for drop manholes.

h) If drop manholes are required, they shall be constructed with an outside drop connection. The entire incoming sewer main leading to the drop shall be made of ductile iron pipe. Drops shall be concrete encased and constructed in accordance with the Standard Details.

i) Inside drop manholes shall only be allowed in unique circumstances on a limited basis and can only be approved by the Director of Utilities.

j) Manholes shall not be obstructed from view or access. It is illegal to bury or obstruct access to manholes.

k) Manhole covers shall be elevated as follows:

- Roadways: Manholes installed in roadways and road shoulders shall be installed with the cover flush with the top of pavement.

- Outside of Roadways: Manholes installed outside of roadways shall be elevated at least 1-ft above the surface grade unless otherwise noted.

- Wooded Outfalls: All manholes installed in wooded, forested or brushy areas shall be elevated at least 2-ft above the surface elevation.

- 100-Year Flood Zone: All manholes located within the 100-year flood elevation shall be elevated at least 24 inches above the 100-year flood elevation or specify watertight covers and vents that extend at least 24 inches above the 100-year flood elevation.

- Well Maintained Areas: All manholes installed in well maintained areas, such as yards, sidewalks or otherwise inside an improved right-of-way shall be installed flush with the finished surface.

l) Manholes higher than 30 inches above finished grade shall be constructed with a flat top and outside steps.

m) Manholes shall be provided with only top and bottom interior steps installed.

n) When connecting a new sewer main to an existing main, the connection shall be established with a “Doghouse” type of manhole inserted over the existing main.

2. Manhole Sizing

a) Manholes shall be sized as shown in the following table. The next larger size shall be required if the pipe size, depth, drop connection or number of main line connections warrants a larger size. In consideration of main line connections, all will be considered regardless of type, whether inside drop, outside drop, force main or standard connection.

Manhole Sizing Guide

Manhole Size	Maximum Allowable Pipe Size	Maximum Depth of Cover	Maximum Depth with Extended Base	Frame and Cover Size (outside of paved areas)	Maximum Sewer Main Connections
(diameter)	*(diameter)*	*(invert to surface)*	*(invert to surface)*	*(diameter)*	*(quantity)*
4-ft	8-12 inches	12-ft	25-ft[1]	24-inches	3[2]
5-ft[4]	14-24 inches	12-ft	35-ft	24-inches	2[3]
6-ft[4]	27-42 inches	12-ft	35-ft	36-inches	2[3]
8-ft[4]	48 inches	12-ft	35-ft	36-inches	2[3]
10-ft[4]	54 inches	12-ft	35-ft	36-inches	2[3]

[1]Depths beyond 14-ft in roadways shall require a 5-ft diameter manhole with extended base.
[2]Four connections may be permitted in a 4-ft diameter manhole when the separation between each incoming connection is at least 85°.
[3]Additional smaller diameter connections that meet the spacing requirements of Section C, Installation, may be approved by the Utilities Department.
[4]Due to the limited manhole wall area that could exist between the invert in and out, some manholes may require upsizing as directed by the Utilities Department.

All manholes 5-ft in diameter shall be extended to surface elevation with no further reduction in diameter until the eccentric cone section.

Manhole transitions for 6-ft and larger diameter manholes are only allowed in the top 5-ft of the manhole. In no case shall the smallest barrel size be less than 5-ft diameter. At least 5-ft of vertical clearance shall be

maintained above the pipe crown before transitioning to a smaller diameter riser, or transition shall not be utilized. An eccentric flat slab reducer from 6-ft diameter or larger manhole base sections to 5-ft diameter risers (non-paved areas) or eccentric cones (paved areas) shall be used to make any transition.

Manholes outside of paved areas that are 6-ft in diameter and greater and are too shallow to maintain 5-ft of vertical clearance above the crown of the pipe shall maintain the full manhole diameter up to the design surface elevation and be provided with a flat top slab cover with eccentric hole.

Manholes inside of paved areas that are 6-ft in diameter and greater shall be constructed with an eccentric, flat top reducer to 5-ft diameter and provided with a 5-ft diameter eccentric, tapered cone at the finished grade. When the depth of the manhole is too shallow to maintain 5-ft of vertical clearance above the crown of the pipe a 3-ft tall eccentric, tapered cone shall be used without any additional 5-ft diameter risers.

B. MATERIALS

1. Concrete Manholes

Manholes shall be precast concrete with a minimum compressive strength of 4000-psi and utilize minimum grade 60 rebar in compliance with ASTM C478. All 4-ft and 5-ft diameter manholes and all 6-ft diameter manholes in paved areas shall be provided with eccentric cone sections. Flat top manholes are required in outfall areas for 6-ft and larger diameter manholes.

Precast concrete manholes shall meet all design and manufacturing requirements of ASTM C478 and all H-20 loading requirements. Minimum wall thickness shall be 5-inches and shall increase with depth and diameter in accordance with ASTM standards. The standard joint shall be sealed with a plastic cement putty meeting Federal Specification SS-S-00210, such as Ram-Nek or a butyl rubber sealant. All lift holes must be plugged with non-shrinking grout after installation.

All manholes greater than 5-ft diameter shall have minimum 8-inch (6-inch for 4-ft diameter manholes), 4,000-psi concrete bottoms resting on a minimum of 12 inches of #57 stone. Sewer mains shall enter and exit radially through the manhole. Inverts shall be constructed with a width equal to the effluent pipe and a height equal to 1/2 that of the effluent pipe. Inverts shall be so finished with sufficient drop across the manhole to compensate for all resulting energy loss across the invert. Flat invert channels shall not be allowed. At each inlet and outlet of 8 inches or greater, resilient connectors or manhole boots shall be provided in

conformance with ASTM C923. Rings and clamps are to meet standards of ASTM A167 and/or ASTM C923.

Precast manhole components shall not be installed, transported, or removed from the casting yard prior to reaching the minimum compressive strength of 4,000-psi and at least 7 days have elapsed since casting.

Manhole flat slab, eccentric reducers provided for 6-ft diameter and larger manholes shall be provided with minimum slab thickness of 12-inches. Flat slab, eccentric reducers shall not be allowed for manhole diameters less than 6-ft.

Manhole flat top slab covers for outfall manholes 6-ft diameter and greater shall be designed and manufactured for H-20 loading and provided in minimum slab thickness of 8-inches. Manhole flat top covers shall be provided with a minimum clear opening of 36-inches when utilized with a 36-inch clear span manhole frame and cover.

Manhole benches shall slope upwards from the spring line of the pipe to the projected level of the pipe crown at the manhole wall, or 8-inches above the spring line, whichever is less. Bowl type inverts recessed inside of precast benches shall not be accepted.

2. Polymer Concrete Manholes

Polymer concrete manhole sections, monolithic base sections and related components shall meet the requirements of ASTM C 478. ASTM C 478 material and manufacturing is allowed compositional and dimensional differences required by a polymer concrete product. Polymer Concrete Manholes shall be domestically manufactured.

Base riser section shall be provided with monolithic floors, unless shown otherwise. Riser sections shall be provided joined with bell and spigot / ship-lap design seamed with butyl mastic and or rubber gaskets (ASTM C 990) so that on assembly, manhole base, riser and top section make a continuous and uniform manhole structure. Riser sections for polymer concrete manholes shall be constructed from standard polymer concrete manhole sections of the diameter indicated on drawings. Use various lengths of polymer concrete manhole sections in combination to provide correct height with the fewest joints.

Wall sections shall be designed for depth and loading conditions with wall thickness as designed by polymer concrete manufacturer.

Manhole tops shall support AASHTO HS-20 loading or loads as required and receiving cast iron frame covers or hatches, as indicated on drawings.

Polymer Concrete Manhole risers, cones, flat lids, grade rings and manhole base sections shall be designed by manufacturer to meet the intent of ASTM C 478 with allowable compositional and sizing differences as designed by the polymer concrete manufacturer.

Covers shall be designed to meet AASHTO HS-20 design or as required by drawings, shall be domestically manufactured, and listed on Cary's Approved Products List. Polymer manholes shall be designed based upon live and dead load criteria in ASTM C 857 and ACI 350-06.

Polymer Concrete Manhole risers, cones, flat lids, grade rings and manhole base sections shall be designed by manufacturer to meet loading requirements of ASTM C 478, ASTM C 857 and ACI 350-06 as modified for polymer concrete manhole design as follows:

Polymer Concrete Mix Design shall consist of thermosetting resin, sand, and aggregate. No Portland cement shall be allowed as part of the mix design matrix. All sand and aggregate shall be inert in an acidic environment.

Reinforcement – Shall use acid resistant reinforcement (FRP Bar) in accordance with ACI 440.1R-06 as applicable for polymer concrete design.

The wall thickness of polymer concrete structures shall not be less than that prescribed by the manufacturer's design by less than 95% of stated design thickness.

Thermosetting Resin - The resin shall have a minimum deflection temperature of 158° F when tested at 264 psi (1.820 mPa) following Test Method D 648. The resin content shall not be less than 7% of the weight of the sample as determined by test method D 2584. Resin selection shall be suitable for applications in the corrosive conditions to which the polymer concrete manhole structures will be exposed.

Each polymer concrete manhole component shall be free of all defects, including indentations, cracks, foreign inclusions, and resin starved areas that, due to their nature and degree or extent, detrimentally affect the strength and serviceability of the component part. Cosmetic defect shall not be cause for rejection. The nominal internal diameter of manhole components shall not vary more than 2%. Variations in height of two opposite sides of risers and cones shall not be more the 5/8 inch. The under run-in height of a riser or cone shall not be more than ¼ in/ft of height with a maximum of ½ inch in any one section.

Marking and Identification - Each manhole shall be marked with the following information - Manufacturer's name or trademark, Manufacturer's location, and Production Date.

Manhole joints shall be assembled with a bell/spigot or shiplap butyl mastic and/or gasketed joint so that on assembly, manhole base, riser and top section make a continuous and uniform manhole. Joint sealing surfaces shall be free of dents, gouges and other surface irregularities that would affect joint integrity.

Minimum clearance between wall penetrations and joints shall meet the requirements laid out in Cary's Standard Specifications and Details.

Construct invert channels in accordance with Cary's Standard Details to provide smooth flow transition with minimal disruption of flow at pipe-manhole connections. Invert slope through manhole is as indicated on drawings. All precast base sections to be cast monolithically. Polymer bench and channel are to be constructed with all polymer concrete material. Extended ballast slab requirements for buoyancy concerns can be addressed with cementitious concrete material.

Provide resilient connectors conforming to requirements of ASTM C 923 or other options as available. All connectors shall be watertight. Install approved resilient connectors at each pipe entering and exiting manholes in accordance with manufacturer's instructions.

All materials needed for grouting and patching shall be a polyester mortar compound provided by the manufacturer or an approved equal by the manufacturer.

Manufacturer shall be included on most current edition of Cary's Approved Products List.

3. <u>Manhole Frame and Cover Materials</u>

a) Manhole Frames and Covers shall be Class 35 gray iron with "Sanitary Sewer" and the Cary symbol forged into the cover as indicated in Standard Details. Ring and cover shall be stamped with make and model. All manhole frames and covers shall be domestically made and manufactured in the USA from domestic iron.

b) Types

i. Manhole Frames and Covers in Paved Areas and some Unpaved Areas: For all installations in roadways or within the right of way, use Type 1 ring and cover, and place sufficient depth of concrete below the pavement around the ring to ensure

contact with manhole. Type 1 covers shall be provided with 1 vent hole. Type 1 covers shall be designed for a proof load of 40,000 lbs. and be provided in Class 35B gray iron in conformance with ASTM A48. At a minimum, Type 1 manhole rings shall weigh 190 lbs. and the cover shall weigh 120 lbs.

ii. Manhole Frames and Covers for Outfalls: For installation in outfall areas, with 4-ft and 5-ft diameter manholes use Type 2 ring and covers. Type 2 covers shall not be installed in areas subject to traffic loading. Type 2 covers shall be provided with an integrated frame and cover assembly in which the cover rotates away from the frame for access. The rotating assembly shall be provided with a cast in stainless steel rod assembly. Type 2 covers shall be provided with a minimum 24-inch clear span opening along the axis with the stainless-steel rod assembly. Security shall be provided by 3 exterior cast lugs at ¾-inch thickness that allow padlock installation or bolting with 3 stainless steel bolts with stainless steel zinc plated nuts. Type 2 covers shall be made of Class 35B iron in conformance with ASTM A48 and designed for a proof load of 12,000 lbs. The frame and cover weight shall not be less than 60-lbs for the cover and 80-lbs for the ring. The Type 2A frame and cover assembly shall be provided with a gasket that makes the cover assembly watertight when bolted at all three lugs. Type 2A covers shall be provided inside the 100-year flood elevation or other areas subject to flooding if the manhole lid is less than 24 inches above the 100-year flood elevation. Type 2B covers are not watertight and are not required to have a gasket.

iii. Manhole Frames and Covers for Large Diameter Outfall Manholes: Type 3 ring and cover assemblies shall be provided with a minimum 36-inch clear span opening and utilized for 6-ft diameter or larger manhole installations with eccentric flat top manholes outside of paved areas. (Within paved areas, use standard Type 1 cover on a 5-ft diameter eccentric cone.) The type 3 frame and cover shall be provided with a 36-inch cover with an inset cover of 26-inches in diameter. The frame and cover assembly shall be provided in the watertight configuration in areas within the 100-year flood elevation or other areas subject to flooding if the manhole lid is less than 24 inches above the 100-year flood elevation.

c) All castings shall be machined to give even and continuous bearing on the full length of the frame. Castings shall be free of porosity and blow holes. All manhole frames shall be bolted to the manhole, except in paved streets.

C. INSTALLATION

1. General Requirements

a) The upstream side of the last manhole(s) of a sanitary sewer line extension under construction shall be plugged by constructing a brick/block wall to prevent the passage of groundwater, runoff, and sediment into the sanitary sewer system. All water upstream of the wall shall be pumped out of the sanitary sewer line and all sediment and solids shall be removed and properly disposed of by the Contractor. The wall shall not be removed until the line has been inspected by Cary to ensure that all possible points of inflow or infiltration have been eliminated. Failure to meet these requirements will be deemed a violation of the Sewer Use Ordinance with fines up to $1,000.00 per day.

b) Manholes shall not be buried or hidden, which is a violation of the sewer use ordinance and subject to penalty by fines.

c) All manhole penetrations, whether sewer main or service lateral, shall be cored with a concrete coring machine. All pipe connections must be made with flexible watertight couplings or boots.

For new manholes, there shall be a minimum of 9-inches or ½ the pipe outside diameter (OD), whichever is greater, between the pipe hole openings. (Pipe hole opening is typically 4" greater than the pipe OD.) When the adjacent pipes are different sizes, the OD of the smaller pipe shall be used to determine the spacing requirement but shall never be less than 9-inches.

For connections to existing manholes, there shall be a minimum of 9-inches or 3.5-inches plus ½ the OD of the existing pipe, whichever is greater, between the pipe hole openings.

d) All external manhole joints shall be wrapped with an approved joint seal material.

2. Manholes Subject to Inundation

a) Manholes subject to flooding shall be watertight and vented 24 inches above the 100-YR flood elevation. In flood prone areas, the manholes shall be vented at least every 1000-ft or every other manhole, whichever is greater.

b) The exterior of all manholes within the 100-year flood elevation and in wetland areas shall receive an exterior coating of an approved bitumastic coal tar epoxy at 40-mils to prevent weepage or attack by acidic soils. In lieu of epoxy coated concrete manholes, approved polymer concrete manholes may be installed. Manufacturer of polymer concrete manholes shall be listed on Cary's Approved Products List.

c) Anti-flotation design measures shall be implemented as required in flood prone areas.

3. Manholes Located on Large Collection Mains

Cary reserves the right to require all manholes located on interceptor or outfall mains 24-inches in diameter and larger to have the manhole interior and bench coated with an approved epoxy coating at 80-mils thickness. The epoxy coating shall be field applied and tested as described herein. An approved polymer concrete manhole may be installed in lieu of epoxy coating the manholes.

4. Force Main Discharge Manholes

All manholes located on gravity mains that serve or will serve as discharge points for sanitary sewer force mains shall receive an interior epoxy coating at 80-mils thickness. In addition to the receiver manhole, Cary reserves the right to require epoxy coating of the next two consecutive manholes downstream of the receiver manhole or all downstream manholes within 1500-lf of the receiver manhole. See Section 7200 for further information on force main discharge manholes. An approved polymer concrete manhole may be installed in lieu of epoxy coating the manholes.

5. Epoxy Coating

a) Material Providers and Installers: Approved coating manufacturers and corresponding installers are identified in Cary's Approved Product List.

b) Surface Preparation: Concrete manholes must be well cured prior to application of the protective epoxy coating. Generally, 28 days is adequate cure time for standard Portland cement. If earlier application is desired, compressive, or tensile strength of the concrete can be tested to determine if acceptable cure has occurred. (Note: Bond strength of the coating to the concrete surface is generally limited to the tensile strength of the concrete itself. An Elcometer pull test to determine suitability of concrete for coating may be required).

Surface preparation shall be based on the requirements of the manufacturer of the epoxy coating and applicable NACE International standards.

c) Installation: A minimum 80-mils thickness shall be field applied to new manholes (120-mils for existing manholes). During application a wet film thickness gage, meeting ASTM D4414 - Standard Practice for Measurement of Wet Film Thickness of Organic Coatings by Notched Gages, shall be used to ensure a monolithic coating and uniform thickness during application.

Temperature of the surface to be coated should be maintained between 40° F and 120° F during application. Prior to and during application, care should be taken to avoid exposure of direct sunlight or other intense heat source to the structure being coated. Where varying surface temperatures do exist, care should be taken to apply the coating when the temperature is falling versus rising or in the early morning. The humidity should also be observed to ensure compliance with the epoxy manufacturers' recommendations.

Manufacturer approved heated plural component spray equipment shall be used in the application of the specified protective epoxy coating. The spray equipment shall be specifically designed to accurately ratio and apply the specified protective coating materials and shall be regularly maintained and in proper working order.

If necessary, subsequent top coating or additional coats of the protective coating should occur as soon as the basecoat becomes tack free, ideally within 12 hours but no later than the recoat window for the specified products. Additional surface preparation procedures will be required if this recoat window is exceeded.

7030 SERVICE CONNECTIONS

A. DESIGN

1. General Requirements

a) Direct sewer service taps shall not be allowed on sewer interceptor or outfall mains 15-inches in diameter or larger, except by manhole connection.

b) All residential subdivision lots shall be served by gravity unless otherwise approved. If a pump is approved, it shall be privately maintained and must pump into either a service connection placed on

the lot or through a private force main to a manhole. The pump and force main (if needed) must have a note on the recorded plat indicating the following: “Privately maintained sewer pump and force main is required to serve this lot”.

Service connections to the main lines shall be perpendicular to the main line and shall extend to the edge of the right of way or easement line. In addition, within townhouse developments, sewer service connections shall be located within 4-feet of driveways, or under driveways, to minimize conflicts between service lines and trees.

c) Cleanouts are required on all services with a maximum spacing of 75 feet on 4-inch services and 100 feet on 6-inch or 8-inch services, and at the right of way line or edge of easement. All cleanouts shall extend a minimum of 6-inches above finished grade with brass caps or meet the optional cleanout method requirements in accordance with the Standard Details.

   Sewer cleanouts located in or within 24-inches of a paved areas, which bear vehicle loading, must have ductile iron risers, ductile iron fittings and a traffic rated cast iron or ductile iron cover assembly. Refer to Standard Details for mini manhole for sewer service cleanout assembly in traffic areas.

d) Where 8-inch sewer services are required, the length of service may not exceed 200-ft and cleanouts should be utilized. The NC Plumbing code (708.1.2) requires that a manhole be set no further than 200-ft from the building. At this manhole, the service must transition to either public or private main. If a private main is required due to site constraints, the sewer permit must be obtained from the State and the most current version of the FTSE form should be submitted to Cary staff. For further information, see NC Plumbing Code 708.1.2 Gravity Building Sewers.

e) All 6-inch and 8-inch service connections shall be into a manhole.

f) Service lines connected to manholes shall not be through the cone section or manhole joints. Service lines shall be installed 6” above, but no more than 30 inches above the invert or shall be installed with a standard drop. Multiple service connections shall not be maintained by Cary. For 6-ft diameter and larger manholes no service is allowed in the reduced diameter riser sections of the manhole.

g) The use of in-line wyes for service connections shall be required for all new construction. When connecting to existing sewer mains, service

saddle taps will be allowable. Taps shall be at the 10 or 2 o'clock position and shall not be top taps.

h) Service connections to mains at depths of 14-ft and greater shall utilize ductile iron pipe between the main and the cleanout, including a ductile iron wye for the cleanout stack. Location and angle of fittings shall be as shown in the Standard Detail drawings.

i) Where the flood level rims of plumbing fixtures are below the elevation of the manhole cover of the next upstream manhole in the public sewer, such fixtures shall be protected by a backwater valve installed in the building drain, branch of the building drain or horizontal branch serving such fixtures. Plumbing fixtures having flood level rims above the elevation of the manhole cover of the next upstream manhole in the public sewer shall not discharge through a backwater valve.

B. MATERIALS

1. Pipe Materials

a) PVC Pipe shall be schedule 40 or greater supplied in minimum 18-ft lengths. Schedule 40 PVC pipe shall be manufactured with a cell classification of 12454 in conformance with ASTM D1784. Schedule 40 pipes shall be manufactured to dimensional tolerances as specified in ASTM D1785 and rated for service conditions up to temperatures of 140-degrees Fahrenheit. The pipe may be joined by solvent weld in conformance with ASTM D2564.

Schedule 40 PVC Service Pipe Sizing

Nominal Pipe Diameter (inches)	Outside Diameter (inches)	Inside Diameter (inches)	Thickness (inches)
4	4.50	4.02	0.24
6	6.62	6.03	0.28

PVC pipe for sewer services shall require bedding based upon depth as follows:

- 4-14-ft Depth – 4-inches of stone bedding extended to springline.
- 8-20-ft Depth – 6-inches of stone bedding extended 6-inches above pipe crown.

b) Ductile Iron Pipe shall be used for sanitary sewer services with less than 4 feet of cover or more than 20 feet of cover. Ductile iron services shall also be used in all cases where a well is located within 100-ft of the sewer service line. Ductile iron service piping shall be provided in

conformance with the ductile iron piping standards outlined herein including cement mortar lining.

DIP Service Pipe Sizing

Nominal Pipe Diameter (inches)	Outside Diameter (inches)	Inside Diameter (inches)	Thickness (inches)
4	4.80	4.30	0.25
6	6.90	6.40	0.25

2. Sewer Service Fittings, New Construction

All sewer service connections for new construction shall be provided with in-line wye fittings.

DIP Main with DIP Service

In-line wye fittings for ductile iron main lines joined with ductile iron service lines shall be typical ductile iron mechanical joint fittings as specified herein. In this case all fitting sizes shall conform to AWWA C153. Wye fittings through 10-inches in diameter shall be provided with cement mortar lining in accordance with AWWA C104 and provided with exterior asphaltic coating per AWWA C151. Wye fittings for lines larger than 10-inches in diameter shall be provided with Cary approved lining as specified herein for ductile iron pipe of the same sizing.

DIP Main with PVC Service

For ductile iron sewer mains to be joined with PVC service lines, the in-line wye fittings shall be slip joint ductile iron with an IPS sized branch for PVC schedule 40 service lines. Ductile iron fittings for connecting PVC service lines shall be deep bell, gasketed joint and air test rated. Gasket grooves shall be machined. Bell depths shall meet the minimum socket depth requirements of ASTM D3034 and ASTM F1336. Wall thickness shall meet the requirements of AWWA C153. Ductile iron wye fittings through 10-inches in diameter with IPS connections shall be provided with cement mortar lining in accordance with AWWA C104 and provided with exterior asphaltic coating per AWWA C151. Ductile iron wye fittings for PVC lines larger than 10-inches in diameter shall be provided with Cary approved lining as specified herein.

PVC Main with PVC Service

For PVC sewer mains to be joined with PVC service lines, PVC in-line wye fittings shall be provided. Typical Schedule 40 PVC fittings shall be provided at the cleanout wye and stack.

PVC Main with DIP Service

A ductile iron tee/wye shall be provided when the service line is required to be ductile iron due to a crossing or other obstruction. The fitting shall be specifically manufactured for ASTM 3034 PVC pipe such that a smooth flow way exists on the main line through the fitting. The branch shall be gasketed to receive the 4-inch DIP service line without additional fittings. The ductile iron tee/wye fitting shall be provided with Cary approved lining.

3. Service Saddle Connections, Existing Sewer Mains

a) PVC service saddles shall be of the same material as the main and shall be solvent welded and fastened with double stainless-steel bands.

For existing DIP main lines, ductile iron service saddles shall be used. The saddle assembly shall consist of a virgin SBR or NBR gasket compounded for sewer service, a ductile iron saddle casting, a 304 stainless steel adjustable strap for fastening the gasket and the saddle casting to the sewer main and a 304 stainless steel adjustable circle clamp for securing the service line into the rubber gasket.

C. INSTALLATION

1. General Requirements

a) Sewer laterals shall not be located in easements when gravity service can be provided to the property frontage at the street.

b) Each separately owned structure requires a separate tap to a public sewer.

c) All service lines with less than 4-ft of cover or deeper than 20-ft shall be made of ductile iron pipe.

d) 4-inch lines shall have a minimum slope of 1.0-ft/100 feet and 6-inch lines shall have a minimum slope of 0.60-ft/100 feet.

e) All service connections to existing sanitary sewer mains shall be made by Cary. Service connections to new mains may be made by the Contractor but shall include the use of wye (not tee) connections. Saddle taps onto new lines shall not be allowed.

f) Saddle taps into existing PVC mains shall be made at the 10 o'clock or 2 o'clock position of the main with the wye saddle angled 45-degrees towards the direction of flow in the main. Taps shall only be made by a

mechanical circular cutting saw providing a smooth and uniform cut for the saddle installation.

g) Service connections shall be made using an approved sewer saddle when the existing sewer line is 8", 10", or 12" in diameter. This service connection shall not be used when the sewer main material is truss sewer pipe. The opening in the sewer main for the sewer saddle shall be cut with a hydraulically or pneumatically driven circular tapping saw of the same nominal diameter as the sewer service line.

h) Grease traps shall not be located within the public ROW or within public easements.

7040 TESTING AND INSPECTIONS

A. GENERAL

The Contractor shall furnish all materials, labor, and equipment to perform all testing. The Contractor may arrange to obtain water for testing purposes from Cary. The Contractor shall reimburse Cary for all water used for construction at current inside utility rates.

B. SEWER MAIN AND SERVICE CONNECTION TESTING

1. Visual Testing and Observation

a) All materials used must be approved by the Infrastructure Field Technician prior to installation. Rejected materials shall be immediately removed from the job.

b) Gravity sanitary sewer lines shall be clean and free from obstructions and shall be visually inspected from every manhole. Lines which do not exhibit a true line and grade, or which have structural defects shall be corrected. Sanitary sewer service connections shall be visually inspected prior to backfilling.

2. Air Testing

a) Low-pressure air testing in accordance with ASTM F1417 shall be performed on all sewer mains before the laterals or stubs are installed on the line, and after the trench has been backfilled to finished grade. Plugs shall be installed at each manhole to seal off the test section.
The line will be pressurized with a single hose and monitored by a separate hose connection from the plug. Air then shall be slowly introduced into the sealed line until the internal air pressure reaches 4.0 psig. The air pressure shall then be allowed to stabilize for a minimum of 2 minutes at no less than 3.5 psig (plus groundwater pressure, if any). When the pressure reaches 3.5, the time required for the pressure to drop 1.0 psi will be observed and recorded. The line shall be "acceptable" if the pressure does not drop more than 1.0 psi in the time prescribed for the test in the Sanitary Sewer Air Test table found in the Standard Details. An abbreviated version of the air test table is shown below.

SPECIFICATION TIME (MIN:SEC) REQUIRED FOR PRESSURE DROP FROM 3-1/2 TO 2-1/2 PSIG

LENGTH OF TEST SECTION	NOMINAL PIPE DIAMETER (INCHES)										
	8	12	15	16	18	21	24	27	30	36	42
50	7:33	11:20	14:10	15:11	17:00	19:48	22:40	25:30	28:19	34:00	39:40
100	7:33	11:20	14:10	15:11	17:00	19:48	22:47	28:51	35:37	51:17	69:48
150	7:33	11:20	14:10	15:12	19:14	26:10	34:11	43:16	53:25	76:55	104:42
200	7:33	11:24	17:48	20:16	25:39	34:54	45:35	57:42	71:13	102:36	139:36
250	7:33	14:15	22:16	25:20	32:03	43:37	56:58	72:07	89:02	128:12	174:30
300	7:35	17:06	26:43	30:23	38:28	52:21	68:22	86:32	106:48	153:54	209:25
350	8:52	19:57	31:10	35:27	44:52	61:05	79:46	101:00	124:42	179:30	244:19
400	10:07	22:48	35:37	40:31	51:17	69:48	91:10	115:24	142:30	205:06	279:13
450	11:23	25:39	40:04	45:35	57:42	78:31	102:36	129:48	160:18	230:48	314:07
500	12:39	28:30	44:31	50:39	64:06	87:15	114:00	144:12	178:06	256:24	349:02

b) If the section fails to meet these requirements, the source of leakage shall be repaired and the pipe section re-inspected.

The Infrastructure Field Technician may require that an infiltration test be performed that shall not exceed 100 GPD/inch/mile.

3. Deflection Testing for Flexible Pipe

a) The mandrel (go/no-go) deflection test shall be performed on each line prior to acceptance and no sooner than 30 days after installation. The pipeline shall be thoroughly clean and free of debris and/or sediment prior to testing. The Contractor shall supply the mandrel used for this performance test. The mandrel device shall be cylindrical in shape

having 9 possible contact points with the pipe. The mandrel's length and diameter (ID of proving ring) shall be in accordance with the following tables and shall be subject to the Infrastructure Field Technician's approval.

b) For flexible pipes (such as PVC), the following shall apply:

Nominal Diameter (inches)	Pipe Class	Average Inside Pipe Diameter (inches)	5% Deflection Mandrel Diameter (inches)	Length of Mandrel (inches)	Minimum Fins Included with Mandrel
8	SDR 26	7.715	7.329	10	9
8	SDR 35	7.891	7.496	10	9
10	SDR 26	9.644	9.162	10	9
10	SDR 35	9.864	9.371	10	9
12	SDR 26	11.480	10.906	10	9
12	SDR 35	11.737	11.150	10	9
15	SDR 26	14.053	13.350	10	9
15	SDR 35	14.374	13.655	10	9
18	SDR 26	17.261	16.398	24	9
21	SDR 26	20.349	19.332	24	9
24	SDR 26	22.891	21.746	24	9
27	SDR 26	25.799	24.509	24	9

Note: Calculated 5% deflection allowance does not include additional manufacturing tolerances provided by pipe manufacturers. For the purposes of testing, 5% deflection shall be calculated from standard pipe inside diameter as published in ASTM D3034 and ASTM F679.

The mandrel shall be advanced through the pipeline to determine if bedding and embedment has been provided in compliance with ASTM D2321 to assure joint deflection of less than 5%. If the mandrel becomes obstructed for any reason while being pulled through the line with less than 100-lbs of force, the location of the defect shall be noted, and the mandrel shall be removed from the pipeline. Under no circumstances shall heavy equipment be utilized to force the mandrel through the pipeline. Deflection testing may be done concurrently with sewer televising inspections, provided the mandrel is kept within visible range of the camera.

4. Video Assessment and Cleaning

a) As a final measure required for acceptance, the Contractor shall clean and televise all newly installed sewer mains and laterals from the demarcation cleanout to the main and shall be clearly identifiable as to the lot of building serviced prior to acceptance by Cary. The Contractor shall televise the sewer main, and all lateral connections installed from the upstream to downstream manhole with no reverse setups or cutaways. Throughout shooting, the camera shall be panned and tilted for a complete view of the main and laterals. Lighting shall

be adequate to view the entire sewer main and service connections from beginning to end. The video inspection shall be submitted to the Infrastructure Field Technician on a Cary approved media type. IT Pipe files shall be included with the submission. Cary shall not be responsible for purchasing additional software necessary to view the submission.

b) The camera shall be advanced at a uniform rate not to exceed 20 feet per minute that allows a full and thorough inspection of the new sewer main. The camera shall be a color, pan and tilt camera capable of producing a five-hundred-line resolution picture. Lighting for the camera shall be sufficient to yield a clear picture of the entire periphery of the pipe. The picture quality shall be acceptable and sufficient to allow a complete inspection with no lapses in coverage. The length of the sewer main shall be measured and recorded on the video screen. The distance counter shall be calibrated before shooting the inspection video.

c) The Contractor shall clean the sewer mains and laterals ahead of video inspection with a high-velocity water jet. The video inspection shall take place within 2-hours of cleaning operations as witnessed by the Infrastructure Field Technician. All construction debris shall be collected in the downstream manhole and shall not be released into the sewer system.

d) The Infrastructure Field Technician shall be present throughout the cleaning and televising of the sewer mains and laterals to verify that the video work complies with the Specifications.

e) Prior to providing the inspection media to Cary's Infrastructure Field Technician, the Contractor shall label the submission with the following information:

- Name of the Project/Development.
- Name and contact information of responsible party.
- Date of televising.
- Manhole identification as shown on the design plans.

5. Marker Tape Testing

Testing of the marker tape shall be performed by the Contractor at the completion of the project to assure it is working properly and completely detectable. It is the Contractor's responsibility to provide the necessary equipment to test the markers. Any defective, missing, or otherwise non-locatable segments shall be replaced at the Contractor's expense.

C. MANHOLE TESTING

1. Vacuum Testing

a) All newly installed manholes shall pass a vacuum test in accordance with ASTM C 1244. The Contractor shall supply all equipment and materials necessary to vacuum test the manholes.

b) Vacuum Testing shall be completed prior to any specified coating and lining materials being installed.

c) The Infrastructure Field Technician shall be present and witness all vacuum testing.

d) The following vacuum testing criteria shall apply for compliance with the testing procedure.

- A vacuum of 10-inches of mercury shall be drawn with an approved vacuum testing unit.

- The testing time shall not be measured until after the vacuum pump has been shut off.

- The time required for the vacuum to drop from 10-inches to 9-inches of mercury shall meet or exceed the values listed in the following table.

Manhole Vacuum Testing Time

Depth	Manhole Diameter (inches)		
(feet)	48	60	72
	Time (seconds)		
8	20	26	33
10	25	33	41
12	30	39	49
14	35	48	57
16	40	52	67
18	45	59	73
20	50	65	81
22	55	72	89
24	59	78	97
26	64	85	105
28	69	91	113
30	74	98	121

2. Holiday Testing of Lined Manholes

All manholes that require an epoxy coating shall undergo discontinuity testing. This shall be a high-voltage spark test conducted in accordance with NACE International Standard Practice 0188. All areas of the manhole coated shall be tested. The spark tester shall be set at a minimum of 100 volts per mil of coating thickness applied. The Contractor shall supply the spark tester and all testing equipment and labor needed to perform this test.

All holidays identified must be repaired. The epoxy coating must be abraded and cleaned prior to re-coating. All touch-up work shall be in accordance with the epoxy manufacturers guidelines.

7050 AERIAL CROSSINGS

A. DESIGN

Aerial crossings shall only be utilized in cases where buried crossings are prohibited due to stream crossings, compliance with riparian buffer standards, minimizing impacts to wetlands, preventing excessive depth of installation, or as otherwise directed by Cary.

In cases where aerial crossings are utilized to cross streams, the bottom of the pipe shall be installed above the 25-year flood elevation of the stream. Piers shall generally be located at a uniform spacing of 20-ft or 1 pier for every joint of pipe. Piers shall be provided in accordance with the Standard Details and designed by a licensed NC Professional Engineer with foundations and structural components, including concrete reinforcements, designed by a licensed Structural Engineer. Aerial crossing with greater than 50 acres of drainage area are subject to Cary floodplain regulations.

All pier footings shall be designed by a licensed NC Professional Engineer and the assumptions provided in the footing design shall be included on the plans. At a minimum, the footing design shall include: 1) the allowable soil bearing capacity, 2) design concrete compressive strength, 3) plan for reinforcing steel with sizing and location of bars, 4) force diagram including buoyant forces, stream velocity impacts 5) depth of installation to prevent frost heaving, 6) bedding design to prevent differential settlement and subbase scour and 7) factors of safety for unanticipated loads such as trees falling across the aerial crossing. At locations inundated by the 100-year design storm shall include foundation anchor design.

At a minimum, all pier foundations shall be constructed on a base of 12-inches of washed stone. The soil conditions under the pier shall be evaluated by a licensed NC Geotechnical Engineer to determine if the allowable soil bearing capacity meets or exceeds the design assumptions included in the structural design and subbase stability. If the soil

conditions fail to meet the specified bearing capacity and stability requirements, a pile foundation shall be provided, or the soils shall be undercut and replaced in conformance with the recommendations of the geotechnical engineer of record.

Piers installed in stream beds shall be avoided in lieu of spanned crossings. Spanned pipe crossings greater than 20-ft shall be provided in accordance with the pipe manufacturer's specifications. The carrier pipe shall be SDR26 PVC installed in a casing meeting the requirements of the standard specifications. The carrier pipe shall be SDR26 between the upstream and downstream manholes. The entire crossing including piers, reinforcement, foundation, truss and/or beam supports, pipe anchor straps, and pipe thickness design shall be provided by a licensed NC Structural Engineer. Spanned pipe crossings shall be designed such that all flanges and exterior pipe connections are located above the 25-year flood elevation.

Each pier exposed to the 100-year design storm shall be protected by the appropriately size rip rap and extends 6-feet beyond the pier radially. Stream bank slopes beneath the aerial crossing shall be protected by appropriately sized rip rap and extend a minimum of 6-feet beyond the centerline of the pipe up and downstream. Rip rap shall not be allowed in the stream.

B. PIPE MATERIALS

1. **Ductile iron pipe** shall not be approved for aerial crossings.

2. **PVC pipe** shall be SDR26 solid wall pipe meeting the requirements of speciation section 7010 above.

3. **Steel pipe** provided for aerial crossings shall be fabricated with grade B steel that has minimum yield strength of 35 KSI in accordance with ASTM A139. Steel pipe for aerial crossings shall be provided with minimum wall thickness consistent with a pressure class of 200-psi or greater. Steel pipe for aerial sewer crossings shall be provided with 40-mils of interior ceramic coating, such as Ceramaline and provided with an exterior tape wrap approved by the manufacturer. All steel pipe joints shall be welded in conformance with manufacturers' specifications.

C. INSTALLATION

Aerial crossings are often utilized to span sensitive environmental areas and installation shall be consistent with plans to preserve the sensitive areas.

Pipe shall be secured to each pier with minimum1/4-inch by 2-inch width steel straps fastened to a minimum 4; ½-inch stainless steel lugs anchored and adhered with epoxy to the concrete pier. The steel straps shall receive a weather resistant painted finish to prevent long term corrosion. All pipe securing methods shall be designed by a NC licensed Professional Engineer.

Precast piers may be submitted for approval provided the footing and foundation designs are completed by licensed structural and geotechnical engineers.

In cases where soil conditions cannot be sufficiently stabilized to provide an adequate foundation for concrete piers, a pile foundation designed by a licensed NC structural engineer and approved by Cary shall be provided.

Reinforcing steel for concrete piers shall be grade 40 and shall be constructed in conformance with the latest edition of the "Recommended Practice for Placing Reinforcing Bars" or other documentation as published by the Concrete Reinforcing Steel Institute.

In cases where rock exists at the foundation or potential scour elevation, the footing shall be drilled and connected with dowels into the rock layer.

7060 REPAIRS AND MODIFICATIONS

A. SEWER MAIN REPAIRS

1. Vitrified Clay Pipe - replace damaged section with D.I.P. and install a Fernco coupling at each end encased in concrete.

2. PVC Pipe - replace damaged section with PVC Pipe and install a Fernco coupling at each end encased in concrete.

3. ABS/PVC Truss Pipe - replace damaged section with D.I.P. and install a Fernco coupling at each end encased in concrete.

4. Asbestos Cement Pipe - Replace damaged section with DIP and couplings encased in concrete.

B. INSTALLATION

1. All repairs to damaged sanitary sewer lines in paved areas shall be backfilled with ABC stone (crusher run) to a density of 95 percent Standard Proctor.

2. All repairs to damaged sanitary sewer lines shall be bedded with 6-inches of washed stone and compacted to a minimum of 95%

Standard Proctor density before installing the new joint of ductile iron or PVC pipe.

C. ABANDONMENT

Sewer service laterals shall be abandoned by removing and replacing the saddle with a 360-degree stainless steel sleeve. At in-line wyes the service lateral shall be cut within 12” of the wye and a mechanical cap installed on DIP/cast services or glued to PVC services and the abandoned wye encased with 1 cubic foot of concrete.

D. DRAINING SEWER MAINS

A detailed pumping and emergency plan shall be required for any sewer line draining event.

All sanitary sewer mains and sewer force mains 20-inches and larger, active, inactive, or abandoned shall begin to be drained by tapping the bottom half of the pipe. A corporation stop or other valve shall be provided to control flow. All effluent shall be pumped to a downstream manhole (when available) or other containment tank utilizing continuous piping. The use of a sump pit on lines 20-inches and larger is not allowed.

In sensitive environmental areas and in other various scenarios the Utilities Department may require lines less than 20-inches also be tapped to be drained.

END OF SECTION 7000

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SECTION 333000 – SANITARY SEWER UTILITY DISTRIBUTION SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Materials, Installation, and Testing shall be in accordance with Town of Cary Standard Specifications. See Section 7000 Wastewater Collection Systems.

1. Please note the highlighted in the sections provided within this Project Manual are from the published Town of Cary Standard Specifications and are not indicative of any special requirements of the Project.
2. All references to pay items, allowances, and Contract language within the Town of Cary Standard Specifications are not applicable to this project and should be omitted from the bid.

B. Section 312317 Trenching

C. Section 312319 Dewatering

D. Section 312324 Flowable Fill

1.2 SUBMITTALS

A. Product Data: For each type of the following manufactured or supplied products required:

1. Pipe Materials
2. Fittings, gaskets, and other appurtenances
3. Manholes
4. Cleanout lids
5. Ring and covers

PART 2 - PRODUCTS

2.1 MATERIALS

A. All materials including but not inclusive of pipe, fittings, gaskets, etc. shall be provided in according to the sewer material standards provided in the Sewer Materials section of the CORPUD

PART 3 - EXECUTION

3.1 EXAMINATION

A. Installation shall be coordinated with Engineer and City of Raleigh inspectors for schedule inspections prior to being backfilled.

3.2 INSTALLATION

A. Installation per respective Town of Cary Standard Specifications section.

3.3 FIELD QUALITY CONTROL

A. All testing shall be performed per the CORPUD Construction Specifications for Sewer Mains

B. Engineer shall be notified of testing schedule and results

C. No additional payments will be made for failed tests.

END OF SECTION 333000

SECTION 8000
STORM DRAINAGE

TABLE OF CONTENTS

8010 DESIGN

A. Location

1. All public and private storm sewers shall be installed in right-of-way or easements. Minimum easement widths shall be 20 feet for pipes up to and including 48 inches in diameter, and 30 feet for pipes greater than 48 inches in diameter. For pipes deeper than 10 feet, the easement width shall be specified by Cary staff.

2. See Sections 6000, 6500, and 7000 for horizontal and vertical separation requirements between storm drainage pipe, water lines, and sanitary sewer lines.

3. Cary shall maintain only the storm sewer systems within Cary maintained right-of-way and on Cary property. All others shall be maintained by the property owner(s).

4. Discharge points shall be a minimum of 10 feet downhill from the building envelope.

5. Structures shall be spaced to intercept flow at the uphill turnout of intersections unless the street design provides a continuous downhill grade around the radius and down the intersecting street.

6. Stormwater inlets shall not be placed within travel areas of roadways, driveways, or parking lots.

B. Sizing

1. Systems shall be designed based on rainfall intensities of 4 inches per hour for street inlet spacing, the 2-year storm for side ditches, the 10-year storm for street drainage pipe sizing, the 25-year storm for cross-street drainage, and the 100-year storm for floodplain areas.

2. Curb inlets shall be spaced to provide a maximum spread of 8 feet for the design storm. In areas of heavy pedestrian traffic, the maximum allowable spread may be decreased by applicable Cary official as laid out in Cary ordinances.

3. Runoff rates shall be calculated by the Rational Method (for drainage areas less than 2 square miles), SCS Method (for drainage areas greater than 2 square miles), or other acceptable procedure. Runoff computations shall be based on rainfall data published by the National Weather Service NOAA Atlas 14 for this area.

4. Time of concentration (t_c) shall be determined using standard acceptable methods and the storm duration shall equal t_c.

5. Pipe shall be sized in accordance with the Manning Equation and applicable nomographs to carry the design flow and to provide a velocity of at least 2 feet per second (fps) during the 2-year storm.

6. Culverts shall be sized in accordance with the Energy Equation and applicable nomographs to carry the design flow and to provide a velocity between 2-10 fps during the 2-year storm.

7. The minimum design slope of a pipe or culvert shall be 0.5 percent.

8. The minimum pipe diameter shall be 12 inches where the inlet is grated and 15 inches where the inlet is not grated.

9. Structures shall be installed at each deflection of line, grade, and/or change in pipe material.

10. No inaccessible storm drainage structures shall be allowed.

11. Drop inlet structures require the ponding elevation of 100-year storm to be calculated and delineated on recorded maps. A building restriction line 2 feet above the 100-year ponding elevation shall also be recorded.

12. The maximum length between access points shall be 400 feet for all pipe sizes.

13. Channels and ditches shall be designed to carry the design flow at nonerosive velocities. Calculations indicating design velocities shall be provided along with typical channel cross-sections. The maximum allowable design velocity in grass channels is 4 fps.

14. A Hydraulic Grade Line (HGL) study shall be performed for all storm drainage systems. The study shall include profiles that show invert slopes, proposed finished grade and hydraulic grade line. Hydraulic grade line shall be required to stay within pipe to ensure no surcharge on system. ASTM Standard C443 (O Ring or Single Offset) flexible watertight sealed pipe shall be used in cases where it is not practicable.

15. Stream crossings will necessitate a backwater study on the 100-year storm.

16. The 100-year backwater shall be delineated on all plans and a backwater easement provided. A building restriction line two feet above the 100-year backwater elevation shall also be delineated on all maps for recording.

17. In cases where more than one pipe is required for a stream crossing, a maximum of three pipes or box culverts consisting of one primary and two overbank conveyances, shall be provided. A two pipe or box culvert crossing with primary and overbank conveyance may be approved with proper justification. Crossing geometry should mimic the natural channel.

8020 MATERIALS

A. Pipe Materials

1. Reinforced Concrete Pipe shall conform to ASTM C76, Table III or Table IV. Joints shall be sealed with a plastic cement putty meeting ASTM C990 (preformed flexible sealant).

2. Reinforced Concrete Box Culvert shall conform to ASTM C1433, ASTM C1504, or ASTM C1786. Joints shall be sealed in conformance with ASTM C990 (preformed flexible sealant) and/or C877 (external sealing bands), based on manufacturer's recommendations for the specific application.

3. Aluminized Steel Type 2 Pipe shall be 36 inches in diameter or greater and be bedded and manufactured according to ASTM A 929 (Manufacturing), 760 (Coating), 796 (Structural Design) and 798 (installation).

4. Corrugated Aluminum Pipe shall conform to ASTM B744 and design standard ASTM B790. Installation and backfill shall comply with standards ASTM B788 and AASHTO M145. The corrugated aluminum pipe shall meet or exceed HS20 loading requirements and NCDOT approvals.

5. High Density Polyethylene (HDPE) Corrugated Pipe shall be used only in areas outside of public right-of-way and easements. When used in private locations, pipe material shall be rated on approved plans and include the submission of design criteria. Installation of HDPE pipe shall adhere to design criteria standards. Pipe material shall meet the product specifications of ASTM F667 and shall have a smooth interior. Pipe joints shall consist of an integral bell and spigot type joint with "O" ring rubber gasket meeting ASTM F477 placed on the spigot end. At least two (2) corrugations of the spigot end must insert in the bell end. Installation shall adhere to the specification of ASTM D2321 and be certified by an engineer. HDPE pipe, 24" or under may be used outside the right-of-way only.

6. Polyvinyl Chloride (PVC) Pipe shall be used only in areas outside of public right-of-way and easements. When used in private locations, material pipe shall be rated on approved plans and include the submission of design criteria. Installation of PVC pipe shall adhere to design criteria standards. Pipe material shall meet the product specifications of ASTM F949-93a and shall have a smooth interior. PVC pipe, 24" or under may be used outside the right-of-way only.

7. Recycled High Density Polyethylene (HDPE) Corrugated Pipe shall be used only in areas outside of public right-of-way and easements. When used in private locations, pipe material shall be rated on approved plans and include the submission of design criteria. Installation of HDPE pipe shall adhere to design criteria standards. Pipe material shall meet the product specifications of ASTM F2648 and shall have a smooth interior. Pipe joints shall consist of an integral bell and spigot type joint with "O" ring rubber gasket meeting ASTM F477 placed on the spigot end. At least two (2) corrugations of the spigot end must insert in the bell end. Installation shall adhere to the specification of ASTM D2321 and certified by an engineer. HDPE pipe, 24" or under may be used outside the right-of-way only.

B. Structure Materials

All storm drainage structures such as manholes, inlets, junction boxes and catch basins shall be constructed of either solid brick, solid block, or precast concrete.

1. Clay Brick shall be solid, rough, sound clay brick conforming to ASTM C32, Grade MS. The brick shall be laid with full shove joints, filling up the joints with mortar. The thickness of the joints shall not exceed 3/8 of an inch.

2. Concrete Block or brick shall be solid and conform to ASTM C139 as to design and manufacture. The block or brick shall be embedded in a mortar bed to form a 1/2-inch mortar joint.

3. Precast Concrete Manholes shall meet ASTM C478 as to design and manufacture. All manhole cones shall be the eccentric type. Joints shall be sealed with a plastic cement putty meeting Federal Specification SS-S-00210, such as Ram-Nek or a butyl rubber sealant. All external joints shall be wrapped with 6-inch minimum width rubberized mastic joint wrap.

4. Precast Concrete Box Structures shall meet ASTM C913 as to design and manufacture. Joints shall be sealed with a plastic cement putty meeting Federal Specification SS-S-00210, such as Ram-Nek or a butyl rubber sealant. All external joints shall be wrapped with 6-inch minimum width rubberized mastic joint wrap.

5. Manhole Frames and Covers shall be as specified in Section 7000, with “STORM SEWER”, “CARY” and the Cary Seal stamped on the cover and two 1-inch holes.

6. Steps shall meet the material, strength, and installation requirements as specified in Section 7000. Location of steps for storm drainage shall be per Detail 8000.6. Manholes shall have one step at the top and one step at the bottom of the structure in the public right-of-way.

7. Headwalls and Endwalls shall be constructed in accordance with NCDOT details, or precast concrete with wing walls and apron by an approved manufacturer. Installation of precast headwalls and endwalls shall be in accordance with the manufacturer's recommendations. Design shall include provision for relief of hydraulic pressure. Voids shall be filled with non-shrink grouting. Gabion basket shall not be allowed.

8. Stormwater Control Measure (SCM) outlet structures shall be cast in-place or precast concrete or aluminum ~~pipe~~ only.

9. Frame, Grate & Hood shall be cast iron and meet the ASTM requirements set forth in the latest edition of the NCDOT “Standard Specifications for Roads and Structures” and the dimensional requirements set forth in the latest edition of the NCDOT “Roadway Standard Drawings #840.03”. Grate shall be stamped with the NCDOT Specification number as evidence of satisfying the above requirements.

   Hoods and drop inlet grates shall be stamped “Drains to River”. Lettering shall be ¾” height and shall be clean, crisp and free of defects.

C. Installation

1. Pipe may enter through the corner of all structure material types except precast concrete "waffle" boxes.

2. A reinforced concrete slab designed by an engineer may be used at oversized structures to adjust an inlet to standard dimensions. They must meet H-20 loading.

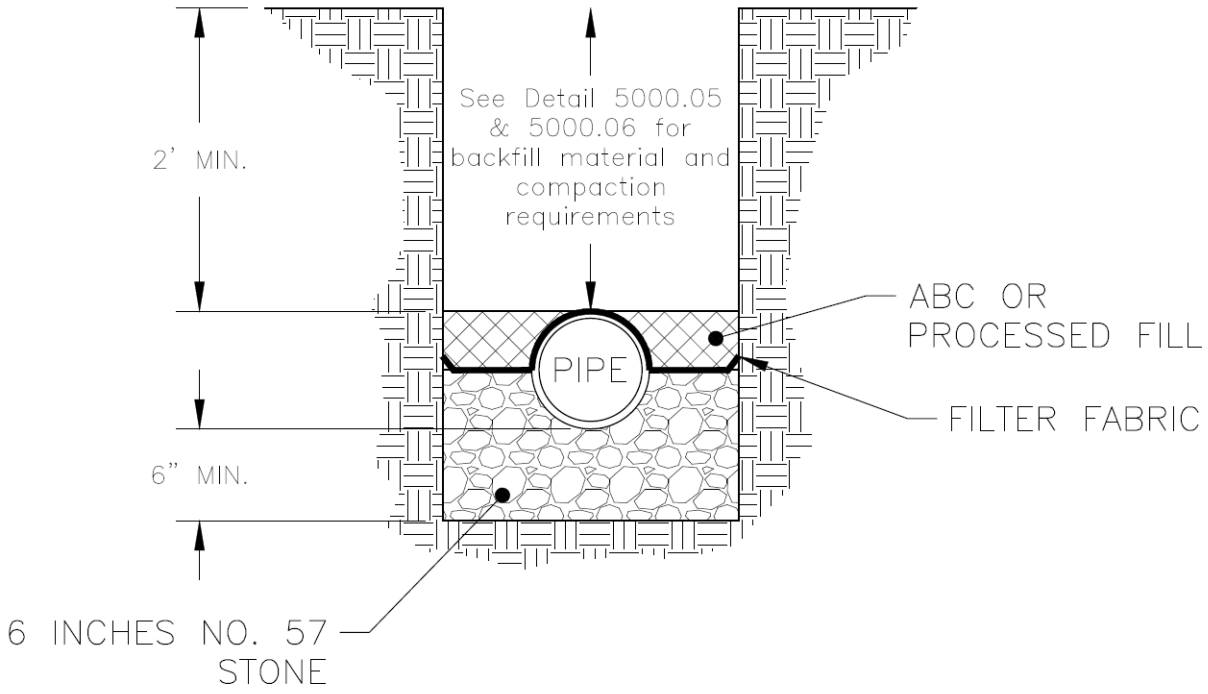
3. Pipe shall be installed to provide a true line and grade between structures.

4. The minimum cover for storm drain pipe shall be 2 feet to finished subgrade under roads and 1 foot to finished grade in non load-bearing areas. Trench excavation and backfilling shall be in accordance with Section 5000 of the Specifications unless more stringent installation requirements are listed with specific material type and certified by an

engineer. However, storm drain trench width shall be the pipe OD plus 36-inches per detail drawings 5000.05 and 5000.06.

5. Dam and Stormwater Control Measures' pipe outlet trench through a dam shall not be bedded in stone and at a minimum include an appropriately designed filter diaphragm, full length concrete cradle, or anti-seep collar per detail 5000.04. Natural ground installations through a dam or SCM bedding shall be at the direction of a licensed professional geotechnical engineer.

6. The trench bottom shall provide a firm and uniform support for the pipe. Where bell and spigot type is used, recesses shall be excavated to receive the pipe bell.



STANDARD STORMWATER INSTALLATION

7. Pipe shall be bedded in No. 57 stone to the center of the pipe and extending a minimum of six inches under the pipe. Filter fabric shall be placed at the interface of the No. 57 stone/top of pipe and the fill material within the pipe trench. Fill material compaction above filter fabric shall meet the compaction requirements outlined in Section 5020 A. 2. and the Standard Stormwater Trench Installation detail 5000.05 and the New Development Stormwater Trench Installation under Asphalt pavement and

in the Right-of-Way. Backfill in natural ground shall be in accordance with Section 5020 A. 2. and Standard Detail 5000.05.

8. In instances where compliance with compaction requirements is questionable as determined by the Inspector, testing shall be provided by the Contractor and a licensed Geotechnical Engineer to verify compliance.

9. The minimum trench width shall be one pipe diameter plus 18 inches on each side of the pipe.

10. Pipe shall not project into a drainage structure but shall be finished flush with the inside of the structure. Voids shall be filled with non-shrink grouting. The exterior annulus between the box and the pipe shall be filled with non-shrink grout and wrapped with an approved joint seal material.

11. All external manhole or box joints shall be wrapped with an approved joint seal material.

12. Catch basins between 5 and 20 feet in depth shall have minimum interior dimensions of 4 feet by 4 feet, and those over 20 feet in depth shall have minimum interior dimensions of 5 feet by 5 feet.

13. Each drainage structure shall have an invert constructed from concrete and shaped to conform with the pipe ID, and a bench with a maximum 5:1 slope. The bench shall begin at a height of one-half the pipe diameter for 12- to 24-inch pipe, one-third the pipe diameter for 30- to 48- inch pipe, and one-fourth the diameter for pipe greater than 48 inches in diameter. Precast headwalls and endwalls shall only be installed at single pipe culverts.

14. Precast concrete structures may be installed only to depths certified as acceptable by the manufacturer.

15. Each curb's inlet must be installed such that the front wall is straight and aligned with the curb and gutter.

D. Inlets and Outlets

1. Headwalls, endwalls or flared end sections shall be installed at all discharge points, and inlets where there is not a structure.

2. Flared end sections, headwalls or endwalls shall be installed on single pipe culverts up to and including 60 inches in diameter, and on multiple pipe culverts up to and including 36 inches in diameter.

3. Headwalls and endwalls shall be installed on single pipe culverts greater than 60 inches in diameter, and on multiple pipe culverts greater than 36 inches in diameter.

4. Energy dissipaters shall be installed at all discharge points and shall be properly sized to ensure that stormwater is released at a nonerosive velocity.

5. A filter fabric barrier shall be installed between dissipation pads and the natural ground.

6. The system shall include scour protection for drainage ways.

9. Weep holes shall be required on all headwalls and endwalls.

8. Details and design of headwalls, endwalls and flared end sections shall be in accordance with NCDOT standard detail requirements. These details shall be shown on plan submissions.

9. Additional information on the impact of stormwater discharge onto adjacent properties may be required by Cary.

8030 INSPECTION AND TESTING

The Contractor shall furnish all materials, labor, and equipment to perform inspections of storm drainage system.

A. Video Assessment and Cleaning

1. As a final measure required for acceptance, the Contractor shall clean and televise all newly installed storm drain systems to include all pipe public and any portions that are to remain privately maintained. The Contractor shall televise all the junction boxes and storm drains 12-inch and larger installed from the upstream to downstream junction box with no reverse setups or cutaways. Throughout shooting, the camera shall be panned and tilted for a complete view of the junction box and storm drain at each joint. Additionally, any pipe defects or damage shall be videoed appropriately to assess potential repair. Lighting shall be adequate to view the entire storm drain system from beginning to end.
2. All CCTV inspections shall be submitted in accordance with the National Association of Sewer Service Companies (NASSCO) Pipeline Assessment Certification Program (PACP).
3. The video inspection shall be submitted to the Infrastructure Field Technician on a Cary approved storage device and formatted with software compatible and readable by Cary. Cary shall not be responsible for purchasing additional software necessary to view the storage devices.

4. The camera shall be advanced at a uniform rate not to exceed 20 feet per minute that allows a full and thorough inspection of the new storm drain. The camera shall be a color, pan and tilt camera capable of producing a five-hundred-line resolution picture. Lighting for the camera shall be sufficient to yield a clear picture of the entire periphery of the pipe. The picture quality shall be acceptable and sufficient to allow a complete inspection with no lapses in coverage. The length of the storm drain shall be measured and recorded on the video screen. The distance counter shall be calibrated before shooting the inspection video.

5. The Contractor shall clean the storm drain system ahead of video inspection with a high-velocity water jet. The video inspection shall take place within 2-hours of cleaning operations as witnessed by the Infrastructure Field Technician. All construction debris shall be collected in the downstream junction box and shall not be released into any stormwater control measure or outfall.

6. The Infrastructure Field Technician shall be present throughout the cleaning and televising of the storm drain system to verify that the video work complies with the Specifications.

7. Prior to submitting the storage devices to the Infrastructure Field Technician, the Contractor shall label the submittal with the following information:

- Name of the Project/Development.
- Name and contact information of responsible party.
- Date of televising.
- Box identification as shown on the design plans.

8. Upon Cary's staff review of the CCTV footage that indicates a repair is required due to a defect, the As-Built/Record Drawing including Engineer's Certification, and CCTV shall reflect such repair.

END OF SECTION 8000

SECTION 334100 - STORM UTILITY DRAINAGE PIPING

PART 1 - GENERAL

1.1 GENERAL NOTES

A. All storm drainage structures, related piping and accessories shall be in accordance with the State of North Carolina Department of Transportation standards, and supplemented with any applicable Town of Cary County standards. If discrepancies exist they should be brought to the Engineer’s attention immediately.

B. Refer to construction drawings for number, location and details of all proposed structures and pipes.

1.2 RELATED DOCUMENTS

A. Materials, Installation, and Testing shall be in accordance with NCDOT and Town of Cary standards and specifications.

1.3 SUMMARY

A. Section includes but not limited to the following items and appurtenances shown on drawings and specified in this Section:

1. Pipe and fittings.
2. inlets and outlets.

1.4 DEFINITIONS

A. RCP: Reinforced Concrete Pipe.

B. HDPE: High Density Polyethylene Pipe.

C. NCDOT: North Carolina Department of Transportation.

1.5 SUBMITTALS

A. Product Data: Manufacturer information describing part, accessories, connections and any standard details.

B. Manufacturer’s Instructions: Special procedures required to install specified products.

C. Shop Drawings: Indicate Part Sizes, connection sizes, elevations and connection parts.

D. Manufacturer's Certificate: Products meet or exceed specified requirements.

E. Qualifications Statements:

1. Qualifications for manufacturer, and installer.
2. Manufacturer's approval of installer.

F. Field quality-control reports.

G. Project Record Documents: Record actual locations of catch basins, drop inlets, yard inlets and grate/rim and invert elevations.

H. Operation and Maintenance Data: Submit any special requirements for maintenance.

1.6 QUALITY ASSURANCE

A. Perform Work according to State of North Carolina Department of Transportation and the Town of Cary standards.

B. Fabricator: Company specializing in fabricating products specified in this Section with three years' experience.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Protect pipe, pipe fittings, and seals from dirt and damage.

B. Store according to manufacturer's instructions.

C. Protect any UV sensitive materials from sunlight by using manufacturer recommendations.

1.8 PROJECT CONDITIONS

A. Interruption of Existing Storm Drainage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:

1. Notify Owner’s Representative no fewer than (72) hours in advance of proposed interruption of service.
2. Do not proceed with interruption of service without Owner’s Representative’s written permission

B. Field Measurements: Verify field measurements prior to fabrication. Indicate field measurements on Shop Drawings.

PART 2 - PRODUCTS

2.1 CONCRETE PIPE AND FITTINGS

A. Reinforced-Concrete Pipe and Fittings: ASTM C 76. Pipe and special fittings installed with 10 feet or less cover over top of pipe shall be Class III, and all other pipe and special fittings shall be Class IV. Basis of acceptance of reinforced concrete pipe shall be the 0.01” crack.

1. Bell-and-spigot ends and sealant joints with ASTM C 990, bitumen or butyl-rubber sealant.

2.2 HDPE PIPE AND FITTINGS

A. Solid-Walled HDPE Watertight Pipe and Fittings: Pipe shall have a smooth interior and annular exterior corrugations.

1. 4- through 10-inch (100 to 250 mm) pipe shall meet AASHTO M252, Type S
2. 12- through 60-inch (300 to 1500 mm) pipe shall meet AASHTO M294, Type S or ASTM F2306.

3. Manning's "n" value for use in design shall be 0.012.

B. Joint Performance: Pipe shall be joined using a bell & spigot joint meeting the requirements of AASHTO M252, AASHTO M294, or ASTM F2306. The joint shall be watertight according to the requirements of ASTM D3212. Gaskets shall meet the requirements of ASTM F477. Gaskets shall be installed by the pipe manufacturer and covered with a removable, protective wrap to ensure the gasket is free from debris. A joint lubricant available from the manufacturer shall be used on the gasket and bel during assembly. 12- through 60-inch (300 to 1500 mm) diameters shall have an exterior bell wrap installed by the manufacturer.

C. Fittings: Fittings shall conform to AASHTO M252, AASHTO M294, or ASTM F2306. Bell and spigot connections shall utilize a welded bell and valley or saddle gasket meeting the watertight joint performance requirements of AASHTO M252, AASHTO M294, or ASTM F2306.

D. Field Pipe and Joint Performance: To assure watertightness, field performance verification may be accomplished by testing in accordance with ASTM F2487. Appropriate safety precautions must be used when field-testing any pipe material. Contact the manufacturer for recommended leakage rates.

E. Material Properties: Material for pipe and fitting production shall be high-density polyethylene conforming with the minimum requirements of cell classification 424420C for 4- through 10-inch (100 to 250 mm) diameters, and 435400C for 12- through 60-inch (300 to 1500 mm) diameters, as defined and described in the latest version of ASTM D3350, except that carbon black content should not exceed 4%. The 12- through 60-inch (300 to 1500 mm) pipe material shall comply with the notched constant ligament-stress (NCLS) test as specified in Sections 9.5 and 5.1 of AASHTO M294 and ASTM F2306 respectively.

2.3 HDPE FLARED END SECTION

A. HDPE Flared End Section: High Density Polyethylene meeting ASTM D3350 minimum cell classification 213320C; contact manufacturer for additional cell classification information. The metal threaded fastening rod shall be stainless steel.

2.2 PIPE OUTLETS

A. Riprap Basins: Broken, irregularly sized and shaped, graded stone according to NCDOT Section 1042 "Riprap Materials". See plans for Class/Sizing.

B. Filter Stone: According to NCDOT Section 1005 "General Requirements for Aggregate", #57 or #67 clean stone as specified on plans.

C. Energy Dissipaters: Broken, irregularly sized and shaped, graded stone according to NCDOT Section 1042 "Riprap Materials". See plans for Class/Sizing.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavation, trenching, and backfilling are per NCDOT Standard Specifications.

3.2 EXAMINATION

A. Verify that excavations, dimensions and elevations are as indicated.

B. Check pipes for cracks or other compromising features.

1. Any irregularities shall be reported and approved prior to installation.

3.3 PREPARATION

A. Correct over-excavation with coarse aggregate.

B. Prepare base in accordance with applicable NCDOT standard.

3.4 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.

C. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.

D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

E. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.

F. Laser Equipment: Contractor shall utilize laser equipment to insure that piping is installed at elevations and slopes indicated on plans.

G. Install gravity-flow, nonpressure drainage piping according to the following:

1. Install piping pitched down in direction of flow.
2. Install piping at invert elevations as specified in the storm drainage table.
3. Install nonreinforced-concrete piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."
4. Install reinforced-concrete piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."

3.5 HDPE FLARED END SECTION INSTALLATION

A. Installation shall be in accordance with the manufacturer’s instructions and with those issued by state or local authorities.

3.5 PIPE JOINT CONSTRUCTION

A. Join gravity-flow, nonpressure drainage piping according to the following:

1. Join reinforced-concrete piping according to ACPA's "Concrete Pipe Installation Manual" for rubber-gasketed joints.

3.6 STORMWATER INLET AND OUTLET INSTALLATION

A. Construct inlet head walls, aprons, and sides of reinforced concrete, as indicated.

B. Construct riprap of broken stone, as indicated.

C. Install outlets that spill onto grade, anchored with concrete, where indicated.

D. Install outlets that spill onto grade, with flared end sections that match pipe, where indicated.
E. Construct energy dissipaters at outlets, as indicated.

3.7 CONNECTIONS

A. Make connections to existing underground manholes.
   1. Make branch connections from side into underground manholes and structures by cutting into existing unit and creating an opening large enough to allow 3 inches of concrete to be packed around entering connection. Cut end of connection pipe passing through pipe or structure wall to conform to shape of and be flush with inside wall unless otherwise indicated. On outside of manhole, or structure wall, encase entering connection in 6 inches of concrete for minimum length of 12 inches to provide additional support of collar from connection to undisturbed ground.
      a. Use concrete that will attain a minimum 28-day compressive strength of 3000 psi unless otherwise indicated.
      b. Use epoxy-bonding compound as interface between new and existing concrete and piping materials.
   2. Protect existing piping, manholes, and structures to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

3.8 CLOSING ABANDONED STORM DRAINAGE SYSTEMS

A. Abandoned Piping: Close open ends of abandoned underground piping indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of abandoned piping have been closed. Use either procedure below:
   1. Close open ends of piping with at least 8-inch thick, brick masonry bulkheads.
   2. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.

B. Abandoned Manholes and Structures: Excavate around manholes and structures as required and use one procedure below:
   1. Remove manhole or structure and close open ends of remaining piping.
   2. Remove top of manhole or structure down to at least 48 inches below final grade. Fill to within 12 inches of top with stone or gravel. Fill to top with concrete.

C. Backfill to grade according to Division 31 Section "Earth Moving."

3.9 IDENTIFICATION

A. Arrange for installation of green warning tape directly over piping and at outside edge of underground structures.
   1. Use identification tape or non-detectable warning tape over all underground lines outside building footprint in the backfill approximately 18” to 30” above the service pipe, but a minimum of 10” and a maximum of 24” below finished grade.
   2. Use detectable warning tape over ferrous and nonferrous piping and over edges of underground manholes. Tape all underground lines outside building footprint directly on top of the pipeline and permanently secured to the pipeline at 10’ intervals.
   3. Use insulated copper tracer wire or other approved conductor installed adjacent to underground

nonmetallic piping and metallic pipe with compression gasket fittings installed underground. Access shall be provided to the tracer wire or the tracer wire shall terminate aboveground at the end of the nonmetallic piping. The tracer wire size shall not be less than 10AWG and the insulation type suitable for direct burial. The tracer wire size shall be copper single-conductor 10AWG minimum and the insulation type suitable for direct burial with type "UF" (Underground Feeder) insulation and shall be continuous along the pipeline passing through the inside of each valve box or manhole.

3.10 FIELD QUALITY CONTROL

A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.
   1. Submit separate reports for each system inspection.
   2. Defects requiring correction include the following:
      a. Alignment: Less than full diameter of inside of pipe is visible between structures.
      b. Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
      c. Damage: Crushed, broken, cracked, or otherwise damaged piping.
      d. Infiltration: Water leakage into piping.
      e. Exfiltration: Water leakage from or around piping.
   3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
   4. Re-inspect and repeat procedure until results are satisfactory.

B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.
   1. Do not enclose, cover, or put into service before inspection and approval.
   2. Test completed piping systems according to requirements of authorities having jurisdiction.
   3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
   4. Submit separate report for each test.
   5. Gravity-Flow Storm Drainage Piping: Test according to requirements of authorities having jurisdiction, UNI-B-6, and the following:
      a. Exception: Piping with soil tight joints unless required by authorities having jurisdiction.
      b. Option: Test concrete piping according to ASTM C 924. C. Leaks and loss in test pressure constitute defects that must be repaired.
      c. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

3.11 CLEANING

A. Clean interior of piping of dirt and superfluous materials. Flush with water.

END OF SECTION 334100

SECTION 334600 - SUBDRAINAGE

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Solid-wall underdrain pipe and fittings.
2. Perforated-wall underdrain pipe and fittings.
3. Aggregate for underdrain placement
4. Geotextile filter fabrics.

1.2 DEFINITIONS

A. Underdrain: System of perforated-wall pipes placed underneath Bioretention Media to convey treated water out of the Bioretention Area and solid-wall clean-outs allowing maintenance access of underdrains from the planting surface.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Geotextile filter fabrics.

PART 2 - PRODUCTS

2.1 SOLID-WALL UNDERDRAIN PIPES AND FITTINGS

A. Solid-wall HDPE Watertight pipe (per AASHTO) shall have a smooth interior and annular exterior corrugations.

1. 4- through 10-inch (100 to 250 mm) pipe shall meet AASHTO M252, Type S
2. 12- through 60-inch (300 to 1500 mm) pipe shall meet AASHTO M294, Type S or ASTM F2306.
3. Manning's "n" value for use in design shall be 0.012.

B. Joint Performance: Pipe shall be joined using a bell & spigot joint meeting the requirements of AASHTO M252, AASHTO M294, or ASTM F2306. The joint shall be watertight according to the requirements of ASTM D3212. Gaskets shall meet the requirements of ASTM F477. Gaskets shall be installed by the pipe manufacturer and covered with a removable, protective wrap to ensure the gasket is free from debris. A joint lubricant available from the manufacturer shall be used on the gasket and bel during assembly. 12- through 60-inch (300 to 1500 mm) diameters shall have an exterior bell wrap installed by the manufacturer.

C. Fittings: Fittings shall conform to AASHTO M252, AASHTO M294, or ASTM F2306. Bell and spigot connections shall utilize a welded bell and valley or saddle gasket meeting the watertight joint performance requirements of AASHTO M252, AASHTO M294, or ASTM F2306.

D. Field Pipe and Joint Performance: To assure watertightness, field performance verification may be accomplished by testing in accordance with ASTM F2487. Appropriate safety precautions must be used when field-testing any pipe material. Contact the manufacturer for recommended leakage rates.

E. Material Properties: Material for pipe and fitting production shall be high-density polyethylene conforming with the minimum requirements of cell classification 424420C for 4- through 10-inch (100 to 250 mm)

diameters, and 435400C for 12- through 60-inch (300 to 1500 mm) diameters, as defined and described in the latest version of ASTM D3350, except that carbon black content should not exceed 4%. The 12- through 60-inch (300 to 1500 mm) pipe material shall comply with the notched constant ligament-stress (NCLS) test as specified in Sections 9.5 and 5.1 of AASHTO M294 and ASTM F2306 respectively.

F. Perforations: Underdrain perforations shall be placed 6” apart along the length of HDPE pipe in accordance with AASHTO Class II Perforation standards.

2.2 PERFORATED-WALL UNDERDRAIN PIPES AND FITTINGS.

A. See 2.1 above for Solid-Wall Underdrain Pipes and Fittings

B. Perforations: Underdrain perforations shall be placed 6” apart along the length of HDPE pipe in accordance with AASHTO Class II Perforation standards.

2.3 AGGREGATE FOR UNDERDRAIN PLACEMENT

A. Number 57 stone: Underdrains shall be placed in layer of double washed #57 stone that is washed onsite prior to installation. See Section 329115 “Soil Preparation” for more information about the aggregates placed in bioretention areas.

2.4 SOIL MATERIALS

A. Soil materials are specified in Section 312000 “Earth Moving”

2.5 GEOTEXTILE FILTER FABRICS

A. Description: Fabric of PP or polyester fibers or a combination of both, with flow rate range from 110 to 330 gpm/sq. ft. (4480 to 13440 L/min/ per sq. m) when tested according to ASTM D4491.

B. Structure type: Nonwoven, needle-punched continuous filament. Specifications to meet or exceed shown below.

Physical Properties	Unit	Typical Value[2]
Weight (ASTM D5161)	oz/yd² (g/m²)	8.0 (271)
Thickness (ASTM D5199)	mils (mm)	70 (1.8)
Roll Dimensions (width x length)	ft (m)	15 x 300 (4.5 x 91)
Roll Area	yd² (m²)	500 (418)
Estimated Roll Weight	lb (kg)	271 (122)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces and areas for suitable conditions where subdrainage systems are to be installed.

3.2 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Section 312000 “Earth Moving”.

3.3 PIPING INSTALLATION

A. Install piping beginning at low points of system, true to grades and alignment indicated, with unbroken continuity of invert. Bed piping with full bearing in filtering material. Install gaskets, seals, sleeves, and couplings according to manufacturer's instructions and other requirements indicated.

1. Bioretention subdrainage: install piping pitched down in direction of flow, at a minimum slope of 0.5 percent and with a minimum cover of 12 inches unless otherwise indicated.

B. Use increasers, reducers, and couplings made for different sizes or materials of pipes and fittings being connected. Reduction of pipe size in direction of flow is prohibited.

3.4 PIPE JOINT CONSTRUCTION

A. Join HDPE pipe and fittings according to ASTM D3212 with loose bell-and-spigot, push-on joints.

B. Special Pipe Couplings: Join piping made of different materials and dimensions with special couplings made for this application. Use couplings that are compatible with and fit materials and dimensions of both pipes.

3.5 CLEANOUT INSTALLATION

A. Comply with the requirements for cleanouts specified in Section 334100 "Storm Utility Drainage Piping"

B. Cleanouts for subdrainage:

1. Install cleanouts from piping to grade. Locate cleanouts at beginning of piping run and at changes in direction. Install fittings so cleanouts open in direction of flow in piping.
2. In bioretention areas, use solid-walled HDPE Watertight pipe meeting AASHTO M252, Type S to connect to perforated-wall HDPE underdrains and extend observation well/cleanouts 9-inches above the planting surface. All cleanouts should be encircled by a concrete collar to protect against mowers and other breakoff hazards.
3. In vehicular-traffic areas, use NPS 4 cast-iron soil pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place concrete anchor, 18 by 18 by 12 inches deep. Set top of cleanout flush with grade.
4. In nonvehicular-traffic areas, use NPS 4PVC pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place concrete anchor, 12 by 12 by 4 inches deep. Set top of cleanout 1 inch above grade.
5. Comply with requirements for concrete specified in Section 033000 "Cast-in-Place Concrete."

3.6 CONNECTIONS

A. Comply with requirements for piping specified in Section 334100 "Storm Utility Drainage Piping". Drawings indicate general arrangement of piping, fittings, and specialties.

3.7 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. After installing drainage course to top of piping, test drain piping with water to ensure free flow before backfilling.
2. Remove obstructions, replace damaged components, and repeat test until results are satisfactory.

B. Drain piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.8 CLEANING

A. Clear interior of installed piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of each day or when work stops.

END OF SECTION 334600

SECTION 334913 - STORM DRAINAGE STRUCTURES

PART 1 - GENERAL

1.1 GENERAL NOTES

A. All storm drainage structures, related piping and accessories shall be in accordance with the State of North Carolina Department of Transportation standards, and supplemented with any applicable Town of Cary standards. If discrepancies exist they should be brought to the Engineer’s attention immediately.

B. Refer to construction drawings for number, location and details of all proposed structures and pipes.

1.2 RELATED DOCUMENTS

A. Materials, Installation, and Testing shall be in accordance with NCDOT and Town of Cary standards and specifications.

1.3 SUMMARY

A. Section includes but not limited to the following items and appurtenances shown on drawings and specified in this Section:

1. Catch Basins.
2. Drop Inlets.
3. Junction Boxes/Manholes.
4. Headwalls.
5. Accessories.
6. Stormwater Structures.
7. Concrete.

1.4 DEFINITIONS

A. RCP: Reinforced Concrete Pipe

B. PVC: Polyvinyl Chloride Pipe.

C. NCDOT: North Carolina Department of Transportation.

1.5 SUBMITTALS

A. Product Data: Manufacturer information describing part, accessories, connections and any standard details.

B. Manufacturer’s Instructions: Special procedures required to install specified products.

C. Shop Drawings: Indicate Part Sizes, connection sizes, elevations and connection parts.

D. Manufacturer's Certificate: Products meet or exceed specified requirements.

E. Qualifications Statements:

1. Qualifications for manufacturer, and installer.
2. Manufacturer's approval of installer.

F. Field quality-control reports.

G. Project Record Documents: Record actual locations of catch basins, drop inlets, yard inlets and grate/rim and invert elevations.

H. Operation and Maintenance Data: Submit any special requirements for maintenance.

1.6 QUALITY ASSURANCE

A. Perform Work according to State of North Carolina Department of Transportation and the Town of Cary standards.

B. Fabricator: Company specializing in fabricating products specified in this Section with three years' experience.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store according to manufacturer's instructions.

B. Protect any UV sensitive materials from sunlight by using manufacturer recommendations.

C. Handle manholes according to manufacturer's written rigging instructions.

D. Handle catch basins, drop inlets, and headwalls according to manufacturer's written rigging instructions.

1.8 PROJECT CONDITIONS

A. Interruption of Existing Storm Drainage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:

1. Notify Owner’s Representative no fewer than (72) hours in advance of proposed interruption of service.
2. Do not proceed with interruption of service without Owner’s Representative’s written permission.

B. Field Measurements: Verify field measurements prior to fabrication. Indicate field measurements on Shop Drawings.

PART 2 - PRODUCTS

2.1 CATCH BASINS

A. All catch basins to be precast in accordance with the NCDOT standard specifications.

B. Catch Basins Lids and Frames:

1. Materials: Cast Iron
2. Lid: Shall be in accordance with applicable NCDOT standard detail as noted.
3. Nominal Lid and Frame Size: *Varies*, see signed construction drawings.

C. Connections

1. All connections to be in accordance with the NCDOT standard specifications.

2.2 DROP INLETS

A. All drop inlets to be precast in accordance with the NCDOT standard specifications.

B. Drop inlet Lids and Frames

1. Materials: Cast Iron
2. Lid: Shall be in accordance with applicable NCDOT standard specifications.
3. Nominal Lid and Frame Size: *Varies*, see signed construction drawings.

C. Connections

1. All connections to be in accordance with the NCDOT standard specifications.

2.3 JUNCTION BOXES/MANHOLES

A. All drop inlets to be precast in accordance with the NCDOT standard specifications

B. Connections

1. Connections to be minimum soil-tight.
2. All connections to be in accordance with NCDOT standard specifications.

C. Lids and Frames:

1. Shall be in accordance with applicable NCDOT standard specifications

2.4 HEADWALLS

A. Materials

1. Reinforced Concrete. To be precast in accordance with the applicable NCDOT standard specifications.

B. Connections

1. Connections to be minimum soil-tight.
2. All connections to be in accordance with NCDOT standard specifications.

C. Design

1. Design of headwall to be completed by registered Professional Engineer licensed in North Carolina.
2. Contractor to submit shop drawings to Engineer and Owner for approval. Engineer to only approve shop drawings on the basis of dimensions and size. Engineer not responsible for any footing, shoring or structural aspect of headwall.

2.5 ACCESSORIES

A. Any other required accessories for installation shall be engineer approved prior to installation.

2.6 STORMWATER STRUCTURES

A. Cast-in-Place Concrete, Stormwater Structures: Construct of reinforced-concrete bottom, walls, and top; according to ASTM C 890 structural loading; of depth, shape, dimensions, and appurtenances indicated.

B. Steps: Provide steps as shown on the Drawings in manholes, risers, transition cones, and transition top sections in accordance with NCDOT STD 840.66. Steps shall be spaced at 16" O.C.

C. Energy Dissipaters: Refer to Drawings for shape and sizing; Design in accordance with NC Erosion and Sediment Control Planning and Design Manual.

D. PVC Risers: The PVC Risers shall be manufactured from PVC pipe stock, utilizing a thermoforming process to reform the pipe stock to the specified configuration. The drainage pipe connection stubs shall be manufactured from PVC pipe stock and formed to provide a watertight connection with the specified pipe system. This joint tightness shall conform to ASTM D3212 for joints for drain and sewer plastic pipe using flexible elastomeric seals. The flexible elastomeric seals shall conform to ASTM F477. The pipe bell spigot shall be joined to the main body of the PVC Riser. The raw material used to manufacture the pipe stock that is used to manufacture the main body and pipe stubs of the PVC Risers shall conform to ASTM D1784 cell class 12454.

1. Grates: The grates and frames furnished for the PVC Risers shall be ductile iron for structure sizes 8", 10", 12", 15", 18", 24", 30", and 36" and shall be made specifically for each riser so as to provide a round bottom flange that closely matches the diameter of the riser. Ductile iron used in the manufacture of the castings shall conform to ASTM A536 grade 70-50-05.

2.7 CONCRETE

A. General: Cast-in-place concrete according to ACI 318, ACI 350/350R, and the following:

1. Cement: ASTM C 150, Type II.
2. Fine Aggregate: ASTM C 33, sand.
3. Coarse Aggregate: ASTM C 33, crushed gravel.
4. Water: Potable.

B. Portland Cement Design Mix: 4000 psi minimum, with 0.45 maximum water/cementitious materials ratio.

1. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.

C. Manhole Channels and Benches: Factory or field formed from concrete. Portland cement design mix, 4000 psi minimum, with 0.45 maximum water/cementitious materials ratio. Include channels and benches in manholes.

1. Channels: Concrete invert, formed to same width as connected piping, with height of vertical sides to three-fourths of pipe diameter. Form curved channels with smooth, uniform radius and slope.
   a. Invert Slope: 2 percent through manhole.
2. Benches: Concrete, sloped to drain into channel.
   a. Slope: 50 percent.

D. Ballast and Pipe Supports: Portland cement design mix, 3000 psi minimum, with 0.58 maximum water/cementitious materials ratio.

1. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavation, trenching, and backfilling are per NCDOT Standard Specifications.

3.2 EXAMINATION

A. Verify that excavations, dimensions and elevations are as indicated.

B. Check structures for cracks or other compromising features.

1. Any irregularities shall be reported and approved prior to installation.

3.3 PREPARATION

A. Correct over-excavation with coarse aggregate.

B. Prepare base in accordance with applicable NCDOT standards.

3.4 INSTALLATION

A. Installation Standards: Install Work according to NCDOT standards and manufacturer recommendations. If discrepancies exist they should be brought to Engineer's attention immediately.

B. Installation of PVC Risers: The PVC Riser shall be installed using conventional flexible pipe backfill materials and procedures. The backfill material shall conform to the Bioretention Media specifications in Section 329115 "Soil Preparation". Bedding and backfill for the PVC Risers shall be well placed and compacted uniformly in accordance with ASTM D2321. The PVC Riser body will be cut at the time of installation to meet the specified final elevation. No brick, stone, or concrete block will be required to set the grate to the final grade height. A concrete sump shall be poured in the bottom of each PVC Riser according to the construction documents.

3.5 FIELD QUALITY CONTROL

A. Request inspection by Engineer prior to back filling any aggregate.

B. If inspections indicate that Work does not meet specified requirements, remove Work, replace and request additional inspections.

C. Provide a signed and sealed as-built survey by a licensed Land Surveyor in North Carolina for all locations, lengths, sizes and inverts of all storm drainage structures and piping. Land surveyor should also indicate any and all underground utilities encountered during excavation, including elevations tied to local control.

3.6 CLEANING

A. Clean interior of structures of dirt and superfluous materials. Flush with water.

END OF SECTION 334913

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