

East Carolina University New Indoor Practice Facility

**SCO ID# 23-26345-01A
AIM #1752**

BID SET PROJECT MANUAL – VOLUME 2



MAR 14, 2025



100 europa dr, #565 | chapel hill, nc 27517

INDOOR PRACTICE FACILITY
EAST CAROLINA UNIVERSITY, GREENVILLE, NC
SCO ID# 23-26345-01A
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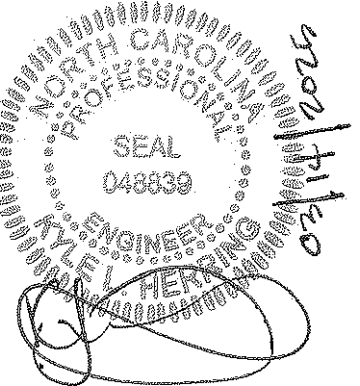
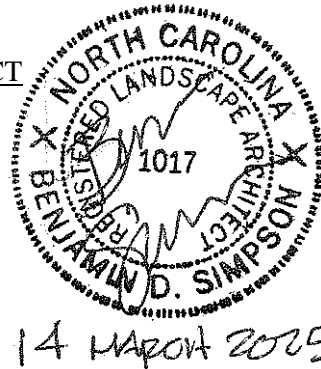
ARCHITECTS

CRA ASSOCIATES, INC.
CHAPEL HILL, NORTH CAROLINA



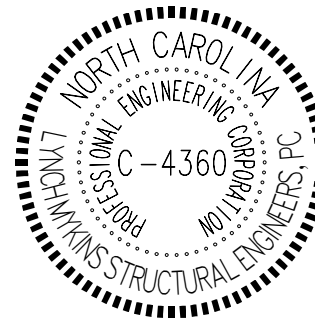
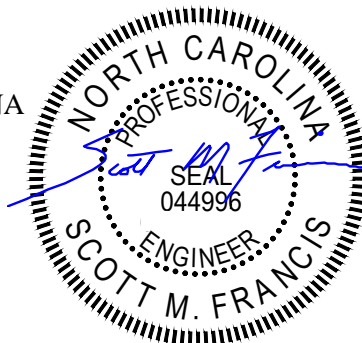
CIVIL ENGINEERS AND LANDSCAPE ARCHITECT

BENESCH
WILMINGTON, NORTH CAROLINA



STRUCTURAL ENGINEERS

LYNCH MYKINS
RALEIGH, NORTH CAROLINA



03/14/2025

MECHANICAL, PLUMBING, FIRE PROTECTION AND ELECTRICAL ENGINEERS

AFFILIATED ENGINEERS, INC
CHAPEL HILL, NORTH CAROLINA
NC LIC. NO. C-2982

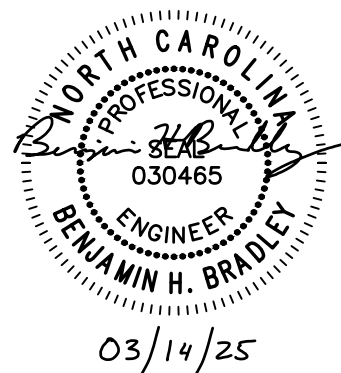
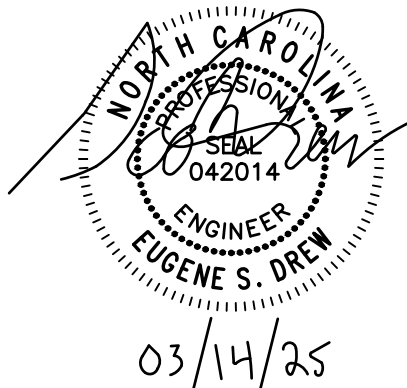
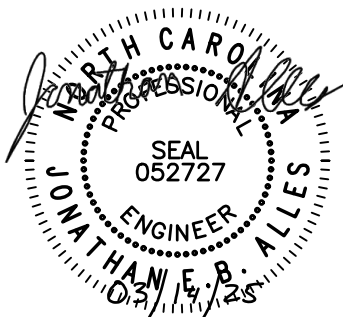


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PART 1 - GENERAL

1.1 DESCRIPTION

- A. Specification requirements defined in Division 20 of this specification apply to, and are in addition to the work associated with equipment, systems, materials, and installation requirements specified in Division 21. Contractor shall provide the requirements specified in Division 20 to obtain complete systems, tested, adjusted, and ready for operation.

1.2 RELATED WORK

- A. Section 220000 - General Plumbing Requirements
- B. Section 220513 - Motors for Plumbing Equipment
- C. Section 220520 - Plumbing Excavation and Backfill
- D. Section 220529 - Plumbing Piping and Equipment Supporting Devices
- E. Section 220553 - Plumbing Systems Identification
- F. Section 078400 - Firestopping
- G. Section 220700 - Plumbing Systems Insulation

PART 2 - PRODUCTS

2.1 NOT APPLICABLE TO THIS SECTION.

PART 3 - EXECUTION

3.1 NOT APPLICABLE TO THIS SECTION.

END OF SECTION 210000

SECTION 211314 - AUTOMATIC FIRE SPRINKLER SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This Section specifies materials, methods, and equipment to be used for automatic sprinkler system fire pump system, and related fire protection piping to 5 ft outside building.
- B. This is not a Factory Mutual Global (FMG) protected property.
- C. As shown on drawings, fire protection system(s) shall consist of:
 - 1. 2 total automatic fire protection system(s) to include::
 - a. 2 Wet-Pipe Sprinkler System (s)
- D. Engineer of Record:
 - 1. Affiliated Engineers is Engineer of Record for fire protection systems for this project. Contractor shall install fire protection systems as indicated on Contract Drawings and as indicated in this section. Nothing in this Section is to preclude Contractor from normal coordination with other trades to provide installation, which complies with Local Codes, NC SCO guidelines, and NFPA standards.
 - a. Contractor shall provide detailed layout drawings based on submittal requirements. These layout drawings shall be based on system as designed by Engineer of Record. Engineer of Record shall provide hydraulic calculations to be submitted to AHJ.
- E. All work shall be installed in conformance with the governing codes, regulations, local ordinances, and requirements of Authorities Having Jurisdiction. It shall be the responsibility of the Fire Protection Contractor to familiarize themselves with all governing codes and requirements and report any noncompliance of the plans or specifications to the Construction Manager/Engineer, prior to entering into the contract. These requirements are minimum criteria and no reductions permitted by Code shall be allowed without written permission of the Engineer.
- F. Fire Protection Contractor shall confirm any local requirements for Fire Department Connection type and location with local Authority Having Jurisdiction prior to submittal.
- G. No additional compensation shall be granted for work which must be changed as a result of the work not originally complying with codes and standards or not in accordance with the multiple trade coordination design criteria set forth in the contract documents.
- H. If code or other requirements exceed provisions indicated in the Contract Documents, the Construction Manager/Engineer shall be notified in writing. Where the work indicated on the Contract Documents exceeds code requirements, the installation shall be done in accordance with the Contract Documents. Any work done contrary to these requirements shall be removed and replaced at the expense of the responsible Contractor.
- I. Fire Protection Contractor shall become familiar with all details of the work, verify dimensions in the field, and advise the Construction Manager/Engineer of any discrepancy prior to entering into the contract.

- J. Fire Protection Contractor shall file all drawings, pay all fees, and obtain all permits and certificates of inspection related to this work. Fire Protection Contractor shall arrange inspection with proper Authorities Having Jurisdiction and include all costs associated with said inspections in their bid.

1.2 RELATED WORK

- A. Section 220000 - General Plumbing Requirements
- B. Section 220513 - Motors for Plumbing Equipment
- C. Section 220520 - Plumbing Excavation and Backfill
- D. Section 220529 - Plumbing Piping and Equipment Supporting Devices
- E. Section 220553 - Plumbing Systems Identification
- F. Section 283113 - Fire Detection and Alarm Systems

1.3 QUALITY ASSURANCE

A. Codes and Standards:

- 1. This installation shall conform to the following:
 - a. Underwriters Laboratories UL (DIR) Fire Protection Equipment Directory
 - b. International Building Code (IBC), 2018 Edition
 - c. International Fire Code ICC (IFC)], 2018 Edition
 - d. NFPA 13, Installation of Sprinkler Systems, 2013 Edition
 - e. NFPA 14, Installation of Standpipe and Hose Systems, 2013 Edition
 - f. NFPA 20, Installation of Stationary Pumps for Fire Protection, 2013 Edition
 - g. NFPA 72, National Fire Alarm and Signaling Code, 2013 Edition

B. Contractor Installation Program:

- 1. Provide licensed persons employed by sprinkler Contractor to perform planning, calculations, layout, installation, and testing of fire protection systems. The following are acceptable:
 - a. Licensed Professional Engineer
 - b. National Institute for Certification of Engineering Technologies (NICET) Level IV
 - c. Certified sprinkler designer
- 2. Provide journeyman sprinkler fitter(s) for installation and supervision.
- 3. Contractor shall be licensed in the State of NC for installation of fire protection systems.
- 4. Contractor shall submit pre-qualification evidence of at least 3 projects of comparable size successfully completed with their Bid.
- 5. Distortion or misrepresentation of qualification evidence may result in contract cessation.
- 6. On-site training for fire protection products:

- a. The grooved coupling manufacturer's factory trained field representative shall provide on-site training for contractor's field personnel in the proper use of grooving tools, application of groove, and installation of grooved piping products.
- b. The flexible sprinkler hose fittings manufacturer's factory trained field representative shall provide on-site training for contractor's field personnel in the proper install and selection of the flexible fittings in terms of bend radius, connection types, and brackets.
- c. The factory trained representative shall periodically visit the jobsite to ensure best practices in grooved product installation are being followed.
- d. Contractor shall remove and replace any improperly installed products

C. Electrical Coordination

1. All relays, wire, conduit, pushbuttons, pilot lights, and other devices required for power side or the control of electrical equipment shall be furnished by Division 26 and Division 28 Contractor, except as specifically noted elsewhere in this Specification.
2. Should any change in electrical equipment size, horsepower rating, or means of control be made to any motor or other electrical equipment after contracts are awarded, Division 21 Contractor is to immediately notify Division 26 and Division 28 Contractors of this change and pay any costs due to this change.
3. Division 26 Contractor shall provide all power wiring and Division 21 Contractor shall be responsible for providing all control wiring and its conduit. Control wiring shall conform to Division 26 and 28 requirements for control wiring.
4. Furnish wiring diagrams to Division 26 and Division 28 Contractors for equipment and devices furnished by Division 21 Contractor which have been indicated to be wired by Division 26 and Division 28 Contractors.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to the site under provisions of Division 01.
- B. Store and protect products under provisions of Division 01.
- C. All materials shall be stored in a clean, dry space.
- D. Promptly inspect shipments to ensure material is undamaged and complies with Specifications. Storage and protection methods must allow inspection to verify products.
- E. Furnish pipe with plastic end-caps/plugs on each end of pipe. Maintain end-caps/plugs through shipping, storage and handling, and installation to prevent pipe-end damage and to eliminate dirt and construction debris from accumulating inside of pipe. Protect fittings and unions by storage inside or by durable, waterproof, aboveground packaging.
- F. Cover pipe to prevent corrosion or deterioration while allowing sufficient ventilation to avoid condensation. Do not store materials directly on grade.
- G. Offsite storage agreements will not relieve Contractor from using proper storage techniques.

1.5 SUBMITTALS

- A. Submittals shall include:
1. Drawings
 2. Hydraulic Calculations
 3. Product data sheets for the following:
 - a. Pipe
 - b. Fittings
 - c. Hanger Assemblies
 - d. Valves
 - e. Double Check Backflow Prevention Assembly (DCBP)] [Reduced Pressure Zone Backflow Prevention Assembly (RPZ)
 - f. Tamper Switches
 - g. Flow Switches
 - h. Pressure Switches
 - i. Pressure Gauges
 - j. Fire Department Connection (FDC)
 - k. Exterior Weatherproof Waterflow Alarm
 - l. Sprinklers
 - m. Spare Sprinkler Cabinets
 - n. Any additional items required to provide complete installation.
- B. Submit Material Safety Data Sheet (MSDS) for corrosion inhibitive paint.
- C. Indicate by red marking or arrow, items that are to be provided, where more than 1 item appears on manufacturer's catalog sheet.
- D. Submit stamped and sealed drawings, product datasheets, hydraulic calculations, and a signed copy of the Owner's certificate to local Fire Department, Engineer, and Owner's insurance representative prior to installation or fabrication of system components.
- E. Review of submittals does not relieve Contractor from coordinating installation of work with other trades, or from compliance with Codes and Standards.
- F. At completion of acceptance tests:
1. Send copy of test log to Engineer
 2. Send copy of Contractor's Material and Test Certificates and fire pump test results to:
 - a. Engineer
 - b. Owner
 - c. Authority Having Jurisdiction
 3. Provide Owner with following:
 - a. Manufacturer's literature and instructions describing operation and maintenance of equipment and devices installed.

- b. Typewritten chart with identification and location of all access panels serving equipment and valves. Incorporate into Operation & Maintenance (O&M) manual.
- c. Typewritten valve schedule indicating valve number, fixture/equipment or areas served by each numbered valve. Incorporate into O&M manual.
- d. For additional O&M manual requirements, refer to Section 230000 - General Mechanical Requirements.
- e. Current copy of NFPA 25 – Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials and Equipment:

- 1. Materials and equipment in system shall be new and current products of manufacturer regularly engaged in production of such materials and equipment.
- 2. Where 2 or more pieces of equipment are required to perform interrelated functions, they shall be products of same manufacturer.
- 3. Clean and cap pipe after fabrication and prior to placing pipe in building.
- 4. Pipe shall be marked with removable tags. No permanent markings are to remain on unpainted pipe located in exposed areas

B. Approval Guides:

- 1. Unless otherwise shown, products shall be UL Listed in the latest publication of the UL Fire Protection Equipment Directory for service intended.

2.2 SPRINKLERS

A. Manufacturers:

- 1. Unless otherwise noted below, sprinklers shall be manufactured by Tyco Fire Products, Viking, Victaulic, Reliable, or equal.

B. Temperature class of sprinklers and cover plates shall vary if installed close to heat sources, under skylights, areas of higher ambient temperatures, or in special hazard areas. Refer to NFPA 13 for requirements.

C. Provide high pressure sprinklers where pressures exceed 175 psi working water pressure.

D. Light hazard and Ordinary Hazard occupancies shall utilize quick-response type sprinklers.

E. Architect will review deviations from specified styles for approval prior to installation.

F. Unless otherwise noted, provide the following type(s) of sprinklers:

- 1. In unfinished areas such as mechanical spaces,:
 - a. Standard coverage, brass upright or pendent; Tyco Fire Products Model TY-FRB, Viking Microfast, or equal.

- b. Extended coverage, brass upright or pendent; Tyco Fire Products Model EC-11 or EC-14, Viking ECOH-ELO, or equal, designed and installed per its listing.
 - c. When exposed to corrosive environments, sprinklers shall be polyester coated with bright white finish.
- 2. In unfinished areas where conditions do not permit installation of upright or pendent sprinkler:
 - a. Standard coverage, brass sidewall; Tyco Fire Products Model TY-FRB, Viking Microfast horizontal (HSW) or vertical (VSW) sidewall or equal.
 - b. Where exposed to corrosive environments, sprinklers shall be polyester coated with bright white finish.
- 3. In areas with finished ceilings:
 - a. Standard coverage, concealed pendent; Tyco Fire Products Model RFII, Viking Mirage, or equal sprinkler with flat cover plate, mounted flush with ceiling. Cover plate shall be factory-finished (i.e. by manufacturer). Finish to be bright white.
 - b. Standard coverage, semi-recessed; Tyco Fire Products TY-FRB, Viking Microfast, or equal. Sprinkler and escutcheon shall be factory-finished (i.e. by manufacturer). Finish to be bright white.
- 4. In areas with finished ceiling conditions that do not permit installation of pendent sprinkler or finished area where sidewall sprinkler provides better coverage of hazard:
 - a. Standard coverage, horizontal sidewall (HSW) or vertical sidewall (VSW); Tyco Fire Products Model TY-FRB, Viking Microfast or equal with adjustable escutcheon; Tyco Fire Products model 401, or equal. Sprinkler and escutcheon shall be factory-finished (i.e. by manufacturer). Finish to be bright white.
- 5. In exposed areas with ceilings subject to temperatures at or below 40°F:
 - a. Standard coverage, concealed dry pendent, intermediate temperature class sprinkler with intermediate temperature class cover plate, mounted flush with ceiling. Cover plate color shall match ceiling color and shall be factory-painted (i.e. by manufacturer), Tyco Fire Products Model DS-C or equal.
- G. Submit samples for examination and approval when appearance is different than sprinkler specified.
- H. Provide high pressure sprinklers where pressures exceed 175 psi working water pressure.
- I. Spare Sprinkler Cabinets:
 - 1. Shall be complete with required number of spare sprinklers of each type and temperature rating per NFPA 13 .
 - 2. Shall be provided with at least one sprinkler wrench for each type of sprinkler installed.
 - 3. Provide multiple cabinets to meet this requirement.
 - 4. Coordinate cabinet locations with Owner's representative.

2.3 FIRE PROTECTION PIPE JOINTS AND FITTINGS

- A. Below Ground:

1. Pipe: Ductile iron, Class 52, American Water Works Association AWWA C151/A21.51, minimum 350 psi working pressure, with standard cement mortar lining, AWWA C104/A21.4, American National Standards Institute (ANSI) A21.4
2. Fittings: Ductile iron or grey iron, mechanical joint, 350 psi working pressure, AWWA C153/A21.53, cement mortar lined, AWWA C104/A21.4.
3. Encasement: Polyethylene encasement, 8 mil thick, AWWA C105/A21.5.
4. Underground Restraint:
 - a. Acceptable manufacturers: EBAA Iron, Inc., Smith-Blair, or equal
 - b. Mechanical Joints Utilizing Setscrew Retainer Glands
 - 1) Mechanical joint restraint device for nominal pipe sizes 3" through 12" per AWWA C151/A21.51, shall consist of multiple gripping wedges incorporated into a follower gland meeting the applicable requirements of AWWA C110/A21.10, body, wedges and wedge actuating components shall be cast from grade 65-45-12 ductile iron material in accordance with ASTM A536, minimum working pressure rating of 350 psi, includes torque limiting breakaway nuts, allows for a minimum of 3° of deflection, and includes fusion-bonded epoxy coating per AWWA C213.
 - 2) Mechanical restraint coupling gasket shall be furnished by same manufacturer.
 - c. Pipe Clamps and Tie Rods
 - 1) Clamps, rods, and washers shall be sized per the requirements listed in NFPA 24.
 - a) Clamps shall be made of steel, used to prevent joint separation through use in combination with rod clamp washers, rod couplings, and heavy hex nuts.
 - b) Rods shall be carbon steel per ASTM A193/A193M GR B7, using rolled threads for improved physical characteristics, greater thread accuracy, and smooth surface finish.
5. Underground Penetration Modular Seal:
 - a. Acceptable manufacturers: GPT Industries, Roxtec, or equal
 - b. Modular sealing device consisting of sealing elements, pressure fittings, and hardware preassembled from manufacturer.
 - 1) Sealing elements: EPDM rubber that adjusts to the outside diameter of the pipe to ensure proper fitment and sealing.
 - 2) Pressure resistant to a minimum of 20 psig (40 ft. of head).
 - 3) Bolts and nuts: 316 stainless steel per ASTM F593
 - c. Basis of Design: GPT Industries Link-Seal, Roxtec Model RS, or equal

B. Above Ground:

1. Steel Pipe: Steel fire protection pipe shall be selected according to nominal pipe diameter. Schedule 30, Schedule 7, or similar thin-walled steel pipes are prohibited. CPVC pipe and fittings are prohibited.
 - a. Carbon (Black) Steel Pipe, 2" and smaller:
 - 1) Schedule 40, ASTM A795/A795M or ASTM A53/A53M
 - b. Carbon (Black) Steel Pipe, larger than 2':
 - 1) Schedule 10, ASTM A135/A135M

- 2) Schedule 40, ASTM A795/A795M or ASTM A53/A53M
- c. Galvanized Steel Pipe, 2' and smaller:
 - 1) Schedule 40, ASTM A795/A795M or ASTM A53/A53M
- d. Galvanized Steel Pipe, larger than 2':
 - 1) Schedule 10, ASTM A135/A135M
 - 2) Schedule 40, ASTM A795/A795M or ASTM A53/A53M
- 2. Steel Pipe Finishes: Unless noted otherwise, galvanized (hot dipped zinc coated) pipe and fittings shall be used when sprinkler system is exposed to weather or other corrosive environments.
- 3. Steel Pipe Joints:
 - a. Black Steel Pipe Joints:
 - 1) Threaded, tapered pipe threads, ANSI B1.20.1
 - 2) Flanged, cast iron, 175 psi CWP rating, ANSI B16.1 , square head machine bolts with semi-finished hexagon nuts, ASTM A183 , neoprene gasket
 - 3) Welded, welding electrodes shall be Lincoln or equal with coating and diameter as recommended by manufacturer for type and thickness of work being done.
 - 4) Cut or roll grooved, with mechanical coupling.
 - 5) Factory-welded pipe outlets, threaded or grooved
 - b. Galvanized Schedule 10 Steel Pipe Joints:
 - 1) Roll grooved with mechanical coupling.
 - 2) Factory-welded pipe outlets, threaded or grooved
 - c. Galvanized Schedule 40 Steel Pipe Joints:
 - 1) Threaded, tapered pipe threads, ANSI B1.20.1
 - 2) Cut grooved with mechanical coupling
 - 3) Factory-welded pipe outlets, threaded or grooved
- 4. Steel Pipe Fittings:
 - a. Black Steel Fittings:
 - 1) Cast iron threaded fittings, Class 125, 175 psi CWP rating, ASME B16.4
 - 2) Ductile iron threaded fittings, Class 150, 175 psi CWP rating, ASME B16.3
 - 3) Malleable iron threaded fittings, Class 150 or 300, ASTM A197/A197M /ANSI B16.3 .
 - 4) Cast iron flanged fittings, Class 125, 175 psi CWP rating, ANSI B16.1
 - 5) Carbon steel butt weld fittings, ASTM A234/A234M Grade WPB/American Society of Mechanical Engineers ASME B16.9 , standard weight, seamless
 - 6) Mechanical grooved fittings, ASTM A536 ductile iron, ASTM A47/A47M malleable iron or ASTM A53/A53M fabricated steel, 175 psi CWP rating, malleable iron conforming to ASTM A47/A47M .
 - a) Acceptable manufacturers: Victaulic, SPF/Anvil, Tyco Grinnell, Viking, or equal.
 - b) Flexible Couplings: Victaulic Style 75, or equal.

- c) Rigid Couplings: Victaulic Style 009N, Victaulic Style 07, Victaulic Style 005H, or equal. Single-bolt or hinged couplings are prohibited.
- d) Wet systems gasket: Grade E EPDM gasket per UL 157 and UL 213
- e) Dry systems gasket: Victaulic "FlushSeal" or equal
- f) Rigid or zero flex type couplings shall be provided when operating pressures cause piping to move out of place or sway on hangers. Flexible couplings may be used where pipe is braced or clamped into rigid position.
- g) Fitting, gasket, and coupling shall be furnished by same manufacturer.
- h) Pre-fabricated, one-piece assemblies that contain the fitting housing, gaskets, and bolts are prohibited.
- b. Galvanized Steel Fittings:
 - 1) Cast iron, threaded, galvanized coating, Class 125, ANSI B16.4
 - 2) Forged steel, threaded, galvanized coating, ANSI B16.11
 - 3) Ductile iron or malleable iron, mechanical coupling, 175 psi CWP rating, malleable iron conforming ASTM A47/A47M, hot dipped galvanized to ASTM A153/A153M or zinc electroplating to ASTM B633.
 - a) Acceptable manufacturers: Victaulic, SPF/Anvil, Tyco/Grinnell, Viking, or equal
 - b) Fitting, gasket, and coupling shall be furnished by same manufacturer.
 - c) Single-bolt or hinged couplings are prohibited.
 - d) Pre-fabricated, one-piece assemblies that contain fitting housing, gaskets, and bolts are prohibited.
- c. Flexible Sprinkler Hose Fittings for Fire Protection Service:
 - 1) Listings and Approvals: complete hose and bracket assembly shall be FM approved and UL Listed. FMRC Approved for its intended use pursuant to FM 1637 and UL Listed for its intended use pursuant to UL 2443 – Standard for Flexible Sprinkler Hose with Fittings for Fire Protection Service.
 - 2) Acceptable Manufacturers: FlexHead as manufactured by ASC Engineered Solutions or VicFlex as manufactured by Victaulic.
 - 3) Flexible Hose Assemblies and End Fittings:
 - a) Application: shall be used in lieu of rigid steel pipe offsets or return bends for sprinkler drops.
 - b) Composition: 100% Type 304 or 316 corrugated braided stainless steel with true 1" minimum ID
 - c) Minimum Bend Radius: 2" minimum bend radius per UL and 7-inch minimum bend radius per FM.
 - 4) Brackets:
 - a) Listed Assemblies: shall be of same manufacturer as flexible sprinkler hose fittings. Mixing of manufacturers shall not be allowed.
 - b) Listings and Approvals: shall be FM approved, UL Listed for use with flexible sprinkler hose fittings.
 - c) Applications: can be used on ceiling grid, hard lid, and open ceiling applications by attaching to framing, concrete deck or walls.

5. Threaded bushings are prohibited.
6. Plain end couplings such as Roust-A-Bouts, Plainloks or similar fittings are prohibited.
7. Slip-style fittings such as Wardlox or similar fittings are prohibited.
8. Adjustable drop nipples are prohibited.
9. Outlet fittings inserted into holes drilled into piping such as Victaulic Style 923 are prohibited.
10. Outlet couplings such as Victaulic Style 72 are prohibited.
11. Grooved reducing couplings such as Victaulic Style 750 are prohibited.
12. Dielectric Fittings:
 - a. Acceptable manufacturers: Epco Sales, Lochinvar, Watts Regulator Co., Wilkins, or equal
 - b. Insulating nipple, metal casing, inert thermoplastic lining, Clearflow dielectric fitting by Perfection Corporation or equal.
 - 1) Dielectric unions 2" and smaller; dielectric flanges 2" and larger; with iron female pipe thread to copper solder joint or brass female pipe thread end connections, non-asbestos gaskets, and pressure rating of not less than 175 psi at 180°F. Provide high pressure type when pressures exceed 175 psi water working pressure.

2.4 VALVES

A. Gate Valve:

1. Acceptable manufacturers: Kennedy, Milwaukee Valve Co., Mueller, Nibco, Stockham, Victaulic, or equal
2. Outside screw and yoke (OS&Y) gate valve, bronze body and trim or cast iron body bronze mounted and rated for 175 psi, non-shock water working pressure, Nibco F-607-OTS or equal.
3. Provide high pressure valves and fittings when pressures exceed 175 psi water working pressure.

B. Butterfly Valve with Integrated Tamper Switch - sizes:2 to 12"

1. Acceptable manufacturers: Kennedy, Milwaukee Valve Co., Mueller, Nibco, Tyco Fire Products, Victaulic, or equal
2. For normally open valves, provide valve equal to Victaulic FireLock Series 705.
3. For normally closed valves, provide valve equal to Victaulic FireLock Series 705C.
4. Provide high pressure valves and fittings when pressures exceed 300 psi water working pressure.

C. Slow-Close Ball Valve with Integrated Tamper Switch - sizes 1 to 2":

1. Acceptable manufacturers: Kennedy, Milwaukee Valve Co., Mueller, Nibco, Tyco Fire Products, Victaulic, or equal
2. Provide valve equal to Victaulic FireLock Series 728

D. Check Valve:

1. Acceptable manufacturers: Globe Fire Sprinkler, Reliable, Tyco Fire Products, Victaulic, Viking, or equal
 2. Iron body, bronze seat, stainless steel clapper with a replaceable rubber seal, Globe Fire Sprinkler Model RCV, Tyco Fire Products CV-1F, Viking Model G-1, or equal.
 3. Check valve shall be equipped with removable cover for inspection and maintenance.
 4. Provide high pressure valves and fittings when pressures exceed 300 psi water working pressure.
- E. Ball Valve:
1. Acceptable manufacturers: Milwaukee Valve Co., Mueller, Nibco, Stockham, Victaulic, or equal
 2. Bronze body and stem, full port design, brass ball with chrome plated finish, conforms to MSS SP-110 standard, Nibco Model KT-585-70-UL or equal.
 3. Provide high pressure valves and fittings when pressures exceed 300 psi water working pressure.
- F. Angle/Drain Valve:
1. Acceptable manufacturers: Milwaukee Valve Co., Mueller, Nibco, Stockham, Victaulic, or equal
 2. Bronze body, stem, bonnet, and packing nut; non-asbestos packing; nitrile seat disc; stainless steel handwheel screw or nut; Nibco Model T-301-W, or equal.
 3. Provide high pressure valves and fittings where pressures exceed 175 psi water working pressure.
- G. Test and Drain Valves:
1. Acceptable manufacturers: AGF, Victaulic, or equal
 2. AGF TESTanDRAIN, Victaulic Style 720 TestMaster II, or equal.
 3. Test and drain valve shall include integral pressure relief valve. Pressure relief valve shall be set to operate at 175 psi or 10 psi in excess of the maximum system pressure, whichever is greater.
 4. Provide high pressure valves and fittings where pressures exceed 175 psi water working pressure.
- H. Air Release Valve:
1. Acceptable manufacturers: Engineered Corrosion Solutions, Potter Electric Signal Co., or equal
 2. Automatic float type air vent, ball valve with tamper switch, Y-type strainer, and single set of normally closed dry contacts rated 24VAC/DC at 2 Amps, UL 2573 Listed, FM Approved "Automatic Air Release Valve for Sprinkler Systems", rated to 175 psi non-shock water working pressure, Potter Electric Signal Co. Model PAAR-B or equal.
 3. Air release valve shall be installed in an accessible location to permit operation, maintenance, and visual inspection of the status of the valve.
 4. Provide high pressure valves and fittings where pressures exceed 175 psi water working pressure.

2.5 FIRE DEPARTMENT CONNECTION (FDC)

A. Manufacturers:

1. Acceptable Manufacturers: Croker Corp.; Dixon Fire; Elkhart Brass; Potter-Roemer; or equal

B. Fire Department Connection:

1. Provide wall mounted straight, 5" Storz inlet connection with cap. Outlet shall be 4"NPSH threaded. Basis of Design: Potter Roemer Series 5795-5799 or equal.

C. Ball Drip

1. Acceptable manufacturer: Potter-Roemer, Tyco Fire Products, or equal
2. Provide bronze ball drip for fire department connection (FDC) inside of building and pipe to nearest floor drain or discharge to exterior.
3. Exterior discharge location must be coordinated with Architect and Owner.

2.6 TAMPER SWITCH

A. Acceptable manufacturers: Potter Electric Signal Co., System Sensor, or equal

B. Outside screw and yoke (OS&Y) supervisory switch, NEMA 4 enclosure, provided with 2 sets of SPDT (Form C) contacts rated at 2.5 Amps at 30 VDC and 15 Amps at 125/250 VAC. For areas identified as hazardous locations, provide "EX" Model. Potter Electric Signal Co. OSY series or equal.

C. Control valve supervisory switch, NEMA 4 enclosure, provided with 2 sets of contacts rated at 2.5 Amps at 30 VDC and 15 Amps at 125/250 VAC. Provide with optional cover tamper kit. For areas identified as hazardous locations, provide "EX" Model. Potter Electric Signal Co. PIBV series or equal.

D. Tamper switch shall be capable of transmitting signal during first 2 revolutions of handwheel or during 1/5 of travel distance of valve control apparatus from its normal position.

E. Unit shall be compatible with building's fire alarm system.

2.7 FLOW SWITCH

A. Acceptable manufacturers: Potter Electric Signal Co., System Sensor, or equal

B. Vane type waterflow switch for use in wet sprinkler systems, minimum 300 psi service pressure rating, 10 gpm minimal flow rate to activate alarm, and 2 sets of SPDT (Form C) contacts. Potter Electric Signal Co. VS series or equal.

C. Unit shall be compatible with building's fire alarm system.

2.8 WATERFLOW ALARM (EXTERIOR OF BUILDING)

A. Acceptable manufacturers: Cooper Wheelock, Potter Electric Signal Co., or equal

B. Device shall be compatible with building's fire alarm system.

- C. If required by code official, provide approved signage per NFPA 13.

2.9 PRESSURE GAUGES

- A. Acceptable manufacturers: Ashcroft, Potter-Roemer, Viking, or equal
- B. Pressure gauges shall be 3-1/2" , corrosion resistant moving parts, polycarbonate window, and provided with connection not smaller than 1/4" NPT.
- C. Include ball valve with provisions for draining on each pressure gauge.

2.10 WET PIPE SYSTEM COMPONENTS

- A. Each wet pipe system shall include:
 - 1. Indicating-type control valve with tamper switch
 - 2. Check valve
 - 3. Pressure gauge
 - 4. Waterflow switch
 - 5. Inspector's test and drain assembly with integral pressure relief valve.
- B. Riser Manifold
 - 1. Acceptable manufacturers: Tyco Fire Products, Victaulic, Viking, or equal
 - 2. Ductile iron or fabricated steel pipe body; threaded or grooved connections; rated to 175 psi non-shock water working pressure; includes test and drain valve with integral pressure relief valve, flow switch, and pressure gauge; Tyco Fire Products Model RM-1, Victaulic UM, Viking EasyPac, or equal.
 - 3. Provide high pressure valves and fittings when pressures exceed 175 psi water working pressure.
- C. Alarm Check Valve Assembly
 - 1. Acceptable manufacturers: Reliable, Tyco Fire Products, Victaulic, Viking, or equal
 - 2. Alarm check valve shall be check valve assembly with retard chamber.
 - 3. Include gauges, waterflow alarm pressure switch, drain valve, bypass piping and valves.
 - 4. Alarm check valve shall be capable of transmitting signal when water flow equals or exceeds discharge of single sprinkler.

2.11 HANGERS

- A. Acceptable manufacturers: Afcon, Anvil, Eaton, Pentair, Tolco, or equal
- B. Concrete expansion hangers, when provided, are to be Hilti, Illinois Tool Works (ITW), Powers Fasteners, or equal
- C. Screw anchors for concrete, when provided, are to be Hilti, Illinois Tool Works (ITW), Powers Fasteners, or equal.
- D. Screw anchors for steel structure, when provided, are to be Illinois Tool Works (ITW), Powers Fasteners, or equal.

- E. Screw anchors for wood structure, when provided, are to be Illinois Tool Works (ITW), Powers Fasteners, or equal.
- F. Hanger rods shall comply with Manufacturer Standardization Society (MSS) standards and manufacturer's published load rating.
- G. Provide hanger rod, hanger rod attachments, pipe stands, bolts, U-bolts, nuts, studs and washers with electroplated zinc coating or with hot-dipped galvanized finish.
- H. Riser clamps shall be electroplated zinc coated or have a hot-dipped galvanized finish and shall not protrude more than 2 " beyond edge of hole, Anvil Fig. 261 or equal.

2.12 FIRE PUMP (FP)

- A. Acceptable Manufacturers: A-C Fire Pump, Fairbanks Nijhuis, Patterson Pump, Peerless Pump, Pentair Aurora or equal
- B. Fire pump shall meet following criteria:
 - 1. Deliver rated flow at rated pressure
 - 2. Deliver not less than 65% of rated pressure at 150% rated capacity
 - 3. Not exceed 140% of rated pressure at shutoff
- C. Pump Type: Electric Driven
- D. Pump Configuration: Vertical Inline
- E. For coordination with other disciplines, a fire pump with the following characteristics has been used as the basis of design. The Engineer of record shall provide the final fire pump selection. If electrical updates are required, the fire protection contractor as Engineer of record is responsible for coordination with the electrical contractor
 - 1. Rated Flow: 400 gpm
 - 2. Rated Pressure: 55 psi
- F. Pump casing shall be pressure rated to handle system pressure.
- G. Pump and motor shall be mounted on common steel baseplate.
- H. Motor:
 - 1. Provide open drip proof, high-efficiency, foot-mounted.
 - 2. 460 VAC, 3 Ph, 60 Hz, and TBD rpm
 - 3. Locked rotor current shall not exceed values specified in NFPA 20.
- I. Accessories to be provided with each fire pump are as follows:
 - 1. Fire Pump Test Connection:
 - a. Test connection shall be flush type, cast brass body, polished brass plated with lettering reading "PUMP TEST CONNECTION".
 - b. Unit shall include two 2-1/2", polished brass plated caps with chains.
 - c. Potter-Roemer Model or equal

2. Discharge pressure gauge and compound suction gauge shall be liquid-filled type.
3. Circulation Relief Valve: 3/4" Cla-Val Model 55L pressure relief valve or equal
4. Automatic Air Release Valve

2.13 CONTROL EQUIPMENT FOR ELECTRIC DRIVE

- A. Acceptable Manufacturers: Eaton, Firetrol, Joslyn Clark, Metron, or equal
- B. Fire Pump Controller:
 1. Shall be completely assembled, wired and tested by control manufacturer before shipment from factory
 2. Shall be labeled "Fire Pump Controller"
 3. Shall be located as close as practical and within sight of motor
 4. Shall be located and protected such that it will not be damaged by water escaping from pump or connections
 5. Shall be combined manual and automatic
 6. Heavy gauge formed steel, NEMA Type 2 enclosure with top drip hood
 7. Provide external disconnecting means for Utility power connection. Disconnect shall be completely enclosed and separate from the controller/transfer switch equipment enclosure, facilitating disconnection of utility power for service without exposing personnel to live terminals supplied from utility transformer.
 8. Provide complete with following:
 - a. Starter: Reduced Voltage Solid State
 - b. Isolating Switch: Externally operable, quick-break type
 - c. Short-Circuit Current Rating (SCCR): 25 kA at 480 V
 - d. Locked rotor protector for drive motor
 - e. Pilot light to show circuit breaker closed and power available
 - f. Ammeter and voltmeter displays on front of panel
 - g. Alarm relay to energize audible or visible alarm
 - h. Pressure recording device
 - i. Voltage surge protection
 - j. Contacts for remote alarm of:
 - 1) Pump Running
 - 2) Loss of Line Power in any phase
 - 3) Phase Reversal
 - 4) Controller Connected to Alternate Source

2.14 JOCKEY PUMP (JP)

- A. Acceptable manufacturers: A-C Fire Pump, Fairbanks Nijhuis, Patterson Pump, Peerless Pump, Pentair Aurora or equal
- B. Jockey pump shall be:
 1. Same manufacturer as main fire pump

2. Centrifugal jockey pump rated for 10 gpm at 65 psig
- C. Pump casing shall be pressure rated to handle system pressure.
- D. Motor shall be:
 1. 230 VAC
 2. 3 Ph, Jockey pump shall be close-coupled.
 3. Open Drip Proof (ODP)
 4. Pump and motor shall be integrally mounted on common steel baseplate.

2.15 JOCKEY PUMP CONTROLLER

- A. Acceptable manufacturers: Eaton, Firetrol, Joslyn Clark, Metron, or equal
- B. Jockey pump controller shall be same manufacturer as main fire pump controller.
- C. Jockey pump controller:
 1. Wall mounted, NEMA Type 2 control cabinet
 2. Maintain automatic sprinkler system at 5-10 psi above fire pump starting pressure.
 3. Mercury-free pressure switch with independent adjustment
 4. Multiple position control switch
 5. 3-pole disconnect switch
 6. Starter

PART 3 - EXECUTION

3.1 GENERAL

- A. Fire Protection System Layout and Installation Drawings:
 1. Contractor shall review Design Drawings and Specifications, and shall provide installation drawings, calculations, and product datasheets.
 2. Conceal sprinkler piping above ceilings where possible.
 3. Contractor shall consult with Architect during development of piping layout to avoid conflicts with general appearance. Pipe routing is a critical issue due to attributes of this building.
 4. Submit stamped and sealed installation drawings, calculations and product data sheets for coordination review to: local Fire Department, Engineer, Architect, Owner's insurance representative, City of **Greenville** and other Authorities Having Jurisdiction prior to installation (see submittals).
 5. Contractor shall be responsible to have examined "Reflected Ceiling" drawings as well as Mechanical, Electrical, Piping, Information Technology, Structural and Architectural building plans prior to system layout.
 6. Contractor shall coordinate routing of piping with other trades and Architect.
 7. Contractor shall participate in coordination process and shall not install piping prior to coordination with other trades.

8. Provide identification sign (enamel on metal) for valves per NFPA requirements. For additional information, refer to Section 220553 - Plumbing Systems Identification.

3.2 DESIGN CRITERIA

- A. Flow Test:
 1. Refer to sheet FP000 for flow test information.
- B. Sprinkler Contractor, prior to preparation of installation drawings and hydraulic design calculations, shall ensure that a hydrant flow test is conducted within the last 12 months.
- C. Send current hydrant flow test data to Engineer.
- D. The hydraulically calculated system shall be designed to a minimum of the recorded flow test static pressure less 10 psi, residual pressure less 10 psi and residual flow less 10%.
- E. Basis of Design:
 1. Office areas and general building spaces shall be hydraulically designed to provide minimum density of 0.1 gpm per sq ft over most hydraulically remote 1500 sq ft. Maximum spacing shall not exceed 225 sq ft per sprinkler.
 2. Field high sloped ceiling sprinklers shall be hydraulically designed to provide minimum density 0.1 gpm per sq ft over most hydraulically remote 1950 sq ft. Maximum spacing shall not exceed 130 sq ft per sprinkler.
 3. Penthouse and other mechanical equipment areas shall be hydraulically designed to provide minimum density of 0.15 gpm per sq ft over most hydraulically remote 1500 sq ft. Maximum spacing shall not exceed 130 sq ft per sprinkler.
 4. General storage areas and chemical transfer area shall be hydraulically designed to provide minimum density of 0.2 gpm per sq ft over most hydraulically remote 1500 sq ft. Maximum spacing shall not exceed 130 sq ft per sprinkler.
- F. Hose Streams:
 1. Add 100 gpm hose stream to sprinkler zone hydraulic calculations, at source, for Light Hazard Occupancies.
 2. Add 250 gpm hose stream to sprinkler zone hydraulic calculations, at source, for Ordinary Hazard Occupancies.

3.3 INSPECTION

- A. Investigate site conditions; verify utility locations and elevations before start of excavation. Forward discrepancies to Architect/Engineer before proceeding with construction.

3.4 INSTALLATION

- A. Install hydraulically designed sprinkler system and associated accessories according to requirements of NFPA 13 and as shown on drawings.
- B. Keep materials within listed temperature range to assure jointing in accordance with manufacturer's requirements.

- C. Pipe and fittings shall be of corresponding materials when assembled.
- D. Underground Pipe:
1. Underground pipe shall be restrained against movement at changes in direction per the requirements of NFPA 24. Restraint shall be provided by using thrust blocks or one of the following methods:
 - a. Mechanical joint restraint utilizing setscrew retainer glands
 - 1) Mechanical joint restraint shall require conventional tools and installation procedures per AWWA C600, while retaining full mechanical joint deflection during assembly as well as allowing joint deflection after assembly.
 - 2) Proper actuation of the gripping wedges shall be ensured by use of torque limiting twist off nuts.
 - b. Pipe clamps and tie rods
 - c. Locking mechanical or push-on joints
 - d. Bolted flange joints
 2. Thrust blocks shall be of concrete, of a mix not leaner than one part cement, two and one-half parts sand, and five parts stone.
 3. Wherever possible, thrust blocks shall be located so that the joints are accessible for repair.
 4. Pipe clamps and tie rods shall not be installed where the pipe penetrates building walls or floors.
 5. Threaded sections of rods shall not be formed or bent.
 6. Except for fittings, valves, glands, and other accessories having an epoxy-coated finish, all rods, nuts, bolts, washers, clamps, and other restraining devices shall be cleaned and thoroughly coated with a bituminous or other acceptable corrosion-retarding material after installation.
 7. Provide metallic bond at each joint of ductile iron and cast iron pipe. Bond wire shall be type RHW-USE size 1/0 neoprene-jacketed copper conductor shaped to stand clear of joint.
 8. Polyethylene encasement shall be installed for ductile iron pipe. Refer to AWWA C105/A21.5 for material standards and installation procedures.
- E. Above Ground Pipe:
1. Provide pipe identification system with flow directional arrows on fire protection pipe in accordance with manufacturer's installation instructions. For additional information, refer to Section 220553 - Plumbing Systems Identification.
 2. Make joints of threaded pipe by cutting pipe square and reaming inside.
 3. Exposed pipe threads shall be protected by one of the following methods
 - a. Coat bare threads with corrosion inhibitive paint, equal to Rust-Oleum. Apply paint per manufacturer's instructions.
 - b. Cover bare threads with thread tape or joint compound. Use of thread tape and joint compound shall not be excessive.
 4. Joints for mechanically coupled pipe shall be made according to manufacturer's instructions. Use manufacturer's gasket lubricant sparingly.
 5. Welded joints shall be made in fabrication shop. Welding at project site is prohibited.

6. Changes in pipe sizes shall utilize one of the following installation methods:
 - a. Concentric threaded reducers. Threaded bushings are prohibited.
 - b. Concentric grooved reducers. Reducing couplings such as Victaulic Style 750 are prohibited.
 - c. Threaded reducing elbows and tees
 - d. Grooved reducing elbows and tees such as Victaulic No. 25 and No. 29T
 - e. Groove x Thread End-Of-Run fitting such as Victaulic No. 67
 - f. Shop-fabricated threaded or grooved weld-o-lets
 7. Provide readily removable fittings at end of cross-mains. Minimum size of flushing connection shall be 2".
- F. Sprinkler heads
1. Install sprinklers as recommended by manufacturer. Sprinklers shall be set level and at locations to avoid interference with spray pattern of sprinkler. When ducts and lights are obstructions to sprinkler distribution, provide additional sprinklers beneath obstruction.
 2. Feed sprinklers, installed in finished ceilings, with [flexible sprinkler drop,] swing joint, or return bend arrangement for final positioning in ceiling grid pattern during construction phases.
 3. All arm-over and flexible sprinkler fittings shall be taken from the sides or top of the branch line. No arm-overs or flexible sprinkler fittings shall be connected to the bottom of the branch line.
 4. Sprinklers are required to be installed in the center of ceiling tiles
 5. Provide minimum 1" outlets with sprigs for sprinklers located in shelled spaces.]
- G. Provide test connection for each flow switch.
- H. Discharge test connections inside building to receptacles provided as part of plumbing system or to standpipe's drain riser. Outside discharge is preferred.
- I. Drain line detailed adjacent to standpipe/sprinkler risers shall be considered as part of Sprinkler System from combination test/auxiliary drain valve for each zone or sub-zone shown on plans to plumbing receptacle.
- J. Provide auxiliary drains at low points of systems per requirements of NFPA 13.
- K. Identify valve with brass tag denoting which flow switch is being tested, when test valves are located remote from flow switch.
- L. Clamp-on or saddle type fittings (i.e. mechanical tees) are not allowed. Outlet fittings inserted into holes drilled into piping or pipe-o-lets are not allowed.
- M. Provide reducing fittings or provide shop fabricated weld-o-lets to change pipe sizes in sprinkler/standpipe systems. No bushings or grooved reducing couplings, such as Victaulic Style 750, are allowed.
- N. Feed sprinklers, installed in finished ceilings, with swing joint, or return bend arrangement for final positioning in ceiling grid pattern during construction phases.

- O. All arm-over and flexible sprinkler fittings shall be taken from the sides or top of the branch line. No arm-overs or flexible sprinkler fittings shall be connected to the bottom of the branch line.
- P. Sprinklers are required to be installed in the center of ceiling tiles.
- Q. System Drains, Inspector's Test Connections, and Auxiliary Drains
 - 1. Provide system drain lines sized in accordance with NFPA 13.
 - 2. Provide inspector's test connection for each vane-type or pressure actuated flow switch in accordance with NFPA 13. When inspector's test valve is remotely located from associated flow switch, identify valve with brass tag denoting which flow switch is being tested.
 - 3. Inspector's test connections and system drains shall discharge to one of the following locations:
 - a. Outside building at location approved by owner.
 - b. Inside building to waste receptacle (hub drain) provided as part of plumbing system.
 - c. Provide auxiliary drains at low points of systems in accordance with NFPA 13.
- R. Valves
 - 1. Valves and associated accessories shall be installed according to manufacturer's instructions.
 - 2. Each shutoff valve shall be equipped with a tamper switch.
- S. Hangers, Bracing, and Restraint of System Piping:
 - 1. Provide hangers and associated parts to support piping in perfect alignment without sagging or interference, to permit free expansion and contraction, and meet requirements of NFPA 13 and manufacturer's installation instructions.
 - 2. Select and size building attachments per Manufacturer Standardization Society (MSS) standards and manufacturer's published load rating.
 - 3. Coordinate hanger support installation to group piping of all trades.
 - 4. Hang pipe from building members using either concrete inserts for concrete construction or beam clamps for steel construction. Installation shall comply with manufacturer's installation instructions. Expansion type inserts may be used for branch piping.
 - 5. Hang pipe from steel purlins via side or bottom screw applications. Install steel screws with restraining nuts. Installation shall comply with manufacturer's installation instructions.
 - 6. Restraining clips/clamps are required in locations where vibration may be a concern. Refer to Section 230550 - Vibration Isolation, for additional information regarding restraining clips/clamps.
 - 7. Suspend hangers by means of electroplated zinc or hot-dipped galvanized finish hanger rods. Perforated band iron and flat wire straps (strap iron) are not allowed.
 - 8. Mains larger than 4" in diameter when installed parallel to open web joists shall not be supported from a single joist. Mains larger than 4" in diameter when installed parallel to joists, shall be supported by trapeze hanger assembly and shall be positioned equally between two joists. Trapeze hangers shall be positioned to load joists at panel points only
 - 9. Support pipe from top flange of beams.

- 10. Where joists are used, locations of pipe supports shall be approved by the structural engineer prior to installation.
- 11. Supporting equipment or piping from metal roof deck is prohibited.
- T. Install pressure gauges as required in manufacturer's installation instructions, and as required per NFPA standards.

3.5 CLEANING

- A. Ensure underground feed pipe has been flushed per NFPA 24 to clear out construction debris, prior to connecting aboveground fire protection system to it. Provide copy of underground pipe flush test certificate to engineer.
- B. Clean systems after installation is complete.
- C. Clean piping both internally and externally to remove dirt, plaster dust, or other foreign materials. When external surfaces of piping are rusted, clean and restore surface to original condition. Replacement of heavily soiled and deteriorated materials shall be done at the Contractor's expense.
- D. Clean equipment as recommended by manufacturers. Thoroughly clean equipment of stains, paint spots, dirt, dust, and any other foreign materials. Remove temporary labels not used for instruction or operation.

3.6 TESTING

- A. Refer to testing paragraph of Section 220000 - General Plumbing Requirements.
- B. Perform all NFPA required acceptance tests.
- C. Test sprinkler system as entire system or partial system. System shall be hydrostatically tested at not less than 200 psi or 50 psi above static pressure in excess of 150 psi for 2 h. No leakage allowed. Replace defective joints with new materials. No caulking of defective joints allowed. Re-test system after defective joints are replaced, until satisfactory results are obtained.
- D. Hydrostatically test piping between the exterior fire department connection (FDC) and the check valve in the fire department inlet pipe in the same manner as the balance of the system.
- E. Pipe shall not be concealed until satisfactorily pressure tested.
- F. Conduct drain test. Record static pressure and residual pressure per NFPA 13.
- G. Owner's representative or engineer may witness tests. Contractor shall notify Owner and Engineer a minimum of 3 days in advance to allow for participation.
- H. Log of tests shall be kept at job site and shall identify:
 - 1. Who performed test
 - 2. Time of test
 - 3. Date of test
 - 4. Section of system tested

5. Results of test
 6. Completed Contractor's Material and Test Certification form(s) from NFPA 13 and NFPA 14
- I. Operate flow switches to test that signals are transmitted to Fire Alarm Control Panel.
 - J. Include test for tamper switches.
 - K. Conduct forward flow test of backflow preventer in accordance with NFPA 13 and NFPA 24.

3.7 FIRE PUMP TESTING

- A. Test fire pump, jockey pump and their controllers per manufacturer's installation instructions and as required in NFPA 20.
- B. Furnish test certificate indicating suction pipe has been flushed and suction and discharge pipe has been hydrostatically tested in accordance with NFPA 20, prior to fire pump acceptance test.
- C. Coordinate fire pump acceptance test so Local Authorities, Owner's representatives, and Insurance Company representatives can witness the test.
- D. Coordinate fire pump test with Division 26 and Division 28 contractors.
- E. Owner's representative or Engineer may witness tests. Contractor shall notify Owner and Engineer a minimum of 3 days in advance to allow for participation.
- F. Representatives from following shall be present for fire pump field acceptance test:
 1. Pump manufacturer
 2. Controller manufacturer
- G. Coordinate fire pump test with local utilities to verify acceptable method for disposal of water.
- H. Provide equipment to perform fire pump test, including:
 1. Calibrated test gauges
 2. Calibrated tachometer
 3. Hoses
 4. Nozzles
 5. Valves
- I. Diesel engine fire pumps shall be run for a minimum of 30 min no less than once per week.

3.8 WARRANTY

- A. Installing contractor shall warranty system installation for a minimum of 1 year from date of substantial completion.
- B. Installing contractor in combination with flexible sprinkler head manufacturer shall provide a warranty of 5 years from date of substantial completion related to leak assurance and water damage.

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- C. Manufacturer shall warranty all pumps and components for 2 years from date of start-up.

SECTION 220000 - GENERAL PLUMBING REQUIREMENTS

PART 1 GENERAL

1.1 REFERENCE

- A. Work under this Section is subject to requirements of Contract Documents, including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.2 DESCRIPTION

- A. Intent of drawings and Specifications is to obtain complete systems, tested, adjusted, and ready for operation.
- B. The terms "provide", "furnish" and "install" as used in Contract Documents shall have the following meanings:
 - 1. "Provide" or "provided" shall mean "furnish and install".
 - 2. "Furnish" or "furnished" does not include installation.
 - 3. "Install" or "installed" does not include furnishing.
- C. Include incidental details not usually shown or specified, but necessary for proper installation and operation.
- D. Check, verify and coordinate work with drawings and specifications prepared for other trades. Include modifications, relocations or adjustments necessary to complete work or to avoid interference with other trades.
- E. Information given herein and on drawings is as exact as could be secured but is not guaranteed. Do not scale drawings for exact dimensions.
- F. Where Architectural features govern location of work, refer to architectural drawings.
- G. Contractor may install additional piping, fittings and valves, not shown on drawings, for testing purposes or for convenience of installation. Where such materials are installed, they shall comply with specifications and shall be sized to be compatible with system design. Remove such installed materials when they interfere with design conditions or as directed by Architect.

1.3 RELATED WORK

- A. Utility Services:
 - 1. Determine utility connection requirements and include in Base Bid all costs to Owner for utility service.
 - 2. Include costs for temporary service, temporary routing of piping or any other requirements of a temporary nature associated with utility service.
- B. Temporary Services:
 - 1. Division 01 - Temporary Facilities and Controls.
- C. Continuity of Service:

1. No service shall be interrupted or changed without permission from Architect and Owner. Obtain written permission before any work is started.
- D. When interruption of services is required, Architect, Owner, and other concerned parties shall be notified and shall determine a time.
- E. Concrete Work:
 1. Provide cast-in-place concrete as required by Contract Documents unless otherwise noted.
 2. Provide concrete housekeeping pad for all floor mounted equipment. Housekeeping pads shall be 4 " thick and shall extend 3" minimum beyond footprint of equipment.
 3. Concrete shall comply with Division 03 - Concrete.
 4. Provide anchor bolts, metal shapes and templates required to be cast in concrete or used to form concrete for support of mechanical equipment.

1.4 REFERENCE STANDARDS

- A. Agencies or publications referenced herein refer to the following:
1. AGA - American Gas Association
 2. AMCA - Air Movement and Control Association
 3. ANSI - American National Standards Institute
 4. AHRI - Air-Conditioning, Heating and Refrigeration Institute
 5. ASHRAE - American Society of Heating Refrigerating and Air Conditioning Engineers
 6. ASPE - American Society of Plumbing Engineers
 7. ASSE - American Society of Sanitary Engineering
 8. AWS - American Welding Society
 9. AWWA - American Water Works Association
 10. ASME - American Society of Mechanical Engineers
 11. ASTM - American Society for Testing and Materials
 12. CDA - Copper Development Association
 13. CISPI - Cast Iron Soil Pipe Institute
 14. FMG - FM Global
 15. FS - Federal Specifications
 16. IEEE - Institute of Electrical and Electronics Engineers
 17. MCA - Mechanical Contractors Association
 18. MSS - Manufacturers Standardization Society
 19. NEC - National Electrical Code
 20. NEMA - National Electrical Manufacturers Association
 21. NFPA - National Fire Protection Association
 22. NIST - National Institute of Standards & Technology
 23. NSF - National Sanitation Foundation
 24. NSPI - National Spa and Pool Institute
 25. OSHA - Occupational Safety and Health Administration

26. PDI - Plumbing and Drainage Institute
27. SMACNA - Sheet Metal and Air Conditioning Contractors National Association
28. UL - Underwriters Laboratories, Inc.
29. WQA - Water Quality Association

- B. Work shall be in accordance with latest edition of codes, standards or specifications unless noted otherwise.

1.5 SUBMITTALS

A. Product Data:

1. Refer to Division 01 - Submittal Procedures.
2. Submit for equipment and systems as requested in the respective specification sections.
3. Unless otherwise indicated submittals shall be in electronic Portable Document Format (pdf) and bookmarks shall be included to facilitate navigation through submittal documentation.
4. Specifically mark general catalog sheets and drawings to indicate specific items submitted and its correlation to specific designation for product in drawings.
5. Specifically indicate proper identification of equipment by name and/or number, as indicated in specification and shown on drawings.
6. When manufacturer's reference numbers are different from those specified, provide correct cross-reference numbers for each item. Clearly mark and note submittals accordingly.
7. Submit complete record of required components when fixtures, equipment and items specified include accessories, parts and additional items under one designation.
8. Include composite wiring diagrams for electrically powered equipment and devices.
9. Where submittals cover products containing non-metallic materials, include "Material Safety Data Sheet" (MSDS) from manufacturer stating physical and chemical properties of components and precautionary considerations required.
10. Submit shop drawings or product data as soon as practicable after signing contracts. Submittals must be approved before installation of materials and equipment.
11. Submittals that are not complete, not permanent or not properly checked by Contractor will be returned without review.
12. Refer to Division 01 - Coordination Drawings.

B. Certificates and Inspections:

1. Obtain and pay for inspections required by authorities having jurisdiction and deliver certificates approving installations to Owner unless otherwise directed.

C. Operation and Maintenance Manuals:

1. Refer to Division 01 - Operation and Maintenance Data.
2. Upon completion of Work but before final acceptance of system, submit to Architect for approval, electronic version of operation and maintenance manuals in pdf format.
2"Electronic file shall contain bookmarks for each submittal contained in manual.
3. Organize manuals by specification section number and furnish table of contents and tabs for each piece of equipment or system.

4. Fire protection system shall be separately bound.
5. Manuals shall include the following:
 - a. Copies of Shop Drawings and Product Data
 - b. Manufacturer's operating and maintenance instructions. Include parts lists of items or equipment, with component exploded views and part numbers. Where manufacturer's data includes several types or models, designate applicable type or model.
 - c. Electronic versions of O&M data with exploded parts lists where available
 - d. Phone numbers and addresses of local parts suppliers and service companies
 - e. Internet/WEB page addresses where applicable
 - f. Wiring diagrams
 - g. Startup and shutdown procedures
 - h. Composite electrical diagrams
 - i. Flow diagrams
 - j. Lubrication instructions
 - k. Factory and field test records (Refer to Test and Balancing in Part 3 of this section.)
 - l. Air and water balance reports
 - m. Valve identification charts as specified in Section 220553 - Plumbing Systems Identification
 - n. Access panel identification charts as specified in Section 220553 - Plumbing Systems Identification
 - o. Additional information, diagrams or explanations as designated under respective equipment or systems specification sections.
6. Instruct Owner's representative in operation and maintenance of equipment. Instruction shall include complete operating cycle on all apparatus.
7. Furnish O&M Manuals and instructions to Owner prior to request for final payment.

D. Record Documents:

1. Refer to General Conditions of Contract, and Division 01 - Project Record Documents. Prepare complete set of record drawings in accordance with Division 01.
2. Use designated set of prints of Contract Documents as prepared by Architect to mark-up for record drawing purposes.

1.6 JOB CONDITIONS

A. Building Access:

1. Arrange for necessary openings in building to allow for admittance of all apparatus.

B. Electrical Coordination:

1. Refer to Section 220513 - Motors for Plumbing Equipment.
2. Contractor shall provide the following items as specified under their respective Division(s):
 - a. Motors
 - b. Electrically powered equipment
 - c. Electrically controlled equipment

- d. Starters, where specified
 - e. Variable frequency drives, where specified
 - f. Control devices, where specified
 - g. Temperature Control wiring
 - h. Wiring diagrams to Electrical Contractor for apparatus indicating external connection and internal controls.
 - i. Disconnect devices furnished with units (VFDs, chillers, prepackaged control devices, etc.)
 - 1) Devices shall have an interrupting rating not less than that of the upstream overcurrent device as shown on electrical drawings.
 - 2) Equipment electrical connection points shall be labeled with listed electrical short circuit current rating (SCCR). SCCR shall not be less than interrupting rating of upstream overcurrent device as shown on electrical drawings. SCCR shall be marked on equipment control enclosure in accordance with UL 508, or other acceptable, accredited third-party testing agency standards.
3. Electrical Contractor will provide the following devices required for control of motors or electrical equipment, unless noted otherwise.
- a. Starters
 - b. Disconnect devices
 - c. Control devices:
 - 1) Pushbuttons
 - 2) Pilot lights
 - 3) Contacts
 - d. Conduit, boxes and wiring for power wiring.
 - e. Conduit, boxes and wiring for control wiring, except temperature control wiring.
4. Electrical Contractor will make connections, from power source to starter or variable frequency drive and from starter or variable frequency drive, where specified, to motor.
5. Where starters or other similar control devices are furnished by this Contractor, they shall be installed by this Contractor and wired by Electrical Contractor.
6. Should any change in size, hp rating, voltage, or means of control be made to any motor or other electrical equipment after Contracts are awarded, this Contractor shall immediately notify Electrical Contractor of change. Additional costs due to these changes shall be responsibility of this Contractor.

C. Cutting and Patching:

- 1. Refer to General Conditions of the Contract, and Division 01 - Cutting and Patching.
- 2. Perform cutting and patching required for complete installation of systems, unless otherwise noted. Patch and restore work cut or damaged to original condition. This includes openings remaining from removal or relocation of existing system components.
- 3. Provide materials required for patching unless otherwise noted.
- 4. Do not pierce beams or columns without permission of Architect and then only as directed. If openings are required through walls or floors where no sleeve has been provided, hole shall be core drilled to avoid unnecessary damage and structural weakening.

5. Where alterations disturb lawns, paving, walks, etc., replace, repair or refinish surfaces to condition existing prior to commencement of work. This may include areas beyond construction limits.

D. Housekeeping and Cleanup:

1. Refer to Division 01 - Closeout Procedures.
2. As work progresses and/or as directed by Architect, periodically remove waste materials from building and leave area of work broom clean. Upon completion of Work, remove tools, scaffolding, broken and waste materials, etc., from site.

1.7 WARRANTY

- A. Refer to Division 01 for general warranty requirements.
- B. Refer to technical sections for warranty requirement for each system.
 1. Where no warranty requirements are called out, warrant equipment, materials, and workmanship to be free from defect as called out in Division 01.
- C. Warrant that systems will operate without objectionable noise, vibration and uncontrolled expansion.
- D. Repair, replace or alter systems or parts of systems found defective at no extra cost to Owner.
- E. In any case, wherein fulfilling requirements of any warranty, if this Contractor disturbs any work warranted under another contract, this Contractor shall restore such disturbed work to condition satisfactory to Architect and warranty such restored work to same extent as it was warranted under such other contract.
- F. Warranty shall include labor, materials, and travel time.

PART 2 PRODUCTS

2.1 PRODUCT SUBSTITUTIONS

- A. Refer to Division 01 - Product Requirements.

PART 3 EXECUTION

3.1 GENERAL

- A. Verify elevations and dimensions prior to installation of materials.
- B. Size of pipe segments shall be equal to largest pipe segment to which it is connected where size for pipes are not indicated. Transition to smaller size shall occur on side of fitting where smaller size is indicated.

3.2 DELIVERY, STORAGE, HANDLING, AND PROTECTION

- A. Deliver products to the site under provisions of Division 01.

- B. Store and protect products under provisions of Division 01.
- C. Store in clean, dry space.
- D. Maintain factory wrapping or provide cover to protect units from dirt, water, construction debris, and traffic.
- E. Handle in accordance with manufacturer's written instructions.
- F. Handle carefully to avoid damage to components, enclosure, and finish. Lift only with lugs provided for the purpose.
- G. Provide supplemental heat if required to prevent equipment from moisture contamination.
- H. Protect openings in equipment until connected to system to prevent entry of foreign materials.

3.3 EXCAVATION AND BACKFILL

- A. Refer to Division 31 - Earthwork.
- B. Provide excavation and backfill for underground work unless otherwise indicated. Blasting is not allowed on this project without written permission of Architect and Owner.
- C. Backfill trenches beneath concrete floor and stair slabs within building and beneath concrete slabs, walks, stairs and drives at exterior of building with gravel fill and compact to same density as surrounding area.

3.4 FLOOR, WALL, ROOF AND CEILING OPENINGS

- A. Coordinate location of openings, chases, furred spaces, etc., with appropriate Contractors. Provide sleeves and inserts that are to be built into structure during progress of construction.
- B. Remove temporary sleeves, if used to form openings, prior to installation of permanent materials. Utilize minimum 24 ga galvanized sheet metal for permanent sleeves unless otherwise noted.
- C. Provide Schedule 40 carbon steel pipe with integral water stop for steel sleeves required in interior floor slabs.
- D. Submit to Structural Engineer for review and approval size and location of core-drilled holes prior to execution.
- E. Submit product data and installation details for penetrations of building structure. Include schedule indicating penetrating materials (metal pipe, plastic pipe, conduit, etc.), sizes of each, opening sizes and sealant products intended for use.
- F. Where penetrations of fire-rated assemblies are involved, seal penetrations with appropriate firestopping systems as specified in Division 07 Thermal and Moisture Protection.

- G. Submit complete penetration layout drawings showing openings in building structural members including floor slabs, bearing walls, shear walls, etc. Indicate and locate, by dimension, all required openings, including those sleeved, formed or core drilled. Drawings shall be approved prior to preparing openings in structural member.
- H. Provide minimum 1" clearance around penetration openings intended for pipe. Where fire resistant penetrations are required, size openings in accordance with written recommendations of firestopping systems manufacturer.
- I. Openings for underground pipes passing through foundations or under footings shall have minimum clearance of 1-1/2" to concrete. Do not disturb footing bearing soil.
- J. Openings for underground pipe passing through on grade concrete slabs shall have minimum 1/4" clearance to concrete. Seal openings with urethane caulk.
- K. Openings for insulated piping shall be sized based on outside diameter of insulation when it is specified or detailed to be continuous through opening.
- L. Seal non fire-rated floor penetrations with non-shrink grout equal to Embeco by Master Builders, or urethane caulk, as appropriate.
- M. Seal non fire-rated wall openings with urethane caulk.
- N. In lieu of openings as specified herein penetration systems as manufactured by Pro Set may be used, including sleeve couplings and plug.
- O. If total ProSet system with Water Guard "CR" is used, opening shall not need additional water proofing or riser clamps.
- P. Finish and trim penetrations as shown on details and as specified.
- Q. Provide chrome or nickel plated escutcheons where piping passes through walls, floors or ceilings and is exposed in finished areas. Size escutcheons to fit pipe and pipe covering for finished appearance. Finished areas shall not include mechanical/electrical rooms, janitors' closets, storage rooms, etc., unless suspended ceilings are specified.

3.5 EQUIPMENT SHUTOFF VALVES

- A. Provide shutoff valves at equipment connected to piping system. Refer to valve section or system section for requirements of valve type.

3.6 EQUIPMENT ACCESS

- A. Install piping, conduit and accessories to permit access to equipment for maintenance. Relocate piping, equipment or accessories to provide access at no additional cost to Owner.
- B. Install equipment with sufficient maintenance space for removal, repair or changes to equipment. Provide ready accessibility to equipment without moving other future or installed equipment (including light fixtures) or system components.

- C. Access doors in walls, chases, or inaccessible ceilings will be provided under Division 08 - Access Doors and Frames, unless otherwise indicated. Access doors for valves, shock stops or other equipment shall provide access for servicing, repairs, and/or maintenance.
- D. Provide necessary coordination and information to the Trade Contractor under Division 08 - Access Doors and Frames. This information shall include required locations, sizes, and rough-in dimensions.
- E. Provide access doors in walls, chases or above inaccessible ceilings for valves, shock stops, unions or equipment/devices requiring access for servicing, repairs or maintenance, unless otherwise noted. Access frames and doors shall be as manufactured by Milcor, Incorporated, or similar, of style applicable to surface. Provide access doors used in fire rated construction with UL (FRD) Label. Provide steel, prime coated access doors unless otherwise specified. Provide stainless steel doors in ceramic tile walls, toilet rooms, locker rooms and in areas subject to excessive moisture. Provide access doors of sufficient size to allow complete maintenance. Coordinate location of access doors with General Contractor and rough-in equipment accordingly.

3.7 EQUIPMENT SUPPORTS

- A. Provide supporting steel not indicated on drawings as required for installation of equipment and materials including angles, channels, beams, hangers, etc.

3.8 EQUIPMENT GUARDS

- A. Provide equipment guards over belt driven assemblies, pump shafts, exposed fans, and elsewhere as indicated in this Specification or required by Code.
- B. Paint equipment guards bright yellow.
- C. Equipment guards shall comply with OSHA requirements.

3.9 SUPPORT PROTECTION

- A. In occupied areas, mechanical rooms and areas requiring normal maintenance access, guard certain equipment to protect personnel from injury.
- B. Provide minimum 1/2" thick Armstrong Armaflex insulation or similar product applied with Armstrong 520 adhesive on lower edges of equipment and mechanical supporting devices suspended less than 7 ft above floors, platforms or catwalks in these areas.
- C. Protect threaded rod or bolts at supporting elements as described above. Trim threaded rod or bolts such that they do not extend beyond supporting element and devices.

3.10 PLUMBING SYSTEMS IDENTIFICATION

- A. Refer to Section 220553 - Plumbing Systems Identification

3.11 TEST AND BALANCING

- A. Tests for equipment, ductwork and piping systems shall be performed as specified in their respective specification sections in accordance with technical requirements noted.
- B. Provide equipment required for testing, including fittings for additional openings required for test apparatus.
- C. All ductwork and piping inspections and testing shall be successfully completed and approved before application of covering materials.
- D. When equipment or systems fail to meet minimum test requirements, replace or repair defective work or material as necessary and repeat inspection and test until equipment or systems meet test requirements. Make repairs with new materials. Caulking of holes or threaded joints is not allowed.
- E. Contractor is responsible for certifying in writing equipment and system test results. Certification shall include identification of portion of system tested, date, time, test criteria, test medium and pressure used, duration of test and name and title of person signing test certification document.
- F. Maintain copies of certified test results, including those for any failed tests, at project site. At completion of project, include copies of test records and certifications in O&M Manuals.
- G. Balancing of various systems shall be in accordance with associated specification sections in addition to requirements noted herein.

3.12 START-UP

- A. Systems and equipment shall be started, tested, adjusted and turned over to Owner ready for operation. This includes "Owner-Furnished, Contractor-Installed" (OFCI) and "Contractor-Furnished, Contractor-Installed" (CFCI) systems and equipment.
- B. Follow manufacturer's pre-start-up check-out, start-up, trouble shooting and adjustment procedures.
- C. Contractor shall provide services of technician/mechanic knowledgeable in start-up and check-out of types of systems and equipment on project.
- D. Provide start-up services by manufacturer's representative where specified or where Contractor does not have qualified personnel.
- E. Coordinate start-up with all trades.

3.13 LUBRICATION

- A. Upon completion of work and before turning over to Owner, clean and lubricate bearings except sealed and permanently lubricated bearings. Use only lubricant recommended by manufacturer.

- B. Contractor is responsible for maintaining lubrication of mechanical equipment under this Contract until Work is accepted by Owner.

3.14 CLEANING

- A. Clean systems after installation is complete.
- B. Clean piping both internally and externally to remove dirt, plaster dust or other foreign materials. When external surfaces of piping are rusted, clean and restore surface to original condition.
- C. Clean pipeline strainers to restore them to original condition or replace with new strainer elements.
- D. Clean equipment and plumbing fixtures as recommended by manufacturers.
- E. Thoroughly clean equipment of stains, paint spots, dirt and dust. Remove temporary labels not used for instruction or operation.
- F. Provide additional cleaning of individual piping systems and apparatus as hereinafter specified.

END OF SECTION 220000

SECTION 220513 - MOTORS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 SUBMITTALS

A. Product Data including the following:

1. Manufacturer
2. hp, voltage, phase, hertz, rpm
3. Motor type
4. Enclosure type
5. Frame type
6. Insulation class
7. NEMA design designation
8. Service factor
9. Nominal efficiency at full load
10. Power factor at full load
11. Full load amperes
12. Bearings
13. Mountings
14. Dimensions
15. Weight
16. Shaft grounding brush for motors driven by Variable Frequency Drives (VFD)

1.2 PRODUCT CRITERIA

- A. Motors covered by this Specification shall conform to applicable requirements of NEMA, IEEE, ANSI, and NEC Standards and shall be UL Listed where applicable for service specified.
- B. Motors shall be designed for conditions in which they will be required to perform; i.e., general purpose, splash proof, explosion proof, standard duty, high torque or other special type as required by equipment manufacturers.
- C. Select motors so they do not exceed nameplate rating nor operate into service factor to meet specified duty.
- D. Motors located in outdoor or wash down environments shall have totally enclosed fan cooled (TEFC) enclosures.
- E. Motors shall be furnished for starting in accordance with utility requirements and be compatible with starters specified hereinafter or under Electrical sections of Specifications.
1. Refer to Section 262913 - Enclosed Controllers for reduced voltage starting requirements.
 2. Starters for NEMA rated 200 or 230 V motors, 25 hp and above shall be reduced voltage starting type.

3. Starters for NEMA rated 460 V motors, 60 hp and above to be reduced voltage starting type.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Materials shall be new and guaranteed for service intended.

2.2 ELECTRICALLY COMMUTATED MOTORS (ECM)

- A. Motor assembly shall be designed for use on direct drive fans or pumps and shall be electrically commutated, DC, brushless type, specifically designed for use with 120 Volt or 208-230/277 Volt, 60 Hz single-phase electrical input or three-phase, 60 Hz electrical input as scheduled.
- B. Motor speed shall be variable via compatible input signal and shall be complete with and operated by single-phase integrated controller/inverter that operates wound stator and senses rotor position to electronically commutate stator. Motor shall maintain minimum of 70% efficiency over entire operating range.
- C. Motors shall:
 1. have permanently lubricated ball bearings
 2. be designed for synchronous rotation.
 3. be permanent magnet type with near-zero rotor losses.
 4. be able to be mounted with shaft in horizontal or vertical orientation.
 5. be controllable from local and remote speed-control adjustments
 6. be designed to overcome reverse rotation without affecting life expectancy
- D. Provide Power Factor Correction / Harmonic Correction module to limit harmonic distortion to less than 10% THDi at input of the filter.
- E. Speed Control (Drive):
 1. Motor manufacturer shall provide factory installed PWM speed control drive for local (manual) and remote speed adjustment. Local PWM drive shall be field adjustable with standard screwdriver. Drive shall also be capable of receiving 0-10 vdc signal from DDC controller to control fan or pump speed.
 2. Drive shall provide soft start and adjustable speed change ramp rate.
 3. Drive shall provide motor protection consisting of locked rotor, over-current, and thermal overload protection at minimum.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install materials in accordance with drawings, approved Shop Drawings and manufacturer's recommendations.

END OF SECTION 220513

SECTION 220520 - PLUMBING EXCAVATION AND BACKFILL

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This Section lists methods and materials for trench excavation and backfill for plumbing piping systems inside and outside the building.
- B. Refer to geotechnical report, available from Construction Manager for data on soil conditions.

1.2 SUBMITTALS

- A. List of materials to be used for backfill.

PART 2 - PRODUCTS

2.1 FILL MATERIAL

- A. Type 1 Fill:
 - 1. Material from excavation separated from materials, which do not compact by tamping and rolling. No stones larger than 3" and no building, organic, corrosive or frozen materials.
- B. Type 2A Fill:
 - 1. Sand or gravel materials with none larger than 2" and of that portion passing #4 sieve less 5% to pass #200 sieve.
- C. Type 2B Fill:
 - 1. Sand or gravel materials with none larger than 1/2" and of that portion passing #4 sieve less 5% to pass #200 sieve.
- D. Type 3 Fill:
 - 1. Gravel of rounded to subangular shape, screened, which will pass 0.75" sieve and retained on #4 sieve.
- E. Type 4 Fill:
 - 1. Pit run rock or gravel with maximum stone size of 1".
- F. Type 5 Fill:
 - 1. Pea gravel, screened, which will pass 0.375" sieve and retained on #4 sieve.
- G. Type 6 Fill:
 - 1. Soils Engineer approved fill material, backfilled and compacted beneath building footprint.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Establish grade lines and locations of mains and manholes. Provide necessary stakes and batter boards.
- B. Verify invert elevations of existing utilities prior to excavation for new utility piping.

3.2 EXCAVATION

- A. Provide excavation for all underground work, including piping, manholes, catch basins, tanks, concrete structures, etc., unless otherwise shown or specified. Lay piping in open trench except when Architect gives written permission for tunneling.
- B. Include all necessary clearing; tree removal; grubbing; pavement removal; substructure removal such as walls, footings and piers and all incidental work such as tunneling, sheet piling, shoring, underpinning, pumping, bailing and transportation. Coordinate excavation extending beyond construction limits with Contractor and Owner.
- C. Blasting is not allowed on this project without written permission of Architect and Owner.
- D. Remove all excess excavation material from site unless directed otherwise.
- E. Use mechanical methods to remove rock in trenches for piping systems.
- F. Include rock excavation in the Bid unless otherwise indicated.

3.3 PIPE INSTALLATION

- A. Keep underground piping to proper line and grade and sealed at all times to prevent entrance of animals or foreign matter.
- B. Provide bracing and sheet piling as necessary to support trenches. Comply with Local Regulations, applicable provisions of OSHA Regulations on trenching, or with provisions of "Manual of Accident Prevention in Construction" published by Associated General Contractors of America.
- C. Under no circumstances lay pipe or install appurtenances in water. Keep trench free from water until pipe joint material has hardened.
- D. Presence of ground water in soil or necessity of sheet piling or bracing trenches shall not constitute condition for which any increase may be made in Contract price, except when sheet piling is left in place on written order of Owner, Contract price will be adjusted.
- E. Cut off sheet piling left in place not less than 2" below new finished grade. Do not remove sheet piling until trench is substantially backfilled.
- F. Install underground plastic pipe per ASTM D2321.

- G. Place underground piping outside and inside building in open excavated trenches. Where trench bottom does not contain stones larger than 1" in size or where bedrock is not encountered, trench may be excavated to final pipe grade. Where bedrock or stones larger than 1" is encountered, excavate entire length of trench to depth 4" below final pipe grade elevation and provide 4" of pipe bedding material compacted to minimum of 90% Standard Proctor Density consisting of Type 2B, 3 or 5 fill to establish final pipe grade. Shape bedding for clearance for all joints and fittings, tamped in place and graded evenly to ensure uniform bearing for full length of pipe. Do not support piping by blocking, planking or mounding of bedding material.

3.4 BACKFILL

A. Interior:

1. Backfill inside building only after piping and appurtenances have been inspected and approved. Backfill to 12" above pipe with Type 2B, 3 or 5 fill in 6" layers. Remainder of backfill shall be Type 2A, 2B, 3, 4, or 6 fill in 12" layers.
2. Install lines passing under foundations with minimum of 1-1/2" clearance to concrete and ensure there is no disturbance of bearing soil.
3. Backfill piping suspended from slab on grade with Type 2B or 5 fill in 6" layers. Same fill materials shall be provided for 12" minimum on each side of pipe.

3.5 ROCK EXCAVATION

- A. Consider material over 1 yd³ in size encountered during excavation as rock. Rock excavation will be paid as extra if it cannot be removed by 200 net hp (150 net kW) crawler tractor with ripper attachment all in good running condition and operated by an experienced individual.
- B. Excavate rock to 4" below intended pipe invert.

3.6 FINISHING

- A. On completion of trenching and backfilling operations, restore grades to original elevation or to new subgrade elevation.
- B. When trenching is through existing areas or beyond constructions limits, replace surfaces to existing conditions.
- C. In landscaped areas use 6" of topsoil and sod to match existing elevations, or as otherwise approved by Landscape Architect.

END OF SECTION 220520

SECTION 220529 - PLUMBING PIPING AND EQUIPMENT SUPPORTING DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Provide all supporting devices not provided as part of building structure or indicated on structural drawings or structural details, as specified and as required for proper supporting, anchoring, and guiding of piping, equipment, materials and systems.
- B. Support for all conditions of operation, including variations in installed and operating weight of equipment, piping and ductwork, to prevent excess stress and allow for proper expansion and contraction.
- C. Support of fire protection pipe shall comply with NFPA 13 Standard for the Installation of Sprinkler Systems, 2024 Edition.

1.2 SUBMITTALS

- A. Product Data for each piping system for all pipe sizes and all applicable equipment including the following:
 - 1. Manufacturer's name
 - 2. Model numbers
 - 3. Materials of construction and load ratings lbs.
 - 4. Schedule of hangers and support devices with pipe support spacing
 - 5. Insulated pipe supports along with application chart or table including pipe support spacing.
 - 6. Insulation protection saddles and weight bearing insulation table
 - 7. Details and calculations for sizing supplementary steel utilized for trapeze or specially designed supports
 - 8. Structural attachments, inserts, and concrete anchors. Submit ICC-ES Evaluation Report for each type of anchor.
 - 9. Calculations and drawings for concrete inserts and anchors for each application
 - 10. Drawings showing specific locations of any weld attachments to structure, including weight supported by such attachments
 - 11. Drawings showing specific locations of any suspended loads which exceed 100 lbs within joist chord panel to be attached to open web steel joist structural members. Include weight supported by such attachments. (Panel is length of chord between two adjacent diagonal web members at point of connection to chord.)
 - 12. Equipment mounting devices
 - 13. Pipe guides and anchors
 - 14. All other appropriate data
- B. Submittals in PDF format shall be organized using PDF bookmarks per detailed instructions on assembling submittal packages identified under Submittal Requirements section of 220000 - General Plumbing Requirements.

1.3 DESIGN CRITERIA

- A. Materials and application of pipe hangers and supports shall conform to the latest requirements of ANSI B31/ASME B31.1 Code for Pressure Piping and MSS Standard Practice SP-58-2018 (Pipe Hangers and Supports Materials, Design, Manufacture, Selection, Application, and Installation), except as supplemented or modified herein.
- B. Support materials shall be steel or stainless steel unless specifically indicated.
- C. Support devices shall be factory fabricated and have published load ratings.
- D. Unless otherwise indicated, design supports, anchors, and related components with safety factor in accordance with AISC Manual of Steel Construction, but not less than 2.0.
- E. Determine maximum deflection using the following equation.
- F. Maximum deflection of support members, including trapeze supports, shall be in accordance with the following equation, but shall not exceed 0.3":

$$D = L/240$$

Where D = Max deflection in "

L = Support member length in "
- G. Unless otherwise indicated, hangers, support devices and hardware shall be steel and shall have factory standard black, primed, galvanized or electroplated finish for indoor application, and hot-dipped galvanized finish for outdoor application and corrosive atmospheres. Coat cut edges, welds or any damaged finish with galvanized paint.
- H. Materials in contact with pipe shall be galvanically compatible with piping material to eliminate conductive path for galvanic corrosion. Where piping and support materials have galvanic potential, Provide galvanic separation, such as nonmetallic coating or inserts between piping and metallic supports. Pipe insulation is acceptable galvanic separation. Materials in contact with pipe shall be galvanically compatible with piping material to eliminate conductive path for galvanic corrosion. Where piping and support materials have galvanic potential, provide galvanic separation, such as nonmetallic coating or inserts between piping and metallic supports. Pipe insulation is acceptable galvanic separation. Galvanic potential shall be determined by table below:

	Galvanized Steel	Carbon Steel	Stainless Steel (Type 304 or 316)	Copper Brass Bronze
Copper, Brass, Bronze	Yes	Yes	No	NA
Stainless Steel (Type 304 or 316)	Yes Note (1)	Yes Note (1)	NA	
Carbon Steel	No	NA		

Galvanized Steel	NA			
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(1) Required where stainless steel surface area near interface is equal or greater than steel surface area

- I. Unless otherwise indicated, steel support devices exposed to ventilation air stream shall be stainless steel or steel with either galvanized finish or paint finish. Paint type shall be approved by Architect/Engineer.
- J. This Contractor is responsible for proper placement and sizing of supporting devices to accommodate insulation thickness and pitching of pipe. Coordinate with Contractor performing work specified in Section 220700 - Plumbing Systems Insulation.
- K. In addition to hangers specified in this Section, piping connected to pumps, compressors, and similar rotating or reciprocating equipment shall have vibration isolation hangers or supports for specified distance from such equipment. Refer to Section 230550 - Vibration Isolation for required distance.
- L. Where piping can be conveniently grouped to allow trapeze type supports, supporting steel shall be by means of standard structural shapes.
- M. Hangers and rods shall be plumb when pipelines are at their normal operating temperatures.
- N. Unless otherwise indicated, continuous insert channels are not allowed.
- O. Punching, drilling, or welding of building structural steel is not allowed unless approved by Structural Engineer.
- P. Refer to Structural Documents and ICC-ES Evaluation Report for application of concrete inserts and concrete anchors.
- Q. Lateral braces shall be designed and detailed to apply loads as directly as possible to structural floor slabs, roof decks, or other building lateral elements. Braces shall not be applied to bottom flanges of steel beams or bottom chords of open web steel joists.
- R. Coordinate with Contractor for any proposed weld attachments to building structure. This may result in use of welding codes or standards, which may apply to "structural work". and may necessitate repair of fireproofing and/or extension of fireproofing to support members. Execution of this work may be assigned to General Trades responsible for building structural steel. Cost for this work, however, will remain the responsibility of this Contractor.
- S. Top or bottom chords of open web steel joists may be used to support loads, provided total load within panel does not exceed 100 lbs and load is placed concentric to joist. (Panel is length of chord between two adjacent diagonal web members at point of connection to chord).
- T. Where fire rated fiberglass products are used for channel and support devices, the following properties shall apply:
 1. Flame Spread Properties
 - a. Polyester Fiberglass (PF) Class 1 ASTM E84
 - b. Vinylester Fiberglass (VF) Class 1 ASTM E84

- U. Fasteners including concrete anchors for seismic application shall have ICC Evaluation Service Report (ESR) and meet requirements of local authorities.

PART 2 - PRODUCTS

2.1 STRUCTURAL SUPPORTS

- A. Unless specifically indicated on structural drawings, design and provide all supporting devices including miscellaneous steel (angles, channels, beams, etc.), required for proper support of piping, equipment and materials.

2.2 PIPE HANGERS AND SUPPORTS (METALLIC)

- A. Manufacturers: Anvil, Erico, Tolco, PHD, National Pipe Hanger Corporation, or B-Line, equal to Anvil figures listed. Corresponding MSS Type is indicated where applicable.

- B. Clevis and Roller Type Hangers:

<u>System</u>	<u>Pipe Size</u>	<u>Clevis</u>	<u>Roller</u>
Hot Pipes with Insulation (105°F and above)	and 2" and smaller	65 (MSS Type-1), 260 (MSS Type-1)	---
Ambient Bare Pipes (61°F to 104°F)	2" and smaller	65 (MSS Type-1), 260 (MSS Type-1)	---
	2-1/2" and larger	260 (MSS Type-1), 216 (MSS Type-4)	---
Cold Pipes with Insulation (33°F to 60°F)	2" and smaller	65 (MSS Type-1), 260 (MSS Type-1)	---
	2-1/2" and larger	260 (MSS Type-1), 295 (MSS Type-1)	---

- C. Flat Surfaces (Trapeze, Rack Type):

- Use structural steel members such as struts, angles, channels and beams to support pipes as required. Select members properly for pipe support types and loading conditions. Refer to Part 1 for design criteria. Submit support details with type of members selected and load calculations. Provide straps, clamps, rollers or slides indicated below at each support point.

<u>System</u>	<u>Pipe Size</u>	<u>Straps or Clamps</u>	<u>Rollers</u>	<u>Slides</u>
Hot Pipes with Insulation (105°F and above)	2" and smaller	Anvil Klo-Shure	---	

Ambient Bare Steel Pipes (61°F to 104°F)	6" and smaller 8" and larger	B-Line BVT Unistrut Cush-a-Clamp	---	---
Ambient Bare (Copper) pipes (61°F to 104°F)	all sizes	B-Line BVT Unistrut Cush-a – Clump		
Cold Pipes with Insulation (33°F to 60°F)	10" and smaller	137 (MSS Type-24)	---	---
Cold Pipes with Insulation (32°F to 59°F and below)	2" and smaller	243, 244	---	---
	2-1/2" and larger	---	171 or 177 (MSS Type-41), 271 (MSS Type-45), 274 (MSS Type-46)	257 or 436 with 212 or 432 clamps, Type 1, 2 or 3 for longitudinal movement only and Type 4, 5 or 6 for both longitudinal and transverse movement.

D. Vertical Pipe within Wall Cavities

1. Use clamps, straps, inserts or channels to support pipes concealed in wall cavity. Select members for pipe support types and loading conditions. Refer to Part 1 for design criteria.
2. Provide clamps, strut channels, insulated supports, or brackets and inserts equal to manufacturer indicated below:

<u>System</u>	<u>Pipe Size</u>	<u>Supports</u>	<u>Clamps, Brackets/Inserts</u>	<u>Pre-insulated Inserts</u>
Hot and Cold Pipes with Insulation	All sizes	Anvil 137	HoldRite 260 series with SBIS bracket, Anvil 262	Anvil Klosure, Pipe Shields A2000
Ambient Bare Pipes (61°F to 104°F)	All sizes	Anvil 137, 138-R	Anvil 262	---

Ambient Bare Copper Pipes (61°F to 104°F)	All sizes	Anvil CT- 138R	HoldRite 260 series with SBIS bracket	---
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2.3 INSULATION PROTECTION SHIELDS

- A. Anvil Fig. 167 (MSS Type-40) constructed of galvanized carbon steel. Per the latest edition of Standard MSS SP-58, select shield to accommodate outer diameter of insulation. Shield length and gauge for insulation compression strength not less than 15 psi, shall be as follows:

<u>Pipe Size</u>	<u>Length</u>	<u>Gauge</u>
1/4" thru 3"	12"	18
4"	12"	16
5" and 6"	18"	16
8" thru 14"	24"	14

2.4 INSULATED PIPE SUPPORTS

A. Description:

- Products designed specifically for weight-bearing support of insulated pipes. Apply products in accordance with manufacturer's recommendations and requirements indicated below:
- Refer to PART 3 – EXECUTION for application of Type A, Type B, and Type C Insulated Pipe Supports specified below.

B. General:

- Supports shall be designed and rated for applied load, including weight of pipe, fluid, insulation, and any other imposed loads, with minimum 1.5 safety factor. Ratings shall be published by manufacturer and included in submittals.
- Load ratings shall be established by pipe support manufacturer based upon testing and analysis conforming to the latest editions of ASME B31.1 and MSS SP-58.
- High compressive strength inserts utilized to support loads shall encircle circumference of pipe. Block-style inserts are not allowed.
- Supports shall be suitable for hot or cold pipe service as applicable.
- Submit chart or table indicating selected model along with pipe sizes, rated loads, support device types and support spacing for each piping system.
- Pipe support spacing shall be in accordance with manufacturer's recommendations but shall not exceed maximum spacing indicated under Hanger and Support Spacing in Part 3 of this Section.
- Testing of insulation for compressive strength properties shall comply with ASTM D1621.
- Insulation thickness shall match adjacent pipe insulation thickness.
- Integrity of vapor barrier jacket shall be maintained continuously through support assembly.
- Insulated pipe support style shall be specifically selected for the application and shall consider the following criteria at minimum:
 - Vertical, lateral and axial support design load limits.

- b. Vertical, lateral, and axial support design travel limits
 - c. Temperature of support, at pipe surface, and ambient conditions
 - d. Test or pre-operational loads that may exceed normal operating conditions
 - e. Material for any items that will be welded directly to the pipe
 - f. Loading and displacements caused by seismic, hydraulic surge, or other forces
 - g. Temperature at support steel
11. All steel components shall have corrosion protection coating consisting of hot-dip galvanizing or zinc-rich primer coating.

C. Type A Insulated Pipe Supports (Light Duty)

- 1. Description:
 - a. Pipe insulation specified in Section 220700 - Plumbing Systems Insulation with insulation protection shields specified in this Section. Weight-bearing inserts are not required.
 - b. Type B or Type C supports may be utilized in lieu of Type A supports.

D. Type B Insulated Pipe Supports (Standard Duty):

- 1. Manufacturers:
 - a. SNAPP ITZ insulation inserts by KB Enterprise, Tru-Balance Insulated Saddles by Buckaroos, Inc., Value Engineered Products, or approved equal.
 - b. Klo-Shure insulation couplings may be used for cold pipes insulated with elastomeric insulation. Mount shall be 7 Series Strup Mount with metal clamps or Clevis System for clevis hangers.
 - c. Type C supports may be utilized in lieu of Type B supports"
 - d. Contractor may propose to utilize contractor-fabricated insulated pipe supports in lieu of manufactured Type B Supports. Use of contractor-fabricated assemblies is subject to approval of appropriate submittal data. Submit detail drawings of assemblies and product data showing equivalency to specified manufactured products for approval.
- 2. Description:
 - a. Load-rated assembly consisting of high compressive strength insulation material completely encompassing circumference of pipe, vapor barrier jacket, and insulation protection shield.
 - b. Insulation protection shield shall conform to ANSI/MSS SP-58. Shield shall be G90 galvanized steel and shall span full circumference of pipe insulation. Half-shields spanning lower 180° degrees arc of insulation outer circumference will be acceptable when used with clevis hangers.
 - c. Axial length of insulation material shall be not less than 9" or 2" longer than insulation protection shields (1" minimum on each end), whichever is longer.
- 3. Insulation Materials:
 - a. Hot Pipes 105°F to 250°F:
 - 1) Rigid closed cell, polyisocyanurate or phenolic insulation by ITW, Resolco, or Kingspan. Minimum compressive strength shall be 100 psi.
 - b. Cold Pipes 60°F and below:

- 1) Rigid closed cell, polyisocyanurate, phenolic insulation similar to ITW, Resolco, Kingspan, or cellular glass insulation similar to Pittsburgh Corning Foamglas.

E. Type C Insulated Pipe Supports (Heavy Duty):

1. Manufacturers:

- a. Pipe Shields, Inc., Bergen Pipe Supports, or Rilco equal to Pipe Shields models listed.
- b. Unless otherwise indicated, pre-insulated pipe supports shall be as indicated in the following schedule. Model numbers are based on Pipe Shields, Inc.
 - 1) Pipe supported on hangers: Model "A" Series and Model "D" Series
 - 2) Pipe supported on flat surfaces and pipe rollers: Models "A" Series
 - 3) Pipe supported on slides: Model "B" Series with lateral guide or restraint
 - 4) Pipe anchors: Model "C" Series
 - 5) Riser clamps: Model "E" Series with thrust plates. Select proper model for restraint for downward load or upward load.
- c. Contractor may propose to utilize contractor-fabricated insulated pipe supports in lieu of manufactured Type C Supports. Use of contractor-fabricated assemblies is subject to approval of appropriate submittal data. Submit detail drawings of assemblies and product data showing equivalency to specified manufactured products for approval.

2. Description:

- a. Load-rated assembly consisting of high compressive strength insulation material completely encircling circumference of pipe, vapor barrier jacket system incorporating structural inserts and insulation protection shield/casing where applicable.

3. Insulation Material:

- a. Water-resistant high density calcium silicate with minimum density of 208 kg/m³(13 lb/ft³) and compressive strength not less than 100 psi. Thermal conductivity shall be not more than 0.055 W/m°C at 24°C(0.38 Btu·in/(hr·ft²°F) at 75°F.

b. Structural Inserts:

- 1) Structural inserts used by manufacturer to reinforce between pipe and insulation jacket for clamping devices shall be water-resistant high compressive strength inorganic materials selected by manufacturer for desired combination of structural strength and insulating properties. Structural inserts shall have minimum compressive strength of 600 psi. Thermal conductivity shall be not more than 0.084 W/m°C at 24°C(0.58 Btu·in/(hr·ft²°F) at 75°F.

c. Jacket:

- 1) Jacket shall consist of G90 galvanized steel conforming to ASTM A653/A653M and shall provide complete vapor barrier around insulation and bearing surface for protection of insulation.
- 2) When recommended by manufacturer, use reinforced insulation protection shield at support bearing surface. Insulation shall extend 1" beyond insulation protection shield to maintain vapor barrier integrity.

2.5 HANGER RODS (METALLIC)

- A. Rods shall conform to the latest MSS Standards except as modified herein. Furnish rods complete with adjusting and lock nuts.

- B. Rods shall have electroplated zinc or hot dip galvanized finish.
- C. Unless otherwise indicated, size rods for individual hangers and trapeze support as indicated in the following schedule. Rod size may be reduced one size for double rod hangers. Total weight of equipment, including valves, fittings, pipe, pipe content and insulation, shall not exceed limits indicated.

<u>Max. Pipe Size With Single Rigid Rod</u>	<u>Rod Diameter (inches)</u>	<u>Max Load (lbs) of Hanger Rod (Not exceeding 650 °F Service Temp.)</u>
2"	3/8	730
3"	1/2	1350
5"	5/8	2160
8"	3/4	3230

- D. Threaded rods are not allowed in clean rooms.

2.6 BOLTS, NUTS, STUDS AND WASHERS

- A. ASTM A307, electroplated zinc finish

2.7 ROD ATTACHMENTS

- A. Anvil Fig. 290 (MSS Type-17), galvanized finish

2.8 U-BOLTS

- A. Anvil Fig. 137 (MSS Type-24), galvanized finish

2.9 BEAM CLAMPS

- A. Beam Clamps: Anvil Fig. 133/134 (MSS Type-21), 218 (MSS Type-30), 228 (MSS Type-28 or 29) and 292 (MSS Type-28 or 29)
- B. Top Beam Clamps: Anvil Fig. 227 (MSS Type-25)
- C. C-Clamps: Anvil Fig. 86, 92 or 93 (MSS Type-19 or 23) with set screw and lock nut

2.10 ADJUSTABLE PIPE SADDLE SUPPORTS

- A. Anvil Fig. 264 (MSS Type-38), galvanized finish. Provide Anvil Fig. 63 Type T stanchion with base, galvanized finish, where applicable.

2.11 RISER CLAMPS (BARE PIPE)

- A. Anvil Fig. 261 (MSS Type-8), galvanized finish
- B. B-Line B3373C, PVC coated carbon steel, in area at pipe contact, for bare copper tubing
- C. Proset system, proseal plug and fire-fill for sleeved and cored holes.

2.12 RISER CLAMPS (INSULATED PIPE)

- A. Unless otherwise indicated, insulated pipe riser clamps shall be Type C insulated pipe supports. Refer to Insulated Pipe Supports in Part 2.
- B. Contractor may propose to utilize contractor-fabricated riser supports. Use of contractor-fabricated riser supports is subject to approval of appropriate submittal data. Submit support detail drawings, bearing stamp of Structural Engineer registered in project jurisdiction, for approval. Supports shall be engineered to withstand static and dynamic forces with minimum safety factor of 2.0. Submit insulation details addressing thermal break from building structure and vapor barriers.

2.13 CONCRETE INSERTS (WOODEN FORMED CONCRETE)

- A. Anvil Fig. 281 or 282, or Hilti HCI-WF (MSS Type-18), suitable for rod diameter and weight supported.

2.14 CONCRETE INSERTS (METAL DECK FORMED CONCRETE)

- A. Anvil Fig. 284, Tolco No. 109DD, B-Line Fig. B3019, DeWalt/Powers "Bang-It+", Hilti HCI-MD, or MSCO No. MX34.

2.15 CONCRETE ANCHORS

- A. Manufacturers: Hilti, DeWalt/Powers or Red Head
- B. Anchors shall be selected, sized, and detailed by Contractor's structural engineer registered in project's jurisdiction, based on project conditions and in accordance with project building code. Calculations and drawings shall be submitted.
- C. Anchors shall meet ICC Acceptance Criteria, and ICC-ES Evaluation Reports (ESRs) shall specifically list the current applicable codes.
- D. Anchors installed in hardened concrete for purpose of transmitting structural loads from one connected element to another, or for safety related elements such as sprinkler pipes, heavy suspended pipes, and barrier rails shall have ICC-ES report demonstrating anchors have met requirements of AC 193 for mechanical anchors in concrete elements.
- E. Post-installed expansion anchors and undercut anchors installed in hardened concrete shall be qualified for strength design and tested according to ACI 355.2. Designs shall be per the requirements of ACI 318, Appendix D.
- F. Anchors for seismic load application shall be approved by ICC-ES Evaluation Reports to resist seismic loads and selected to meet project seismic design requirements. Refer to Section 220548 - Plumbing Seismic Anchorage and Restraints and Structural drawings.
- G. Anchors shall be zinc plated in accordance with ASTM B633.
- H. Select anchors with load ratings based on cracked concrete conditions.

2.16 CONTINUOUS INSERT CHANNELS

- A. Manufacturers: Unistrut, Anvil, B-Line, Michigan, Halfen, Hilti or Kindorf. Brackets inserts and accessories shall be suitable for channel insert selected.
- B. Length and support capabilities to be suitable for supporting plumbing piping in vicinity.

2.17 METAL FRAMING SUPPORT SYSTEM (STRUT SYSTEM)

- A. Manufacturers: Unistrut, B-Line Strut Systems, Anvil-Strut, Power-Strut, Erico, Superstrut, Kindorf, Hilti, and Hydra-Zorb
- B. Channels shall have epoxy paint or electroplated zinc finish.
- C. Channels shall not be lighter than 12 ga.

2.18 PIPE MOUNTING PEDESTALS

- A. Equal to Roof Products & System Corporation consisting of equipment rail, "U" shaped mounting brackets, galvanized threaded rod and cast iron pipe rollers. Rail shall have built-in raised cant to match roof deck insulation.

2.19 EQUIPMENT RAILS

- A. Manufacturers: Roof Products & Systems, ThyCurb, Custom Curb, Inc. or Vent Products equal to Roof Products & Systems Model ER-4 with raised cant style. Mounting rails shall be galvanized steel with integral base plate, continuous welded corner seams, factory installed 2" x 4" wood nailer and 18 ga galvanized steel counter flashing.
- B. Mounting rail gauge shall be selected to support equipment adequately but shall be not less than 18 ga.
- C. Height shall be as detailed, but not less than 8" above finished roof.
- D. Equipment rails shall span minimum of 2 joists and not cantilever more than 6") where joists are used. Rails shall be level at top with pitch built in when deck slopes 1/4" per foot or greater.

2.20 PIPE ROOF PENETRATION PROTECTIONS

- A. Manufacturers: Roof Products & Systems, ThyCurb or Vent Products equal to Roof Products & Systems "RPS-Pipe Portals" consisting of 12" OD prefabricated roof curb, laminated acrylic coated ABS plastic curb cover with EPDM protective rubber cap and stainless steel clamp.

2.21 PIPE GUIDES

- A. Unless otherwise indicated, guides shall be equal to Pipe Shields "B" Series, selected by load and movement. Refer to Insulated Pipe Supports in Part 2.

2.22 PIPE ANCHORS

- A. Unless otherwise indicated, anchors shall be Type C Insulated Pipe Supports. Refer to Insulated Pipe Supports in Part 2.
- B. Contractor may propose to utilize contractor-fabricated anchors. Use of contractor-fabricated anchors is subject to approval of appropriate submittal data. Submit anchor system detail drawings, bearing stamp of Structural Engineer registered in project jurisdiction, for approval. Anchors shall be engineered to withstand static and dynamic forces with minimum safety factor of 3.0. Submit insulation details addressing thermal break from building structure and vapor barriers.

2.23 FIXTURE SUPPLY SUPPORT

- A. Acceptable manufacturers: Erico, Holdrite, Siou
- B. Vertical Pipe Support:
 - 1. Galvanized steel stud support bracket, pre-drilled tube support mounting holes, adjustable stud width, Holdrite SB3 or equal.
 - 2. UV resistant nylon tube support, rated for (0-130°F through 0-130°F, resealable locking mechanism, Holdrite 255 or equal.
 - 3. Support bracket and tube support to be from same manufacturer.
- C. Through Stud Support:
 - 1. Polypropylene stud insert for isolation of water tubing through metal wall studs, rated for maximum water temperature of ([130°F] ([54°C]), Holdrite 426 or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install supports to allow for free expansion of piping. Support piping from building structural members using concrete inserts, beam clamps, ceiling plates, wall brackets, or floor stands. At no time shall hangers and supports overload building structural members. Fasten ceiling plates and wall brackets securely to structure and test to demonstrate adequacy of fastening.
- B. Select and size building attachments properly in accordance with MSS Standards and manufacturer's published load rating information.
- C. Coordinate hanger and support installation to properly group piping of all trades.
- D. Suspend piping hangers by means of hanger rods. Perforated band iron and flat wire (strap iron) are not allowed.
- E. Piping and ductwork shall be supported independently from other piping or ductwork.
- F. Pipe hangers and supports shall not penetrate vapor barrier of pipe insulation.
- G. Do not support equipment, or piping from metal roof decking or ceiling grid.

- H. Install adequate supports so as not to over stress either piping or equipment to which piping is connected.
- I. Refer to Section 220000 - General Plumbing Requirements for requirements of personnel injury protection guards for supporting devices.

3.2 HANGER AND SUPPORT SPACING

- A. Space pipe hangers and supports for horizontal pipe accordance with the following schedule, with exceptions as indicated herein:

- B. Copper Tube (Domestic Water, Non-potable Water):

<u>Pipe Size</u>	<u>Max Spacing</u>
1-1/4" and smaller	6 ft-0"
1-1/2" and larger	10 ft-0"

- C. Cast Iron Pipe:
 - 1. Maximum hanger and support spacing shall be 10 ft for all pipe sizes. Provide minimum of one hanger per pipe section close to joint on barrel, at each pipe fitting, at change of direction and branch connections.
 - 2. Support Cast Iron No-Hub pipe as recommended in CISPI Publication "Cast Iron Soil Pipe and Fittings Handbook, Chapter IV - Installation of Cast Iron Soil Pipe and Fittings."
- D. Maximum spacing shown above may be restricted by strength of attachment to building structure. Submit data with calculations with published load ratings showing attachment to be utilized and maximum spacing allowable for that type of attachment and pipe size.
- E. Spacing less than indicated above may be required to conform to building structure design or loading limitations.
- F. Spacing less than indicated may be required depending on compressive strength of pipe insulation and insulated pipe supports.
- G. If pipe size changes between support points, maximum spacing shall be based on the smaller pipe size.
- H. If trapeze hangers are used to support multiple services, spacing shall be based on the most restrictive pipe size and material on trapeze hanger.
- I. Install supports for vertical piping and anchors as recommended by pipe manufacturer.
- J. Place hangers and supports to meet requirements of Section 232116 - Pipe and Pipe Fittings or specific pipe system sections, with regard to pitch for drainage and venting and clearance between services.
- K. Hangers and supports shall bear on outside of insulation when pipes are to be insulated.
- L. Place hangers and supports within 1 ft of each fitting, such as elbows and tees, and at each valve, strainer, and other piping specialty for piping 4" and larger.

- M. Place hanger or support at first elbow upstream of pump inlet and first elbow downstream of pump outlet.

3.3 RISER SUPPORTS

A. Insulated Piping:

1. Unless otherwise indicated, support vertical piping as indicated below:
2. Support vertical piping at bottom of riser, secured and anchored to building structure. Provide guides on vertical piping. Use spring hangers at top and bottom of riser and at take offs from riser at each floor. Use spring hangers for minimum 3 hangers away from top and bottom elbows and from each take off at riser.
3. Guide vertical piping 2-1/2" and smaller at every floor. Guide 2-1/2" and larger at every other floor. Spring hangers (Type 6) and guides (Type VSG) are specified in Section 230550 - Vibration Isolation.

B. Bare Piping:

1. Unless otherwise indicated, maximum vertical support spacing for ambient bare steel and cast iron pipes shall be 15 ft.
2. Maximum vertical support spacing for other piping including copper tubing and plastic piping shall be 10 ft.
3. Install riser clamps and intermediate supports as required.
4. Rest riser clamps on floor or on pipe sleeve.
5. Bare piping above 120°F such as steam vents shall be supported per insulated piping requirements.

3.4 INSULATED PIPE SUPPORTS APPLICATION

- A. Install insulated pipe support at each support point of insulated pipe.

B. Pipe Size 1-1/2" and Smaller:

1. Use Type A insulated pipe support. Pipe insulation specified in Section 220700 - Plumbing Systems Insulation shall be continuous through support points.
2. Use one shield (bottom) for clevis hanger.
3. Use 2 shields (top and bottom) for roller hanger/support or strap/clamp support. Apply 2 metal straps to hold top and bottom shields onto insulation jacket.
4. Type B or Type C insulated pipe supports may be used in lieu of Type A support.

C. Pipe Size 2" through 2-1/2":

1. Use Type B insulated pipe supports. Refer to Part 2 for acceptable products.
2. Type C insulated pipe supports may be used in lieu of Type B supports.

3.5 PIPE FLOOR SUPPORTS

- A. Unless specifically shown otherwise, use adjustable pipe saddle supports with associated stanchion similar to Anvil Fig. 264/63. Select supports properly for weight and height of pipe stand.

3.6 CONCRETE INSERTS

- A. Concrete insert application, size, loading, and placement shall be this Contractor's responsibility.
- B. Coordinate with General Contractor for placement of inserts before concrete pour. Minimize use of inserts and anchors after concrete pour.

3.7 CONTINUOUS INSERT CHANNELS

- A. Mount continuous insert channels when used for pipe support on 8 ft-0" maximum centers and 8 ft-0" from corners.

3.8 BEAM CLAMPS

- A. Provide locknut for hanging rod at clamp.
- B. C-clamps are allowed for rod size 3/8" or smaller and only for static loading such as air piping, cold water piping, fire protection piping and, other similar piping. C-clamps are not allowed for hot water piping and steam and steam condensate piping, except hot water runouts to terminal heating devices.
- C. C-clamps are not allowed for open web steel joist application.
- D. C-clamps are not allowed for seismic application.

3.9 TRAPEZE SUPPORTS

- A. Construct trapeze supports with struts, angles, or channels and hang them by inserts or welded beam attachments and rods.
- B. Determine trapeze supports spacing by the smallest pipe on trapeze.
- C. If trapeze supports are used to support multiple services, support spacing shall be based on the most restrictive pipe size and material on trapeze supports.
- D. Refer to Part 1, Design Criteria for maximum deflection allowed for trapeze supports.

3.10 PIPE MOUNTING PEDESTALS

- A. Use for all piping on roof. Install bottom of pedestal flat on roof deck, insulate exterior of pedestal, flash and counter flash.

3.11 EQUIPMENT RAILS

- A. Use for all roof-mounted equipment, which is not curb mounted. Install bottom of equipment rail flat on roof deck. Insulate exterior of equipment rail.
- B. Flashing will be by General Contractor. Provide counter flashing as specified and secure to wood nailer with stainless steel truss head screws.

3.12 CONCRETE ANCHORS

- A. Anchor application, size, and placement shall be this Contractor's responsibility.

3.13 PIPE ROOF PENETRATION PROTECTIONS

- A. Install at points where pipes are penetrating roof. Install as shown and according to manufacturer's installation instructions.

3.14 PIPE GUIDES

- A. Install where shown on drawings.
- B. For manufactured expansion devices, install minimum of 2 pipe guides at each side of manufactured pipe expansion device. Locate first guide no more than 4 pipe diameters from expansion device and second guide at 14 pipe diameters from first guide. Install intermediate guides in accordance with guide spacing data recommended by manufacturer or the following table, whichever is more stringent.

MAXIMUM DISTANCE BETWEEN INTERMEDIATE GUIDES (FT)				
<u>Pipe Operating Pressure</u>				
Pipe Size (inches)	0-50 psig	51-100 psig	101-150 psig	151-200 psig
3	21	19	17	16
4	35	29	25	22
6	57	44	37	32
8	66	52	45	40

- C. If anchor is located within 4 pipe diameters from expansion joints, guides need not be installed on anchor side.

3.15 PIPE ANCHORS

- A. Install anchors where shown on drawings or in conjunction with expansion joints, loops and swing joints as required to allow proper expansion and contraction of piping without damage to structure, equipment or piping.
- B. Do not anchor piping to concrete block walls, wood, or partition walls.

END OF SECTION 220529

SECTION 220533 - ELECTRICAL HEAT TRACING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This Section specifies materials and installation methods necessary for electrical heat tracing system for domestic, laboratory, process, or other hot water distribution networks for freeze protection.

1.2 SUBMITTALS

- A. Manufacturer's technical data and installation instructions for the following:
 - 1. Heat trace cable, voltage, phase, and temperature.
 - 2. Heat output chart for each pipe size.
 - 3. Circuit riser diagram.
 - 4. Circuit schedule with circuit length, breaker panel number, breaker number, and amperage.
 - 5. Contractor certification from heat trace manufacturer.
 - 6. Written warranty statement.
- B. Shop drawings on items specified herein.

1.3 SHIPPING

- A. Package accessory kits in individual plastic bags to prevent loss of components. Subject heat cable to high-frequency spark test and braids to dry dielectric test as instructed by manufacturer.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Items shall be new, UL Listed or FM approved for their intended use.
- B. Heat trace cable shall meet requirements of IEEE Standard 515.1 – Standard for the Testing, Design, Installation and Maintenance of Electrical Resistance Heat Tracing for Commercial Applications.

2.2 FREEZE PROTECTION HEAT TRACE

- A. Manufacturers: Chromalox, Dekoron, nVent, or Thermon.
- B. Heaters:
 - 1. Self-regulating type, 2 nickel-plated copper bus wires, self-regulating polymer core maintaining temperature of pipe above freezing. Cover heater with modified polyolefin dielectric jacket, tinned-copper braid jacket and outer modified polyolefin jacket. Heater shall be compatible with 208, 220, 240 or 277 V, single phase electrical power without transformers. XL-Trace by Pentair Thermal Management.

2. Provide controller with ground fault protection.
- C. Accessories:
 1. Include power connection kits, tee kits, end seal kits, splice kits, and transformers by same manufacturer as heater. Include fiberglass tape or cable ties to fasten heater to pipe.
- D. Control:
 1. Automatic control by means of bulb-sensing thermostat with the following features:
 - a. Stainless steel bulb on 10 ft capillary
 - b. Set at 35°F with adjustable range of 25°.
 - c. Electrical rating of 22 amp with voltage from 125 to 480V AC
 - d. NEMA - 4X metal enclosure
 2. Automatic control by means of an ambient sensing thermostat with the following features:
 - a. Stainless steel air temperature sensor
 - b. Set point of 35°F with adjustable range of 25° to 325°F
 - c. Electrical rating of 22 amp with voltage from 125 to 480V AC
 - d. NEMA - 4X metal enclosure
 - e. nVent ECW-GF or equal

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Domestic Cold Water system shall be maintained at 35-45°F.
- B. Attach heater to clean, dry pipe with glass tape or nylon cable ties as stated in manufacturer's installation instructions.
- C. Manufacturer's representative shall instruct Contractor in proper installation techniques and certify in writing that instruction has been given and proficiency demonstrated by Contractor in installation fabrication. Only those individuals so certified shall be permitted to work on system. Certification document signed by manufacturer's representative and certified individuals shall be submitted with product shop drawings. No shop drawings will be processed without this documentation.
- D. Manufacturer shall supply isometric drawings as part of material package including heater layout, location of power points, and load chart. Plumbing Contractor shall obtain these isometrics and submit to engineer for review and approval prior to installation of heating cable. One set of "as built" drawings shall be turned over to Engineer upon completion of installation and testing.
- E. Attach heat cable linearly or spirally to pipe as required to effectively distribute heat along pipe and develop proper temperature. Consult manufacturer's data for sizing and spacing of heat cable strip.
- F. Provide extra length of heat trace cable at power connections, tees and end seals to permit servicing.

G. Install heat cable and appropriate accessories and controls in conformance with applicable sections of Division 26 Electrical.

H. Protect heat trace cable circuits with Ground Fault Interrupt (GFI).

3.2 INSPECTION

A. Inspect heat cable installation with manufacturer's representative prior to insulating piping. Manufacturer's representative shall certify that heat cable is properly installed and successfully tested. Documentation shall be included in operation and maintenance manuals and/or Commissioning Documentation. Building occupancy will not be allowed without this Documentation.

3.3 TESTING

A. Measure insulation resistance of heat cable with 1000 V DC megohmmeter (megger) after plumber has attached heat cable to pipe and before thermal insulation has been installed. Insulation resistance, measured between braid and either bus wire, should be at least 20 megohms regardless of heat cable length. Record these readings for each circuit.

B. Test continuity of both heater bus wires to verify connection of splices or tees.

C. Megger heater after thermal insulation has been installed and record readings. Insulation resistance should be at least 20 megohms when measured at 1000 V DC per IEEE 515.1.

D. If heat cable circuit fails either insulation resistance test or continuity test, Plumbing Contractor must repair or replace circuits yielding unacceptable readings. Megger tests must be witnessed by Owner's Representative and manufacturer's representative. Copy of test report shall be submitted to Engineer. Manufacturer's representative shall retain one copy for their file and mail copy to factory for record.

END OF SECTION 220533

SECTION 220553 - PLUMBING SYSTEMS IDENTIFICATION

PART 1 - GENERAL

1.1 SUBMITTALS

- A. Product Data: For identification materials and devices
- B. Valve Schedules: For each piping system
- C. Samples: Of color, lettering style, and graphic representation required for each identification material and device.

PART 2 - PRODUCTS

2.1 IDENTIFYING DEVICES

- A. Marker System:
 - 1. Manufacturers: Brady USA, Marking Services Inc. (MSI), Kolbi, or Seton
 - 2. Manufacturer's standard, preprinted with color coding, lettering size, and length of color field according to ASME A13.1.
 - 3. Use pressure-sensitive type or "snap-on" type.
 - 4. "Strap-on" type may be used for piping over 6" size, including insulation.
- B. Valve Tags:
 - 1. Minimum 1-1/2" diameter, 0.032" thick, polished brass or 316 stainless steel.
- C. Laminated Plastic Nameplates:
 - 1. Nameplates shall be approximately 1-1/2" x 4", 1/16" thick, and have 1/2" high lettering. Face of plastic nameplates shall be black with white letters.
 - 2. Fasteners shall be self-tapping, stainless steel screws or contact type with permanent adhesive.
- D. Underground Warning Tape:
 - 1. Manufacturers: Brady USA, Marking Services Inc. (MSI), Kolbi, or Seton
 - 2. Underground warning tape, 5.0 mil overall thickness, 2" width minimum, aluminum foil core where required to be detectable, bonded polyethylene jacket. Brady "Identoline" or equal.
 - 3. Following services shall be provided with warning tape with colors and trace wire as indicated:
 - a. Water Lines: Blue with black letters, (non) detectable
 - b. Sanitary Sewer: Green with black letters, (non) detectable
 - c. Storm Sewer: Green with black letters, (non) detectable

PART 3 - EXECUTION

3.1 GENERAL

- A. After painting and/or covering is completed, identify equipment and piping as indicated. Locate identification as conspicuously as possible except where such would distract from finished area.
- B. Where markers are used in high heat applications or exposed to harsh chemical or acid environments, specifically select marker materials for those applications.
- C. Coordinate, obtain and confirm mechanical systems identification criteria and requirements from Owner.

3.2 PIPING SYSTEM IDENTIFICATION

- A. Install pipe identification on each system.
- B. Place flow directional arrows at each pipe identification location.
- C. Identify all piping not less than once every 25 ft, not less than once in each room, at each branch, adjacent to each access door or panel, at each valve and where exposed piping passes through walls and floors.
- D. Identify piping with marker system.
 - 1. For “strap-on” type, ensure marker is fitted snugly to pipe or pipe insulation surface with sufficient straps.

3.3 VALVE IDENTIFICATION

- A. Identify valves with brass tags bearing system identification and valve sequence number in 1/2” black characters. Attach tag to valve body with brass jack chain and “S” hook for brass tag and SS jack chain or SS braided wires with swag sleeves and “S” hook for stainless steel tag. Non-metallic fasteners are not allowed.
- B. Valve numbers shall be prefixed with corresponding piping system identification in 1/4” black letters.
- C. Furnish typewritten valve schedule indicating valve number, fixtures, equipment or areas served by each numbered valve and incorporate in O&M Manuals.

3.4 EQUIPMENT IDENTIFICATION

- A. Identify major equipment, including heat exchangers, pumps, water heaters, tanks, compressors, etc.
- B. Identify equipment with laminated plastic nameplates.
- C. Identify control equipment and panels with laminated plastic nameplates.
- D. Nameplate Markings:

INDOOR PRACTICE FACILITY
EAST CAROLINA UNIVERSITY, GREENVILLE, NC
SCO ID# 23-26345-01A
AIM # 1752

1. Identify model number, size, capacity, electrical characteristics, serial number, along with other items scheduled for equipment on drawings.
 2. Indicate motor horsepower, voltage, phase, cycles, RPM, full load amps, locked motor amps, frame size, manufacturer's name and model number, Service Factor, Power Factor, efficiency, minimum circuit amps, minimum feeder conductor size, disconnect or fuse size, refrigerant, and other pertinent information.
- E. Locate motor nameplates for easy reading. Relocate or provide new nameplates on motors if original nameplates are not located for easy reading.

3.5 ACCESS PANEL IDENTIFICATION

- A. Identify each service opening or access opening with minimum 1/2" high letters indicating type of damper.
- B. Furnish typewritten charts with identification and location of all access panels serving equipment and valves and incorporate in O&M Manuals.

3.6 SPRINKLER ZONE CONTROL VALVE IDENTIFICATION

- A. Identify sprinkler zone control valves with laminated plastic nameplates. Nameplate shall include name of sprinkler zone served and description of area served.
- B. Identify inspector's test valve with laminated plastic nameplate if valve is located remote from sprinkler control valve. Nameplate shall include name of sprinkler zone served.

3.7 UNDERGROUND WARNING TAPE

- A. Install detectable warning tape 4" to 6" below grade to allow for accurate above surface detection.
- B. Install non-detectable warning tape 6" to 12" below grade.
- C. Repair and replace existing underground warning tape where disturbed by excavation.

END OF SECTION 220553

SECTION 220700 - PLUMBING SYSTEMS INSULATION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Provide insulating materials and accessories as required for mechanical systems as specified below.
- B. Insulating products delivered to construction site shall be labeled with manufacturer's name and description of materials.

1.2 DEFINITIONS

- A. Concealed areas, where indicated in this Section, shall apply to shafts, furred spaces and space above finished ceilings, inaccessible tunnels and crawl spaces. All other areas, including walk-through tunnels, shall be considered as exposed.
- B. Unless otherwise indicated, unit of thermal conductivity is Btu in/(h ft² °F).
- C. Interstitial spaces are considered as concealed areas.

1.3 SUBMITTALS

- A. Product Data for each piping system for all pipe sizes, each ductwork system but not limited to, the following:
 - 1. Manufacturer's name
 - 2. Schedule of insulating materials
 - 3. Insulation material and thickness
 - 4. Jacket
 - 5. Adhesives
 - 6. Fastening methods
 - 7. Fitting materials
 - 8. Intended use of each material
 - 9. Manufacturer's data sheets indicating density, thermal characteristics, temperature ratings
 - 10. Insulation installation details (manufacturer's installation instruction/details, Contractor's installation details, MICA plates where applicable)
 - 11. Literature data sheet from sealants and adhesive manufacturers stating VOC compliance with USGBC LEED IEQ 4.1.
 - 12. Literature data sheet from coatings and mastics (including lagging adhesives) manufacturers stating VOC compliance with USGBC LEED IEQ 4.2.
 - 13. All other appropriate data

1.4 DELIVERY, STORAGE AND HANDLING

- A. Insulation material shall be delivered to project site in original, unbroken factory packaging labeled with product designation and thickness. Shipment of materials from manufacturer to installation location shall be in weather-tight transportation. Protect insulation materials from moisture and weather during storage and installation. Protect insulation material against long exposure to UV light from sun.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Insulation:
 - 1. Owens Corning, Johns Manville, Manson, Knauf or CertainTeed similar to product indicated except where product of manufacturers not listed above is specifically identified for special type of insulation.
- B. Coatings, Mastics, Sealants and Adhesives:
 - 1. Foster, Childers, Design Polymerics, Vimasco, Miracle or Pittsburgh Corning

2.2 MATERIALS

- A. Products used for or related to air conditioning and ventilating systems shall conform to NFPA 90A possessing flame spread index of not over 25 and smoke developed index no higher than 50.
- B. Unless otherwise indicated, all products, material itself or on composite basis, shall have flame spread index not more than 25 and smoke developed index not more than 50, when tested in accordance with ASTM E84 or UL 723.
- C. Pipe insulation installed outdoors may have smoke developed index not exceeding 450.
- D. Insulation shall not contain formaldehyde.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in manufacturing process.
- F. Insulation applied on stainless steel shall meet requirements of ASTM C795 and NRC 1.36.

2.3 INSULATION

- A. Insulation materials shall be fire retardant, moisture and mildew resistant, vermin proof, and suitable to receive jackets, adhesives and coatings as indicated.
- B. Glass fiber insulation shall be of inert inorganic material, non-corrosive to mechanical surfaces.
- C. Insulating cement shall be Quick-Cote by PK Insulation MFG Co. or Ryder GP, with dry density of no more than 38 lb/ft³ thermal conductivity of 0.96 at 400°F mean temperature, and service temperature to 1200°F.

D. Filling and finishing cement shall be Super-Stik by PK Insulation MFG Co., or Ryder MW, with dry density of no more than 24 lb/ft³, thermal conductivity of 0.74 at 500°F mean temperature, and service temperature to 1900°F.

E. Type A Insulation (Flexible Elastomeric):

1. Flexible, closed-cell, elastomeric cellular insulation.
 - a. ASTM Standard: ASTM C534/C534M, Type I (tube form) or Type II (sheet form), Grade I
 - b. Thermal Conductivity: Maximum 0.28 at 75°F mean temperature
 - c. Water Vapor Permeability: Maximum 0.08 perm-"
 - d. Water Absorption: Maximum 0.2 % by volume
 - e. Service Temperature: -297 to 220°F
2. Manufacturers/Products:
 - a. Armacell, AP Armaflex FS
 - b. Aeroflex, Aerocel
 - c. K-Flex, Insul-Tube

F. Type R Insulation (Rigid Mineral Fiber Pipe Insulation):

1. Mineral fiber (fiberglass) preformed pipe insulation faced with specified jacket.
 - a. ASTM Standard: ASTM C547, Type I
 - b. Density: Minimum nominal 3 lb/ft³
 - 1) Thermal Conductivity: Maximum 0.23 at 75°F and 0.29 at 200°F
 - 2) 0.29 at 200°F mean temperature
 - c. Service Temperature: To 850°F
2. Manufacturers/Products:
 - a. Johns Manville, Micro-Lok HP
 - b. Owens Corning, ASJ Max Fiberglas Pipe Insulation
 - c. Knauf, Earthwool 1000° Pipe Insulation

2.4 JACKETS

A. Jacket puncture resistances shall be based on ASTM D781 test methods. Vapor barrier permeance ratings shall be based on ASTM E96/E96M Procedure A.

B. Type P-1 Jackets:

1. Heavy-duty, fire retardant material with glass fiber reinforcing and self-sealing lap. Jacket shall have neat, white Kraft finish suitable for painting, with burst strength of 1.5 Joules(50 beach units) minimum and tensile strength 45 lbs/in minimum. Vapor barrier shall be adhered to inner surface of jacket. Permeance shall not exceed 0.02 perm.
2. Manufacturer/Products:
 - a. Owens Corning: ASJ-SSL
 - b. Johns Manville, ASJ
 - c. Knauf, ASJ+

2.5 ADHESIVES, MASTIC, COATINGS, SEALANTS, AND REINFORCING MATERIALS

- A. Adhesives and sealants shall comply with the South Coast Air Quality Management District SCAQMD 1168; VOC limits shall comply with Indoor Environmental Quality Section, Credit IEQ-4.1.
- B. Coatings and mastics shall comply with VOC limits set forth by Green Seal BS-11 and comply with the South Coast Air Quality Management District SCAQMD 11133; VOC limits shall comply with Indoor Environmental Quality Section, Credit IEQ-4.2.
- C. Products shall be compatible with surfaces and materials on which they are applied and shall be suitable for use at operating temperatures of systems to which they are applied.
- D. Products shall be fire retardant, moisture resistant and mildew resistant and vermin proof.
- E. Vapor Barrier Mastic: Below ambient insulation. Water vapor permeance shall be less than 0.08 perms at 45 mils dry film thickness per ASTM F1249.
 - 1. Foster 30-33
 - 2. Childers CP-33
 - 3. Vimasco 749
- F. Weather Barrier Breather Mastic: Above ambient insulation. Permeance shall be greater than 1.0 perms at 1/16" dry film thickness per ASTM E96/E96M.
 - 1. Foster 46-50 Weatherite
 - 2. Childers CP-10/CP-11 Vi Cryl
 - 3. Vimasco WC-5
- G. Lagging Adhesive/Coatings: Indoors applications used in conjunction with canvas/glass cloth.
 - 1. Foster 30-36
 - 2. Childers CP-50 AMV1
 - 3. Vimasco 713
- H. Insulation joint sealant for Type P, Type PP, and Type G insulation:
 - 1. Foster 95-50 Flextra
 - 2. Childers CP-76 Chil Byl
 - 3. Pittsburgh Corning CW Sealant
- I. Glass fiber fabric reinforcing shall be 10 x 10 mesh similar to Childers Chil Glas #10 or Foster Mast A Fab.
- J. Wire mesh reinforcing shall be 22 ga, 1" galvanized.
- K. Insulation cement shall be ANSI/ASTM C195, hydraulic setting mineral wool.
- L. Finishing cement shall be ASTM C449.
- M. Butt joint and longitudinal joint adhesive for Type A insulation shall be Armstrong 520, Rubatex 373, Childers CP-82 or Foster 85-75.

- N. Weather-resistant protective finish for Type A insulation shall be equal to Armstrong WB Armaflex finish or Foster 30-64 elastomeric coating.

2.6 METAL BANDS AND WIRES

- A. Aluminum bands shall be 0.5 x 0.20" up to 48" diameter and 0.75 x 0.020" over 48" diameter.
B. Stainless steel bands shall be 0.5 x 0.015" or 0.75 x 0.015".
C. Stainless steel wires shall be 16 ga.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Provide insulation and jackets with minimum insulation thickness as indicated in the following schedule. The schedule applies to both exposed and concealed applications unless noted otherwise:

Piping System							
Service	Jacket Type	Minimum Insulation Thickness According to Pipe Size					
		Insulation Type	3/4" and Smaller	1" - 1-1/4"	1-1/2" - 3"	4" - 6"	8" and Larger
Domestic Cold Water	P-1	R	1"	1"	1"	1"	1"
Domestic Hot Water and Hot Water Return 105-140°F	P-1	R	1"	1"	1-1/2"	1-1/2"	1-1/2"
Domestic Hot Water and Hot Water Return 141-200°F	P-1	R	1-1/2"	1-1/2"	1-1/2"	1-1/2"	1-1/2"
Nonpotable Cold Water	P-1	R	1"	1"	1"	1"	1"
Storm and overflow piping including roof drain body	P-1	R	NA	1"	1"	1"	1"
Sanitary waste piping downstream of cooling coil condensate connection	P-1	NA	1"	1"	1-1/2"	1-1/2"	1-1/2"
	P-1	A	3/4"	3/4"	3/4"	3/4"	NA
(Type A insulation is an option.)							
Clearwater Waste	P-1	R	1"	1"	1"	1"	1"
	---	A	3/4"	3/4"	3/4"	3/4"	NA

(Type A insulation is an option.)							
Piping Provided with Heat Tracing	P-1	R	1"	1-1/2"	2"	2"	2"
Insulation thickness shall be the greater thickness specified for piping system or thickness specified above.							

3.2 INSTALLATION - GENERAL

- A. All insulation installation methods shall be performed in accordance with the latest edition of National Commercial and Industrial Insulation Standards published by MICA (Midwest Insulation Contractors Association) and manufacturer's installation instructions, except as modified in this Section of specifications.
- B. Install products with good workmanship, with smooth and even surfaces. Use full-length factory-furnished material where possible. Do not use scrap pieces.
- C. Apply insulation only on clean, dry surfaces, after all rust and scale have been removed and testing of systems has been completed. Do not insulate any section of system that must be pressure tested until after it has been successfully tested. Any removal and reinstallation to correct system defects prior to end of guarantee period shall be accomplished at no expense to Owner.
- D. Install insulating materials with necessary joints and terminations, to permit easy access and removal of equipment sections where inspection, service or repair is required, and to allow for expansion.
- E. Where possible longitudinal joints in jackets shall face toward wall or ceiling.
- F. Apply insulation to each pipe or duct individually. Common insulation applied to adjacent pipes or ducts will not be accepted.
- G. Unless otherwise indicated, pipe and duct insulation shall be continuous through walls and floors.
- H. Where multiple layers of insulation are used, stagger and secure each layer with metal bands.
- I. Where penetrations occur through fire-rated walls, partitions, or floors, provide fire seal as specified in Section 220000 - General Plumbing Requirements and Section 078400 - Firestopping.
- J. Insulate the following systems for complete vapor barrier protection:
 1. Storm
 2. Clearwater Waste
 3. Cold Water
- K. Apply Type A insulation for insulation and jackets requiring vapor barrier protection where specified insulations are cut for mounting sensors, control devices, parts of valves, devices or components which extend out from specified insulation to prevent condensation.

3.3 PIPING, VALVE AND FITTING INSULATION

- A. Apply insulation to pipe, unions, flanges, fittings, valves and piping specialties with butt joints and longitudinal seams closed tightly. Valve insulation shall cover entire valve body including bonnets and packing nuts.
- B. Laps on factory-applied jackets shall be 2" minimum width firmly cemented with lap adhesive, or shall be pressure sealing type lap.
- C. Cover joints with factory furnished tape 3" minimum width) to match jacket. Cement firmly with lap adhesive. On systems requiring a vapor barrier (ASJ), vaporseal all longitudinal and butt joints ASJ/Saran seams with 4" wide coat of vapor barrier mastic or 3" minimum tape.
- D. Where staples are used, they shall be on 6" maximum centers. When used for systems requiring vapor barrier, cover lap and staples with finish coat of vapor barrier mastic or 3" minimum tape.
- E. For finishing of insulated pipe fittings and valves where surface temperature of insulation is not higher than 125°F, use one piece PVC fitting covers, minimum thickness of 0.05 mm(20 mil), Fitting cover shall be Johns Manville Zeston 2000 PVC, PROTO Fitting Covers, or similar by other manufacturers listed. Where fitting and valve insulation requires vapor barrier, seal joints of PVC covers with vapor barrier adhesives. Insulation type, R-value and density of insulation used at fittings shall match insulation of adjacent piping. Install insulation at pipe fittings and valves completely prior to applying PVC covers.
 - 1. For Type R (Rigid glass fiber) pipe insulation, PVC fitting covers with flexible mineral fiber blanket insulation inserts are acceptable, except those located in mechanical rooms within 6' above floor. For fitting covers located in mechanical room within 6' above floor, insulation inserts shall be pre-molded rigid fiber glass type wrapped around elbows.
- F. Stove pipe style insulation on elbows (Detail A on Plate 2-200 of MICA 8th Edition) is not allowed. It may be used for closed cell elastomeric insulation.
- G. Where terminations of pipe insulation are required, insulation shall have tapered ends, built up and finished as specified for fittings.
- H. For pipes 1" and smaller, install specified pipe insulation and jacket continuous through hanger or support locations. Install insulation protection shields to protect insulation from compressing.
- I. For pipes 1-1/2" and larger, where manufactured pre-insulated pipe supports are used at hanger or support locations, extend insulation to insulated pipe supports. Where vapor barrier is required, this Contractor shall be responsible for continuity of vapor barrier at insulated pipe supports. 3" wide vapor barrier tape on hot and cold systems at pipe supports.
- J. For pre-insulated pipe supports and insulation protection shields, refer to Section 220529 - Plumbing Piping and Equipment Supporting Devices.

- K. For Contractor-fabricated anchors, secure insulation directly to pipe surface and extend insulation up anchor for distance of 4 times insulation thickness. For pre-insulated anchors, cover entire surface of anchors with Type A insulation. Where applicable, take special care to assure vapor seal at anchor.
- L. Where mechanical grooved pipe connections are used in piping system, insulate couplings as specified for pipe.

END OF SECTION 220700

SECTION 221118 - WATER DISTRIBUTION SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This Section covers interior domestic cold water, domestic hot water (140°F), domestic hot water return, and nonpotable cold water to a point 5 ft outside building wall.
- B. All components shall comply with NSF 61 and NSF 372 to be compliant with requirement for lead content of $\leq 0.25\%$ maximum weighted average.

1.2 QUALITY ASSURANCE

- A. Order pipe with each length marked with manufacturer's name or trademark and type of pipe; with each shipping unit marked with purchase order number, metal or alloy designation, temper, size, and supplier's name.
- B. Installed material not meeting specification requirements must be replaced with material that meets these Specifications without additional cost to Owner.

1.3 DELIVERY, STORAGE, AND HANDLING

- A. Promptly inspect shipments to ensure material is undamaged and complies with specifications.
- B. Cover pipe to prevent corrosion or deterioration while allowing sufficient ventilation to avoid condensation. Do not store materials directly on grade. Protect pipe, tube, and fitting ends from damage. End caps shall remain in place. Protect fittings, flanges, and unions by storage inside or by durable, waterproof, above ground packaging.
- C. Offsite storage agreements will not relieve Contractor from using proper storage techniques.
- D. Storage and protection methods must allow inspection to verify products.
- E. Before shipping, piping shall be cleaned, free of rust and scale, and chemically treated to protect inside of pipe from rusting and furnished with end caps.

1.4 SUBMITTALS

- A. Manufacturer's technical data for the following:
 - 1. Pipe
 - 2. Fittings
 - 3. Joints
 - 4. Valves
 - 5. Unions and Flanges
 - 6. Dielectric fittings
 - 7. Water hammer arrestors
 - 8. Expansion joints

9. In-line Centrifugal Pumps

- B. Shop Drawings on items specified herein.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Materials as specified shall be new unless otherwise noted.
- B. Materials shall be provided from list of approved manufacturers. Home Market, Generic Broker, or Wholesaler's house brands are not acceptable.

2.2 PIPE, FITTINGS, AND JOINTS

A. Underground -2-1/2" and Smaller:

1. Copper:
- a. Pipe: Copper tube, Type K, soft (annealed) temper in coils, ASTM B88
 - b. Fittings:
 - 1) Cast copper alloy, solder joint, pressure rated, ASME B16.18
 - 2) Wrought copper, solder joint, pressure rated, ASME B16.22
 - c. Joints: Where joints are permitted, brazed, silver solder, BCuP-5 Type, AWS A5.8M/A5.8, 1250°F melting point minimum.
 - d. Pre-insulated with polyurethane insulation and PVC jacket.

B. Above Ground:

1. Copper (1-1/2" and Smaller):
- a. Pipe: Copper tube, Type L, hard drawn, ASTM B88
 - b. Fittings:
 - 1) Cast copper alloy, solder joint, pressure rated, ANSI/ASME B16.18
 - 2) Wrought copper, solder joint, pressure rated, ANSI/ASME B16.22
 - 3) Where press fittings are permitted, copper, press fit joint, EPDM O-ring, ASME B16.51, 0 degrees - 250°F, maximum 200 psi. Propress by Viega, ApolloPress by Apollo Flow Controls, Copper Press by Merit Brass or Presssystem by Nibco.
 - a) Press fittings shall be specified only where hot work is not allowed.
 - c. Joints:
 - 1) Lead free (<0.2%) solder, ASTM B32, flux, ASTM B813
 - 2) Where press fittings are permitted, press fit joint, EPDM O-ring, made with electro-hydraulic crimping tool and jaw correct for pipe size.
 - a) Press fittings shall be specified only where hot work is not allowed.
 - d. Nipples: Red brass pipe, threaded
 - e. Exposed tubing and fittings in kitchen and areas subject to chemical cleaning shall have chrome plated finish.
2. Copper [2" through 2-1/2" ([65 mm])]:

- a. Pipe: Copper tube, Type L, hard drawn, ASTM B88
- b. Fittings:
 - 1) Brazed, BCuP-3 or BCuP-5 type, AWS A5.8M/A5.8, [1250°F] ([677°C]) minimum melting point
 - 2) Where press fittings are permitted, copper, press fit joint, EPDM O-ring, ASME B16.51, 0 degrees - 250°F, maximum 200 psi. Propress by Viega, ApolloPress by Apollo Flow Controls, Copper Press by Merit Brass or Presssystem by Nibco.
 - a) Press fittings shall be specified only where hot work is not allowed.
- c. Joints:
 - 1) Brazed, BCuP-3 or BCuP-5 type, AWS A5.8M/A5.8, 1250°F minimum melting point
 - 2) Where press fittings are permitted, press fit joint, EPDM O-ring, made with electro-hydraulic crimping tool and jaw correct for pipe size.
 - a) Press fittings shall be specified only where hot work is not allowed.

2.3 UNIONS AND FLANGES

A. General:

- 1. Unions, flanges and gasket materials to have pressure rating of not less than 150 psi at 180°F.

B. Copper (3" and Smaller):

- 1. Wrought copper union, Nibco Figure 633-W. Mueller Brass equal.

2.4 VALVES

A. Shutoff Valves:

- 1. Ball Valves (2" and smaller):
 - a. Acceptable manufacturers: Apollo, Hammond, Milwaukee, Nibco, Stockham and Watts with indicated features and equal to model listed. Note that not all manufacturers make all sizes.
 - b. Full Port, 2 Piece: Bronze body, ASTM B584, stainless steel ball and stem, teflon seats, stem extension with length according to installed system insulation thickness, 600 psi CWP pressure rating, Apollo Series 77CLF-240-01.
 - c. Full Port, 3 Piece: Bronze body, ASTM B584, stainless steel ball and stem, teflon seats, stem extension with length according to installed system insulation thickness, 600 psi CWP pressure rating, Apollo Series 82LF-240.
 - d. Standard Port, 2 Piece: Bronze body, stainless steel ball and stem, teflon seats, stem extension with length according to installed system insulation thickness, 600 psi CWP pressure rating, Apollo Series 70LF-240-01.
 - e. Insulated Handle: For insulated systems to prevent condensation on valve body with thermal and vapor seal, equal to Apollo Therma Seal.
- 2. Gate Valves:

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- a. Acceptable Manufacturers: Apollo, Crane, Hammond, Kennedy, Milwaukee, Nibco, and Stockham with indicated features and equal to model listed. Note that not all manufacturers make all sizes.
 - b. Size 2-1/2" and Smaller: Lead-free bronze body, bronze trim, 150 psi steam pressure rating, union bonnet, rising stem, Apollo 102TLF/102SLF.
- B. Swing Check Valves:
- 1. Size 2" and Smaller:
 - a. Bronze body, ASTM B62, Y pattern, PTFE resilient disc, horizontal swing, 200 psi CWP rating, Apollo 163-LF series
- C. Spring Check Valves:
- 1. Valves 2" and Smaller:
 - a. Bronze body, ASTM B584, in-line lift type with spring, Buna-N or PTFE disc, 250 psi CWP rating, Apollo 61LF-500 series
 - 2. Size [1/2" thru 2"]:
 - a. Stainless steel body, in-line pattern, stainless steel seats, spring and valve disc. DFT, Inc. Basic Check, Model BSS, rated for 300 psi WSP.
 - b. Manufacturers: Nibco, Watts, Mission, DFT, Inc., Circle Seal, Milwaukee, Stockham
- D. Mixing Valves
- 1. MV-1 Individual Fixture Mixing Valve
 - a. Acceptable manufacturers: Bradley, Watts or approved equal
 - b. Standard: ASSE 1070, thermostatically controlled, water tempering valve.
 - c. Pressure Rating: 125 psig minimum unless otherwise indicated.
 - d. Body: Bronze body with corrosion-resistant interior components.
 - e. Temperature Control: Adjustable.
 - f. Inlets and Outlet: Threaded.
 - g. Finish: Rough or chrome-plated bronze.
 - h. Tempered-Water Setting: 110 deg F.
 - i. Refer to Mixing Valve Schedule on Plumbing drawings for manufacturer and model.

2.5 DIELECTRIC FITTINGS

- A. Insulating nipple, metal casing, inert thermoplastic lining; Anvil Figure 7090, Clearflow dielectric fitting by Perfection Corporation or Victaulic Style 47.
- B. Dielectric unions 2" and smaller; dielectric flanges 2-1/2" and larger; with iron female pipe thread to copper solder joint or brass female pipe thread end connections, non-asbestos gaskets and pressure rating of not less than 175 psi at 180°F. Watts Regulator Company, Lochinvar, Wilkins or Epco Sales, Inc.
- C. Copper-silicon casting, UNS C87850, threaded or grooved end. UL classified in accordance with NSF 61 for potable water service. Victaulic Style 647

2.6 WATER HAMMER ARRESTORS

A. Mechanical Water Hammer Arrestors:

1. Piston-compressed air column type, with sealed air chamber.
2. Manufacturers: Watts, Sioux-Chief, and Precision Plumbing Products (PPP), Inc., equal to size shown. Provide access panels when mechanical shockstops are installed in non-accessible concealed locations.

2.7 EXPANSION JOINTS/LOOPS

A. Galvanized steel pipe, Schedule 40, with mechanical couplings, Victaulic 150 Mover

B. Copper Tubing:

1. Use expansion loops where space is available. Size expansion loops as listed in the following table:

<u>Pipe Size</u>	<u>Length of Each Loop</u>	<u>Number of Legs</u>
3/4"	38"	3
1"	40"	3
1-1/4"	42"	3
1-1/2"	46"	3
2"	50"	3
2-1/2"	54"	3
3"	60"	3
4"	68"	3

C. Copper Tubing:

1. Mechanical expansion fittings, size 3/4" thru 4", copper tube sweat ends, stainless steel laminated internal bellows, 200 psi working pressure, 600°F rated; Keflex Model 7QT.
2. Mechanical expansion fittings, sizes 3/4" thru 4", copper tube sweat ends, stainless steel laminated internal bellows, 175 psi working pressure, 500°F rated, Hyspan Model 8509 or 8510.
3. Allowable length of copper tube per mechanical expansion fitting shall be in accordance with the following table:

System Operating Temperature	Length of Pipe
110°F	300 ft
110°F	275 ft
130°F	250 ft
140°F	225 ft
150°F	175 ft
160°F	175 ft
170°F	150 ft
180°F	140 ft

- D. Pre-manufactured expansion loop will be allowed: Metraflex Model MLS Series for sweat ends, MLT Series for threaded ends and MLF Series for flanged or groove ends. Verify pipe size required, laying length, and face-to-face dimension required. Coordinate location with other trades.

2.8 IN-LINE CENTRIFUGAL PUMPS FOR TEMPERATURE MAINTENANCE OF POTABLE HOT WATER

- A. Manufacturers: Armstrong, Aurora, Bell and Gossett, Deming, Ingersoll-Rand, Taco, Weinman, or Worthington
- B. Pumps shall be pipeline mounted, stainless steel, NSF rated, single suction type with working pressure of 125 psi and operating temperature of 200°F continuous.
- C. Impellers shall be plastic and shall be directly hung from motor shafts without using flexible couplings.
- D. Pump shafts shall be ceramic, steel or stainless steel, sealed and gasketed from pumped fluid.
- E. Pumps shall be furnished with mechanical carbon/silicon carbide seals.
- F. Bearing assemblies and motor shall be permanently oil lubricated and maintenance free.
- G. Pump shall be controlled by aquastat located in return pipe at pump with 100°F to 240°F operating temperature with 5°F to 30°F adjustable differential, remote bulb, UL listed similar to Honeywell L6006A1012.
- H. Refer to Section 262913 - Enclosed Controllers.
- I. Refer to Pumps schedule on Plumbing Drawings for capacity requirements of pumps.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install pipe and fittings in accordance with reference standards, manufacturer's recommendations and recognized industry practices.
- B. Maintain piping system in clean condition during installation. Remove dirt and debris from assembly of piping as work progresses. Cap open pipe ends where left unattended or subject to contamination.
- C. Include connections to plumbing fixtures, to equipment by others, and to equipment requiring water. Provide proper backflow and back siphonage protection to safeguard potable water system from contamination.
- D. Lay out water system so as to conform to intent of drawings. Coordinate piping with building features and work of other trades. Install water piping plumb and square with building. Plans indicate, general routing, provide additional offsets as required. Install piping with necessary swing joints and offsets to allow for expansion.

- E. Install shut-off valves on branch lines near mains to avoid long dead-leg branches when valves are closed.
- F. Install shut-off valves where indicated and at base of risers to allow isolation of portions of system for repair.
- G. Do not install water piping within exterior walls.
- H. Provide drain valves at base of risers and at low points of trapped piping 2" and larger where trapped water volume exceeds 5 gallons.
- I. Provide protective sleeve covering of elastomeric pipe insulation where copper or steel piping is embedded in masonry or concrete.
- J. Provide dielectric fittings between dissimilar piping materials.
- K. Do not route piping through transformer vaults or above transformers, panelboards, or switchboards, including required service space for this equipment, unless piping is serving this equipment.
- L. Install valves and piping specialties, including items furnished by others, as specified and/or detailed. Provide access to valves and specialties for maintenance. Make connections to equipment, fixtures and systems installed by others where same requires piping services indicated in this Section.
- M. In-line pumps 3 hp and larger shall be independently supported from building structure.
- N. Install water pipe using proper pipe and fittings. Use reducing fittings for changes in pipe size.

3.2 UNDERGROUND WARNING TAPE

- A. Provide warning tape for exterior buried utilities per Section 220553 - Plumbing Systems Identification.

3.3 COPPER TUBING

- A. Copper tubing shall be installed per Copper Development Association guidelines in addition to methods specified herein.
- B. Soldered Copper Joints:
 - 1. Use non-acidic and lead free flux on cleaned pipe and fittings for soldered joints.
 - 2. Cut tube square, remove burrs from exterior of tube and ream interior of tube before assembly.
 - 3. Fill joints with solder by capillary action. Solder shall cover joint periphery. Wipe joint clean.
 - 4. Apply heat carefully to prevent damage to pipe, fittings and valves.
 - 5. Follow manufacturer's recommendations when heating valves and equipment for soldered connections.
- C. Brazed Copper Joints:

1. Cut tube square, remove burrs from exterior of tube and ream interior of tube before assembly.
2. Joints shall be cleaned and polished before brazing.
3. Flux of any type shall not be used.
4. Apply heat carefully to prevent damage to pipe, fittings and valves. Disassemble valves where possible to prevent damage to seats during brazing.

D. Press Fit Copper Joint:

1. Cut tube square, remove burrs from exterior of tube and ream interior of tube before assembly.
2. Tubing shall be clean and dry before inserting into fittings.
3. Insert pipe fully into fitting and mark on pipe at shoulder of fitting.
4. Check fitting alignment against mark on pipe to ensure pipe is fully engaged.
5. Crimp joint with pressing tool approved by fitting manufacturer. Mark crimped joints with permanent marker after each joint has been pressed.
6. Provide initial joint leak test at 45 psig prior to performing final pressure test as defined later in this Section.

3.4 SPRING LOADED CHECK VALVES

- A. Provide spring loaded check valve in each pump discharge line.

3.5 WATER HAMMER ARRESTORS

- A. Use water hammer arrestors to control water hammer. Installed devices shall be sized and located according to manufacturer's recommendations, PDI Standards, or as shown on drawings.
- B. Use water hammer arrestors with flush valves and quick-closing valves. Provide access panels when water hammer arrestors are installed in non-accessible concealed locations.

3.6 DIELECTRIC UNIONS AND FLANGES

- A. Install dielectric unions or flanges at points where copper-to-steel pipe connection is required in domestic water systems.
- B. Install unions on equipment side of shutoff valves for items such as: water heaters, water softeners, pumps, filters, and similar equipment requiring periodic replacement.

3.7 EXPANSION JOINTS

- A. Install one anchor on either side of expansion joint, opposite direction of expansion.
- B. Install pipe guides on each side of mechanical expansion fittings.

3.8 CLEANING

- A. Flush and clean piping prior to testing. Remove corrosion by mechanical or chemical means. Use chemicals that are non-toxic.

3.9 TESTING

- A. Refer to Testing paragraph of Section 220000 - General Plumbing Requirements.
- B. Water test system may be applied to system in its entirety or in sections. Test piping with water to pressure of 100 psi] for 2 h. No decrease in pressure allowed. Provide pressure gauge with shutoff and bleeder valve at highest point of system tested. Inspect joints in system under test.
- C. Defective work or material shall be replaced or repaired as necessary and inspection and test repeated. Repairs shall be made with new materials. No caulking of threaded joints or holes will be allowed.
- D. Do not conceal pipe until satisfactorily tested.
- E. Testing with air will not be allowed.

3.10 BALANCING

- A. Balance water distribution system. Adjust control valves for proper operation. Set balancing valves to maintain hot water in hot water system.
- B. Balance flush valves, flow control valves and mixing valves for adequate flow and temperature to plumbing fixtures and equipment.

3.11 DISINFECTION

- A. Disinfect water piping in the following manner:
 - 1. Clean and flush water pipe with water until water at remote tap is clear.
 - 2. Fill water systems with solution containing 50 ppm of chlorine (minimum concentration). Allow solution to stay in water system for 24 h. Alternately use solution of 200 ppm of chlorine (minimum concentration) for 3 h.
 - 3. Flush water system of chlorine solution.
 - 4. Allow clean water to stand in system for 24 h. Take sample from remote tap for bacteriological test.
- B. Do not use water system for potable water supply until safe bacteriological test is obtained. Repeat steps 1 through 4 until safe water system is obtained.

3.12 BACTERIOLOGICAL TESTS

- A. Take representative water samples and test to ensure bacteriologically safe water supply system. Include HPC (Heterotrophic Plate Count) test and test for presence of *Pseudomonas aeruginosa* as well as regular coliform bacteria test. HPC test maximum containment level of 500 organisms/ml. Perform bacteriological tests shortly before Owner's acceptance of building. If tests fail, make corrections and retest.

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- B. When connecting to existing water supply of unknown quality, sample for analysis and comparison with finished water system analysis shall be taken prior to making new connection. This will allow isolating source of contamination from within scope of work or pre-existing water supply. Final conditions shall meet criteria specified above for areas within scope of work.

END OF SECTION 221118

SECTION 221314 - SANITARY WASTE AND STORM DRAINAGE SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This Section includes materials and methods for sanitary waste and vent, clearwater waste and vent, storm drainage, and overflow storm drainage piping systems within and including piping to 5 ft outside building wall.

1.2 QUALITY ASSURANCE

- A. Order piping with each length marked with manufacturer's name or trademark and type of pipe; with each shipping unit marked with purchase order number, metal or alloy designation, temper, size, and supplier's name.
- B. Installed material not meeting specification requirements must be replaced with material that meets these specifications without additional cost to Owner.

1.3 DELIVERY, STORAGE, AND HANDLING

- A. Promptly inspect shipments to ensure material is undamaged and complies with Specifications.
- B. Cover pipe to prevent corrosion or deterioration while allowing sufficient ventilation to avoid condensation. Do not store materials directly on grade. Protect pipe, tube, and fitting ends from damage. End caps shall remain in place. Protect fittings by storage inside or by durable, waterproof, above ground packaging.
- C. Offsite storage agreements will not relieve Contractor from using proper storage techniques.
- D. Storage and protection methods must allow inspection to verify products.

1.4 SUBMITTALS

- A. Manufacturer's technical data for the following:
 - 1. Pipe and fittings
 - 2. Joints
 - 3. Cleanouts
 - 4. Floor drains and floor sinks
 - 5. Roof drains
 - 6. Downspout nozzles
 - 7. Air gap fittings
 - 8. Traps

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials herein specified shall be new, unless otherwise noted.

2.2 PIPE, FITTINGS, AND JOINTS

A. Interior Underground 15" and Smaller:

1. Cast Iron:

- a. Pipe: Hub and spigot pipe, service weight, ASTM A74, NSF certified with material test reports from marked with collective trademark of Cast Iron Soil Pipe Institute or receive prior approval by Engineer.
- b. Fittings: Hub and spigot fittings, service weight, ASTM A74, NSF certified with material test reports from marked with collective trademark of Cast Iron Soil Pipe Institute or receive prior approval by Engineer
- c. Joints: Neoprene rubber compression gaskets, ASTM C564(ASTM C564)

B. Interior Above Ground:

1. Cast Iron:

- a. Pipe: Hubless cast iron pipe, ASTM A888, CISPI 301, NSF certified with material test reports from marked with collective trademark of Cast Iron Soil Pipe Institute or receive prior approval by Engineer.
- b. Fittings: Hubless cast iron fittings, ASTM A888, CISPI 301, NSF certified with material test reports from marked with collective trademark of Cast Iron Soil Pipe Institute or receive prior approval by Engineer.
- c. Joints: Medium duty no-hub couplings with stainless steel clamps, FM 1680 Class 1, Husky Series SD-2000, Ideal Tridon "MD", or Clamp-All Hi Torq 80

2. Roof Drain Conn

- a. Pipe: Hub and spigot pipe, service weight, ASTM A74, NSF certified with material test reports from marked with collective trademark of Cast Iron Soil Pipe Institute or receive prior approval by Engineer
- b. Fittings: Hub and spigot fittings, service weight, ASTM A74, NSF certified with material test reports from marked with collective trademark of Cast Iron Soil Pipe Institute or receive prior approval by Engineer
- c. Joints: Neoprene rubber compression gaskets, ASTM C564

C. Adapter Couplings for Joining Dissimilar Pipe Materials:

- 1. Acceptable Manufacturers: Fernco, Mission
- 2. 1" through 6" diameter: Fernco Proflex 3000 Series shielded coupling with neoprene gasket, stainless steel shield, and stainless steel clamping bands. Adapter couplings shall be specifically designed for pipe materials being joined.

2.3 CLEANOUTS

- A. Josam, Mifab, Smith, Wade, Watts or Zurn, equal to number listed in Drains and Cleanout Schedule.
- B. Provide recessed, solid brass, cleanout plugs where fittings are used as cleanouts. Provide taper-thread plug with Teflon tape thread wrap.
- C. Floor Cleanouts: Cleanout with cast iron ferrule, adjustable top, nickel-bronze scoriated cover and frame, bronze taper-thread plug, equal to J.R. Smith 4033L. Provide flashing flange and clamp where cleanout is installed in elevated slabs, equal to J.R. Smith 4033L-F-C.
- D. Floor Cleanouts, Carpeted Areas: Cleanout with cast iron ferrule, adjustable round top, nickel-bronze scoriated cover and frame, bronze taper-thread plug, and small stainless steel carpet marker, equal to J.R. Smith 4033L-Y. Provide flashing flange and clamp where cleanout is installed in elevated slabs, equal to J.R. Smith 4033L-F-C-Y.
- E. Floor Cleanouts, Tiled Areas: Cleanout with cast iron ferrule, adjustable square tile top, nickel-bronze scoriated cover and frame, and bronze taper-thread plug, equal to J.R. Smith 4053L. Provide flashing flange and clamp where cleanout is installed in elevated slabs, equal to J.R. Smith 4053L-F-C.
- F. Floor Cleanouts, Unfinished Floors and Areas Outside Building: Cleanout with cast iron ferrule, adjustable round top, scoriated cast iron tractor cover, and bronze taper-thread plug, equal to J.R. Smith 4239L. Provide flashing flange and clamp where cleanout is installed in elevated slabs, equal to J.R. Smith 4239L-F-C.
- G. Floor Cleanouts, Areas with Heavy Traffic: Cleanout with cast iron ferrule, adjustable housing, heavy-duty ductile iron scoriated top, and brass taper-thread plug, equal to J.R. Smith 4233L-M. Provide flashing flange and clamp where cleanout is installed in elevated slabs, equal to J.R. Smith 4233L-M-F-C.
- H. Wall Cleanouts: Cleanout with cast iron counter sunk ferrule, bronze or brass taper-thread plug, secured stainless steel access cover, equal to J.R. Smith 4472T.

2.4 FLOOR DRAINS

- A. Josam, Mifab, Smith, Wade, Watts or Zurn, equal to number listed herein or in Drains and Cleanout Schedule.
- B. Floor drains shall be in accordance with ANSI/ASME A112.21.1M. Provide with caulked or no-hub connection. Floor drains shall have internal seepage collar for embedding in floor construction and weep holes to provide adequate drainage to drain pipe. Include trap seal insert where indicated on drawings.

2.5 ROOF DRAINS AND OVERFLOW DRAINS

- A. Josam, Mifab, Smith, Wade, Watts or Zurn, equal to number listed in Cleanouts and Drain Schedule

- B. Roof drains and overflow drains shall have cast iron body with adjustable collar, cast iron flashing ring, gravel stops, 10" diameter cast iron dome strainer, and cast iron underdeck clamp. J.R. Smith 1010Y-RC-CID.
- C. Expansion joints shall be cast iron joint with bronze pipe sleeve and neoprene gasket. J.R. Smith 1710.

2.6 AIR GAP FITTINGS

- A. Air gap fittings constructed of cast iron with integral air gap having free area of at least twice the inlet area. Josam, Mifab, Smith, Wade, Watts or Zurn, equal to J.R. Smith 3950 or 3951.

2.7 DOWNSPOUT NOZZLES

- A. Acceptable Manufacturers: Josam, Smith, Wade or Zurn equal to number listed
- B. Downspout nozzles shall be polished bronze body, wall flange and threaded inlet, equal to J.R. Smith #1770-PB.

2.8 TRAPS

- A. Same material as pipe or fittings unless specified with fixtures. Refer to Section 224000 - Plumbing Fixtures. Provide 17 ga brass, chrome plated traps for exposed traps.

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

- A. Install pipe and fittings in accordance with reference standards, manufacturer's recommendations and recognized industry practices.
- B. Provide rigid bracing to resist movement of upstream pipe for horizontal pipes 4" and larger with changes in direction greater than 45 degrees.
- C. Connect piping to fixtures, each piece of equipment, and drains. Install required piping as shown on drawings.
- D. Grade horizontal lines with minimum of 1/8" per ft, except piping 2" diameter or smaller which shall be run at 1/4" per ft (21 mm per m) slope.
- E. Install piping parallel with building lines and at heights, which do not obstruct any portion of window, doorway, stairway, or passageway, except, as may be shown on plans. Install overhead piping as high as possible.
- F. Grade vent pipe for complete drainage by gravity to soil or waste pipes. Vent terminations shall be set true and level. Locate vent piping at least 10 ft away from window, door or intake openings. Coordinate closely with roofing Contractor to prevent damage to roofing membrane. Flashing shall be in accordance with requirements of roofing manufacturer.

- G. Where interferences develop, offset or reroute piping as required to clear interferences. Coordinate locations of plumbing piping with piping, ductwork, conduit and equipment of other trades to allow sufficient clearances. Consult drawings for exact location of pipe spaces, ceiling heights, door and window openings, or other architectural details before installing piping.
- H. Provide protective sleeve covering of elastomeric pipe insulation, where piping and/or fittings are embedded in masonry or concrete.
- I. Maintain piping in clean condition internally during construction.
- J. Mitered ells, notched tees, and orange peel reducers are not allowed. Bushings are not allowed on threaded piping.
- K. Do not route piping through transformer vaults or above transformers, panelboards, or switchboards, including required service space for this equipment, unless piping is serving this equipment.
- L. Set cleanouts true and level and protect properly throughout construction.
- M. Set floor drains true and level and protect properly throughout construction. Weep holes shall be filled with removable material and kept free from concrete and other debris during construction. Weep holes shall be cleaned out for final working order. Provide safing for floor drains installed in elevated slabs.
- N. Trap each fixture and piece of equipment requiring sanitary drainage connections. Trap seals shall be standard depth, except when deep seals are required by code. Traps shall be set true and level and located within limits of code requirements. Traps shall not be used as separator, interceptor or other type of device to retain solids. Traps shall be provided with thread type approved cleanout plugs when specified. Protect traps during construction and seal off to prevent stones, debris and other foreign matter from entering before use. Locate running traps for full accessibility with double cleanout.
- O. Provide plugs or caps for pipe openings during construction to prevent debris from entering pipe. Temporary plug shall be plastic cap or equivalent.

3.2 UNDERGROUND WARNING TAPE

- A. Provide warning tape for exterior buried sewers per Section 220553 - Plumbing Systems Identification.

3.3 CAST IRON PIPE

- A. No-hub Piping: Place gasket on end of one pipe or fitting and clamp assembly on end of other pipe or fitting. Firmly seat pipe or fittings ends against integrally molded shoulder inside neoprene gasket. Slide clamp assembly into position over gasket. Tighten fasteners to manufacturer's recommended torque.

- B. Hub and Spigot Piping: Clean pipe end, bell, gasket seat and gasket of dirt or debris. Coat end of pipe and gasket with gasket lubricant. Ensure pipe is supported off ground so lubricant does not pick up dirt. Push spigot end into end of gasket bell with levered pipe joining tool recommended by pipe manufacturer. Large diameter exterior mains may be joined by pushing end of pipe section with backhoe against wood blocking over pipe end. Insert to fully seated position or to reference mark on pipe.
- C. Hub and Spigot Piping: Shall be used for connections to roof drain bodies.
- D. Install cast iron pipe and fittings as recommended by CISPI in their publication "Installation of Cast Iron Soil Pipe and Fittings".
- E. Support piping at every coupling. Locate hanger within 18" of coupling.
- F. Installations with multiple joints within a 4 ft developed length shall be supported at every second joint.
- G. Secure base of risers with thrust restraints to prevent joint separation. Restraint shall be in accordance with CISPI recommendations.
- H. In addition to horizontal bracing defined previously, provide additional bracing on horizontal piping 5" and larger to prevent horizontal movement. Install bracing at every branch connection and every change of direction in accordance with CISPI recommendations.

3.4 TESTING

- A. Refer to Testing paragraph of Section 220000 - General Plumbing Requirements.
- B. Gravity Systems:
 - 1. Water test may be applied to system either in its entirety or in sections. Piping shall be tightly plugged and submitted to 10 ft head of water located at highest point. Provide separate standpipe above highest point being tested or extend system to obtain required 10 ft head of water. Head shall be maintained for at least 30 minutes before inspection starts.
- C. Defective work or material shall be replaced or repaired as necessary and inspection and test repeated. Repairs shall be made with new materials. No caulking of threaded joints or holes will be allowed.
- D. Do not backfill pipe until successfully tested.
- E. Testing with air will not be allowed.

END OF SECTION 221314

SECTION 222114 - PLUMBING SPECIALTIES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This Section covers material specialties for piping systems.
- B. All components installed on water systems defined in Section 221118 - Water Distribution System shall comply with NSF 372 to be compliant with requirement for lead content of <0.25% maximum weighted average.

1.2 SUBMITTALS

- A. Manufacturer's technical data for the following:
 - 1. Thermometers
 - 2. Pressure gauges
 - 3. Pressure relief valves
 - 4. Strainers
 - 5. Vacuum Breakers
 - 6. Backflow preventers
 - 7. Flexible connections
 - 8. Air vents
 - 9. Trap primers
 - 10. In-line check valves
 - 11. Flashings
 - 12. Safings
- B. Shop drawings and product data on items specified herein.
- C. Certificates: Submit performance testing certificates for reduced pressure backflow preventers and double check backflow preventers.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Materials herein specified shall be new unless otherwise noted.

2.2 THERMOMETERS

- A. Manufacturers: Miljoco, Taylor, Trerice, Weksler, Winters and Weiss equal to Trerice number listed

- B. Thermometers shall be 9" die cast aluminum case and frame, double strength glass window, adjustable angle stem, permanently stabilized glass tube with mercury free indicating fluid, readable scale with gradations from 30°F to 240°F. Provide brass extension neck sockets of appropriate length. Terice Series No. A400 (old catalog number BX91400).
- C. Thermometers shall be 5" round bi-metal type, stainless steel case, readable scale and gradations from 30°F to 240°F, external calibrator adjustment, back or bottom connection as appropriate. Provide brass extension neck sockets of appropriate length. Terice Series No. B85200. Provide with minimum or maximum registering pointers.

2.3 THERMOMETER SOCKETS AND TEST WELLS

- A. Brass construction with threaded connections suitable for thermometer stems or bulbs and control sensing devices, well length suitable for pipe diameter with extended neck as required to suit pipe insulation. Furnish with brass cap and short chain to secure cap to body for test well.
- B. Test wells for stainless steel piping shall be same material as piping.

2.4 PRESSURE GAUGES

- A. Manufacturers: Ashcroft, Marsh, Marshalltown, Miljoco, Taylor, Terice, U.S. Gauge, Weiss, and Winters, equal to Terice number listed
- B. Pressure gauge shall be 4-1/2" die cast aluminum case, double strength glass window, readable dial scale with gradations from 0 to 200 psi, phosphor bronze bourdon tube, brass socket. Provide shutoff valve with pressure gauge, Terice Series No. 600.
- C. Gauge accuracy shall meet ASME B40.1 Grade 1A (1% full scale).
- D. Pressure gauges shall be calibrated for the following pressure ranges:
 - 1. Domestic Water: 0 to 160 psi at 2 psi increments
- E. Pressure Snubbers:
 - 1. 1/4" or 1/2" size, matching gauge size, 1000 psig WP. Brass for copper or carbon steel pipe, stainless steel for stainless steel pipe.

2.5 PRESSURE RELIEF VALVE

- A. Manufacturers: Apollo, Cash-Acme, Consolidated, Kunkle, Lonergan, and Watts
- B. Bronze body, resilient seat/seal, ASME Section VIII, stainless steel spring
- C. Refer to Schedules on drawings for performance requirements.

2.6 STRAINERS

- A. Manufacturers: Apollo, Hoffman, Keckley, Metraflex, Mueller, Watts, Wheatley or Zurn

- B. Strainers shall be comparable to regulator or control valve specified. Strainers shall be "Y" type for liquid service to 300 lbs WOG at 210°F, with 20 mesh stainless steel screen. Body material shall be compatible with installed piping, stainless steel, or FDA approved, heat fused, epoxy coated interior.

2.7 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers

1. 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: Cash Acme, Watts and Zurn
2. Standard: ASSE 1001
3. Size: NPS 1/4 to NPS 3, as required to match connected piping
4. Body: Bronze
5. Inlet and Outlet Connections: Threaded
6. Finish: Rough bronze
7. Basis of Design for Cold Water: Watts LF288A, Cash Acme V101
8. Basis of Design for Hot Water: Cash Acme V101

B. Hose-Connection Vacuum Breakers

1. 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: Cash Acme, Woodford, Watts and Zurn
2. Standard: ASSE 1011
3. Body: Bronze, non-removable, with manual drain.
4. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7
5. Finish: Chrome or nickel plated Rough bronze
6. Basis of Design: Cash Acme VB-222

C. Pressure Vacuum Breakers

1. 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: Cash Acme, Watts and Zurn
2. Standard: ASSE 1020
3. Operation: Continuous-pressure applications
4. Pressure Loss: 5 psig maximum, through middle third of flow range
5. Accessories:
 - a. Valves: Ball type, on inlet and outlet
6. Basis of Design Cold Water: Watts series LF800M4QT
7. Basis of Design Hot Water: Cash Acme PVB
8. Basis of Design Freeze Proof Cold Water: Watts series 800M4FR

D. Spill-Resistant Vacuum Breakers

1. 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: Cash Acme, Watts and Zurn
2. Standard: ASSE 1056
3. Operation: Continuous-pressure applications
4. Size: NPS 3/4
5. Accessories:
 - a. Valves: Ball type, on inlet and outlet
6. Basis of Design: Zurn Model 460, Watts LF008PCQT

2.8 BACKFLOW PREVENTER

A. Reduced Pressure Zone Backflow Preventers:

1. Manufacturers: Apollo, Cla-Val, Febco, Watts or Zurn, equal to model listed
2. 3/4" through 2": Bronze body, resilient check valve seats, shut-off valves, Y-pattern strainer with bronze body and stainless steel screen, drain line air-gap fitting, bronze test cocks, certified in accordance with ASSE 1013 and AWWA C511, equal to Watts number 919-S.
3. 3/4" through 2": Lead free cast copper silicon body, resilient check valve seats, shut-off valves, Y-pattern strainer with bronze body and stainless steel screen, drain line air-gap fitting, bronze test cocks, certified in accordance with ASSE 1013 and AWWA C511, equal to Watts number LF919-S

2.9 IN-LINE TRAP SEALER

- A. Manufacturers: Mi-Gard by Mifab, Quad Close Trap Seal by Jay R. Smith, Sure Seal by Rector Seal, Trap Guard by Proset, Green Drain by Green Drains Inc., or ZShield by Zurn
- B. Inline trap sealer shall be ABS plastic housing and neoprene rubber diaphragm, silicone, or Elastomeric PVC material with self-closing bottom. In-line trap sealer shall conform to ASSE 1072.

2.10 FLEXIBLE CONNECTIONS

- A. Bronze, braided flexible hose or neoprene twinsphere connectors by Mason Industries with 150 psi WOG working pressure rating.
- B. Alternate manufacturers are Redflex, Resistoflex and Flexonics.

2.11 AIR VENTS

- A. Manual Air Vents: Bell and Gossett Model 4V, 125 psi pressure at 210°F temperature, or approved equal. Use 1/2" ball valve for main pipes.

2.12 FLASHINGS

- A. Elastomer Membrane Roofing:
 1. Pipe clamps, Fernco Series 1056 flex coupling with Series 300 stainless steel clamps.

B. Built-Up Roofing:

1. 4 lb/ft² sheet lead, to 18" beyond drain perimeter.
2. Preformed lead vent collar, 4 lb/ft² sheet lead, to 18" beyond vent perimeter; 18" minimum square base flange.
3. Nobleflex roof drain flashing of Chloraloy and 20 lb/ft² asphalt saturated roofing felt bonded together.

2.13 SAFINGS

- A. 4 lb/ft² sheet lead, to 18" beyond edge of drain on all sides.
- B. Chlorinated polyethylene (CPE) as manufactured by Noble Company under trade name Chloraloy 240.
- C. Polyvinyl Chloride (PVC) shower pan line, 40 mil thickness, ASTM D4551.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Provide thermometers where indicated on drawings. Thermometers shall be easily read from floor or maintenance platforms. Calibrate thermometers to ensure accuracy.
- B. Install pressure gauges where indicated on drawings. Gauges shall be easily read from floor or maintenance platforms. Provide extensions as required to make gauges easily readable. Calibrate gauges to ensure accuracy.
- C. Install backflow preventers as indicated on drawings. Flush debris from strainers. Certified tester shall test reduced pressure zone backflow preventers to verify that functions are operational. Route vent line to adjacent hub drain.
- D. Install strainers for equipment including pumps, meters, backflow preventers, reducers and regulators, and as shown on drawings.
- E. Install in-line trap sealer as recommended by manufacturer.
- F. Install in-line check valves where specified or as indicated on drawings.
- G. Install flexible connections for base mounted pumps and other vibrating equipment.
- H. Install air vents at high points in water systems where air may collect.
- I. Safing:
1. Install safing for floor drains. Extend safing to 18" from edge of drain. Safing shall be clamped to floor drain body and pitched to drain to weep holes. Floor drains installed in unexcavated areas do not require safing.
 2. Where core drilled floor drain installation into existing floor slab has been approved by A/E, drain strainer inlet shall be grouted in place with non-shrink epoxy concrete approved by Structural Engineer. Refer to detail Section 220690 - Plumbing Details.

3. Membrane roofing material, preformed elastomer pipe pots, and flashing seams are provided by Roofing Contractor for pipe penetrations and drain flashing. Plumbing Contractor shall provide drain flashing clamps and stainless steel strap clamps for piping penetrations. Coordinate with Contractor to facilitate sealing drain flashing and pipe penetrations.

J. Flashing:

1. Coordinate flashings on roof closely with Roofing Contractor. Install flashings as required to ensure proper vapor barrier and as directed by Architect.
2. Install flashing for roof drains and overflow drains. Flashing shall extend minimum of 18" beyond edge of drain and shall be clamped into drain body.

3.2 TESTING

- A. Safings shall be subject to standing water test to detect leaks and proper drainage to weep holes of floor drain.

END OF SECTION 222114

SECTION 223314 - WATER HEATING EQUIPMENT

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

- A. Water heating equipment shall conform to State and Local Codes, meet national standards, and be certified by respective organization and bear its stamp.

1.2 SUBMITTALS

- A. Shop drawings and product data on items specified herein.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Materials specified herein shall be new unless otherwise noted.

2.2 STORAGE TYPE ELECTRIC WATER HEATER

- A. Manufacturers: A. O. Smith or approved equal
- B. Water heater shall be electric storage type heater. Water heater shall be UL listed and have 5 yr tank warranty and 1 yr parts warranty.
- C. Heating element(s) shall be zinc plated copper sheaths. Temperature control shall be adjustable from 110° to 170°F for single heating element.
- D. Water heater design shall include electronic controls for element sensing low water cut off and economy made with programmable operating set points.
- E. Tank shall be glass lined steel ASME rated for 150 psi. Tank shall have removable magnesium anode rod, pressure and temperature relief valve, drain valve, polyurethane insulation and painted steel jacket.
- F. Provide thermometers on inlet and outlet to heater.
- G. Refer to Water Heater Schedule for water heater capacity required.

2.3 THERMAL EXPANSION TANK

- A. Manufacturers: Amtrol, Goulds, Wessels
- B. Expansion tank shall be precharged, diaphragm-type tank designed for hot water systems. Tank shall be ASME rated for 125 psig and come with replaceable rubber bladder, air charge fitting, steel base ring stand (floor mounted tanks only), factory primed and enamel painted exterior, and ASME relief valve. Materials exposed to water to be NSF or FDA approved for potable water service.

INDOOR PRACTICE FACILITY
EAST CAROLINA UNIVERSITY, GREENVILLE, NC
SCO ID# 23-26345-01A
AIM # 1752

C. Refer to Expansion Tank Schedule for tank capacity.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install water heaters as recommended by manufacturer. Provide final connections as required.
Coordinate water heater location with other Contractors.

B. Initial start up and balancing service shall be provided by representative of manufacturer.

END OF SECTION 223314

SECTION 224000 - PLUMBING FIXTURES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This Section lists plumbing fixtures and accessories including method of installation.

1.2 SUBMITTALS

- A. One package of manufacturer's technical data for all items. Submittal shall be assembled brochure, showing cuts and full detailed descriptions for each item.
- B. Shop drawings and product data on items specified herein.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Materials as specified shall be new unless otherwise noted.
- B. Vitreous china fixtures shall be of highest quality, non-absorbent, hard-burned, and vitrified throughout.
- C. Enameled ware shall be quality cast iron of uniform thickness and density, glazed to uniform depth and high gloss rubbed smooth, without chips or flaws, craze, or cracks, and completely acid resisting.
- D. Stainless steel fixtures shall be 302/304 types of non-corrosive steel, 18 ga self-rim for cabinet sinks, 14 ga for free standing compartment type sinks. Sink material shall have satin finish and coved corners, with faucet holes punched to match specified faucet fitting.
- E. Precast receptors and shower basins shall be "terrazzo" concrete. Receptor and basin colors shall be standard colors unless otherwise noted. Assembly of drain to waste piping shall be made from floor level on which basin or receptor is installed.
- F. Insulation for traps and supplies shall be molded closed cell vinyl insulation and shall meet ASTM E84 for flame and smoke spread. Insulation shall be vandal resistant and be color as listed.

2.2 MANUFACTURERS

- A. Plumbing fixtures shall be provided from list of approved manufacturers. Home Market, Generic Broker, or Wholesaler's house brands are not acceptable.
- B. Water closets, urinals, and lavatories: Sloan, American Standard, or Kohler equal to number listed
- C. Water Closet Seats: Bemis, Beneke, Centoco, Olsonite or Zurn equal to number listed

- D. Flush Valves: Sloan, American Standard or Kohler equal to number listed
- E. Stainless Steel Sinks: American Standard, Kohler or Just equal to number listed
- F. Electric Water Coolers: Elkay or equal to model listed
- G. Service Sinks: American Standard or Kohler equal to number listed
- H. Mop Basins (Janitor Sinks): Fiat, Mustee, Stern-Williams, or Zurn equal to number listed
- I. Manual Faucets: Moen Commercial, Kohlet, American Standard, T and S Brass, or Zurn equal to number listed
- J. Sensor Activated Faucets: Bradley, Chicago Faucet, Kohler, Sloan, TOTO or Zurn equal to model listed
- K. Fixture Traps: Engineered Brass Company, Kohler, McGuire, or Zurn equal to number listed
- L. Insulated Traps and Supplies: McGuire or True-Bro equal to model listed
- M. Supplies and Stops: Chicago Faucet, Kohler, McGuire or Zurn equal to number listed
- N. Supplies and Stops: Brasscraft, Engineered Brass Company, Kohler, LSP Aqua-Flo or McGuire equal to number listed

2.3 CARRIERS AND SUPPORTS

- A. Carrier manufacturers shall be Josam, J.R. Smith, Wade, Watts or Zurn, as outlined herein, with models suitable to fixture and use intended. Provide carriers with adjustable faceplate, rectangular steel uprights and at least 3 bolt lugs for securing carrier to floor. Adjustable water closet carriers shall be either right or left, single or double, horizontal or vertical as suggested by drawings and riser diagrams.
 - 1. Water Closet: Adjustable face plate, rear support for single carries, barrier-free fixtures mounted with top of bowl at 17" from finished floor, Zurn Z-1203 and Z-1204.
 - 2. Urinal: Rectangular uprights, bearing plate, barrier-free fixtures mounted with rim 17" maximum from finished floor, Zurn Z-1222.
 - 3. Lavatory: Concealed arms, rectangular steel uprights, Zurn Z-1231.

2.4 WATER CLOSETS AND URINALS

- A. Provide appropriate gaskets for fixture installation.
- B. Provide bolts with chromium plated caps, nuts and washers.

2.5 WATER CLOSET SEATS

- A. Heavy duty, elongated bowl, open front, plastic seat less cover, with stainless steel self-sustaining hinge, white, Bemis 1955-SSCT.

2.6 DRAINS

- A. Lavatories: Chrome plated brass grid drain, 1-1/4" seamless tailpiece, McGuire 155A
- B. Barrier-free Lavatories: Chrome plated brass offset grid drain, 1-1/4" seamless tailpiece, McGuire 155WC
- C. Self-rimming Stainless Steel Sinks: Stainless steel, 1-1/2" diameter tailpiece with conical strainer basket, Elkay LK99

2.7 TRAPS

- A. Lavatories: P-traps shall be chrome plated brass body with cleanout plug, 17 ga seamless tubular wall bend, cast brass slip nuts and wall escutcheon. Trap size to match fixture connections.
- B. Sinks: P-traps shall be chrome plated brass body with cleanout plug, 17 ga seamless tubular wall bend, cast brass slip nuts and wall escutcheon. Trap size to match fixture connections.

2.8 STOPS AND SUPPLIES

- A. Lavatories: Angle pattern, lock shield cap, loose key handle, copper alloy control valve body, stem and gland nut, 1/2" NPT inlet x 3/8" compression outlet, McGuire LF2165LK
- B. Sinks: Angle pattern, lock shield cap, loose key handle, copper alloy control valve body, stem and gland nut, 1/2" NPT inlet x 1/2" compression outlet, McGuire LF2167LK
- C. Electric Water Cooler: Angle pattern, lock shield cap, loose key handle, copper alloy control valve body, stem and gland nut, 1/2" NPT inlet x 1/2" compression outlet, McGuire LF2167LK

2.9 PROTECTIVE PIPE INSULATION COVERS

- A. Manufactured plastic wraps for covering plumbing fixture hot and cold water supplies, trap and tailpieces shall comply with Americans with Disabilities Act (ADA) requirements.
- B. Lavatories: Offset strainer, p-trap and angle stop and supply insulation cover, white, True-Bro Lav Guard 2

2.10 PLUMBING FIXTURES

- A. Refer to schedule on drawings for detailed fixture selection criteria not contained herein.
- B. Submittal sheets for water closets, urinals, public lavatories and shower heads shall contain EPA WaterSense Label.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install plumbing fixtures as recommended by manufacturer. Caulk around fixtures mounted on irregular surfaces such as tile or stone with silicone sealant, same color as fixture.

- B. Support fixtures with proper carrier for each use. Ensure that carrier is solidly anchored to prevent rocking whatever piping is used. Anchor bolts in carrier foot shall extend 3" minimum into concrete slab.
- C. Fixture carriers shall be suitable for securing each plumbing fixture in place solidly, yet allowing its removal when necessary. Carriers shall be capable of mounting "Barrier Free" fixtures at suitable heights.
- D. Install each fixture with trap easily removable for servicing and cleaning. Install fixture stops in readily accessible location for servicing.
- E. Install barrier free fixtures in compliance with local code and Federal ADA Accessibility Guidelines. Install barrier free lavatory traps parallel and adjacent to wall and supplies and stops elevated to 27" above finished floor to avoid contact by wheelchair users.
- F. Return fixture waste and supply piping into wall as high as practical under fixture. Provide accessible shutoff in fixture supply. Protect "barrier free" supply and drain piping with white colored wrap neatly trimmed to prevent contact with hot or sharp surfaces by user.
- G. Coordinate with Electrical Contractor for electronic sensor wiring necessary to install "sensor" operated fixtures. Provide "shockstops" at supplies to solenoid activated fixtures.
- H. Provide individual supplies to fixtures and rough-in fixture piping with adequate support to prevent movement fore, aft and laterally. Provide additional blocking as required.
- I. Install flush valves for barrier-free water closets with operator handle facing wide side of toilet stall.
- J. Provide unions at water connections to drinking fountains and electric water coolers.

3.2 PROTECTION

- A. Protect finished surfaces of fixtures from accidental damage or discoloration by use of protective covering.

3.3 CLEANING

- A. Prior to Owner acceptance, clean fixtures with compounds recommended by manufacturer and remove stains and marks from surrounding walls and countertops.

END OF SECTION 224000

SECTION 230000 - GENERAL MECHANICAL REQUIREMENTS

PART 1 GENERAL

1.1 DESCRIPTION

- A. Intent of drawings and Specifications is to obtain complete systems, tested, adjusted, and ready for operation.
- B. The terms "provide", "furnish" and "install" as used in Contract Documents shall have the following meanings:
 - 1. "Provide" or "provided" shall mean "furnish and install".
 - 2. "Furnish" or "furnished" does not include installation.
 - 3. "Install" or "installed" does not include furnishing.
- C. Include incidental details not usually shown or specified, but necessary for proper installation and operation.
- D. Check, verify and coordinate work with drawings and specifications prepared for other trades. Include modifications, relocations or adjustments necessary to complete work or to avoid interference with other trades.
- E. Information given herein and on drawings is as exact as could be secured but is not guaranteed. Do not scale drawings for exact dimensions.
- F. Where Architectural features govern location of work, refer to architectural drawings.
- G. Contractor may install additional piping, fittings and valves, not shown on drawings, for testing purposes or convenience of installation. Where such materials are installed, they shall comply with specifications and shall be sized to be compatible with system design. Remove such installed materials when they interfere with design conditions or as directed by Architect.

1.2 RELATED WORK

- A. Utility Services:
 - 1. Determine utility connection requirements and include in Base Bid all costs to Owner for utility service.
 - 2. Include costs for temporary service, temporary routing of piping or any other requirements of a temporary nature associated with utility service.
- B. Temporary Services:
 - 1. Division 01 - Temporary Facilities and Controls.
- C. Continuity of Service:
 - 1. No service shall be interrupted or changed without permission from Architect and Owner. Obtain written permission before any work is started.
- D. When interruption of services is required, Architect, Owner, and other concerned parties shall be notified and shall determine a time.

E. Concrete Work:

1. Provide cast-in-place concrete as required by Contract Documents unless otherwise noted.
2. Concrete shall comply with Division 03 - Concrete.
3. Provide anchor bolts, metal shapes and templates required to be cast in concrete or used to form concrete for support of mechanical equipment.

F. Painting:

1. Painting of mechanical equipment will be done under Division 09 unless specified otherwise or unless equipment is to be furnished with factory applied finish coats.
2. Contractor shall ensure mechanical equipment to be painted in the field be properly protected as not to void any equipment manufacturer warranties. Factory applied labels shall also be protected prior to any field painting. Equipment manufacturer's representative shall visually verify any field painted equipment for any warranty issues. If voided warranty items are found, contractor shall replace the item at no additional cost to the owner.
3. Equipment
 - a. Furnish equipment with factory applied prime finish unless otherwise specified.
 - b. If factory finish on equipment furnished by Contractor is damaged in shipment or during construction, refinish equipment to satisfaction of Architect.
4. Piping:
 - a. Uninsulated Piping
 - 1) Paint cast iron, carbon steel, and copper piping.
 - 2) Galvanized steel and stainless steel piping shall not be painted.
 - b. Insulated Piping
 - 1) Paint exposed insulated piping.
 - 2) Aluminum, stainless steel, PVC, and pre-colored insulation jackets shall not be painted.

1.3 REQUIREMENTS OF REGULATORY AGENCIES

- A. Rules and regulations of Federal, State and Local Authorities and utility companies, in force at time of execution of Contract shall become part of this specification.

1.4 REFERENCE STANDARDS

- A. Agencies or publications referenced herein refer to the following:

1. AGA - American Gas Association
2. AMCA - Air Movement and Control Association
3. ANSI - American National Standards Institute
4. AHRI - Air-Conditioning, Heating and Refrigeration Institute
5. ASHRAE - American Society of Heating Refrigerating and Air Conditioning Engineers
6. ASPE - American Society of Plumbing Engineers
7. ASSE - American Society of Sanitary Engineering
8. AWS - American Welding Society

9. AWWA - American Water Works Association
10. ASME - American Society of Mechanical Engineers
11. ASTM - American Society for Testing and Materials
12. CDA - Copper Development Association
13. CISPI - Cast Iron Soil Pipe Institute
14. FMG - FM Global
15. FS - Federal Specifications
16. IEEE - Institute of Electrical and Electronics Engineers
17. MCA - Mechanical Contractors Association
18. MSS - Manufacturers Standardization Society
19. NEC - National Electrical Code
20. NEMA - National Electrical Manufacturers Association
21. NFPA - National Fire Protection Association
22. NIST - National Institute of Standards & Technology
23. NSF - National Sanitation Foundation
24. NSPI - National Spa and Pool Institute
25. OSHA - Occupational Safety and Health Administration
26. PDI - Plumbing and Drainage Institute
27. SMACNA - Sheet Metal and Air Conditioning Contractors National Association
28. UL - Underwriters Laboratories, Inc.
29. WQA - Water Quality Association

- B. Work shall be in accordance with latest edition of codes, standards or specifications unless noted otherwise.

1.5 SUBMITTALS

A. Product Data:

1. Refer to Division 01 - Submittal Procedures.
2. Unless otherwise indicated submittals shall be in electronic Portable Document Format (pdf) and bookmarks shall be included to facilitate navigation through submittal documentation.
3. Submit for equipment and systems as requested in the respective specification sections.
4. Specifically mark general catalog sheets and drawings to indicate specific items submitted and its correlation to specific designation for product in drawings.
5. Specifically indicate proper identification of equipment by name and/or number, as indicated in specification and shown on drawings.
6. When manufacturer's reference numbers are different from those specified, provide correct cross-reference numbers for each item. Clearly mark and note submittals accordingly.
7. Submit complete record of required components when fixtures, equipment and items specified include accessories, parts and additional items under one designation.
8. Include composite wiring diagrams for electrically powered equipment and devices.

9. Where submittals cover products containing non-metallic materials, include "Material Safety Data Sheet" (MSDS) from manufacturer stating physical and chemical properties of components and precautionary considerations required.
 10. Submit shop drawings or product data as soon as practicable after signing contracts. Submittals must be approved before installation of materials and equipment.
 11. Submittals that are not complete, not permanent or not properly checked by Contractor will be returned without review.
 12. Submit Coordination Drawings to coordinate work among various trades and to facilitate installation. These drawings typically include dimensioned piping, ductwork or electrical raceway layouts. Coordinate with other trades to identify equipment connections, clear space requirements and specific system routing. Coordination drawings shall be reviewed for conformation with general system design intent.
- B. Certificates and Inspections:
1. Obtain and pay for inspections required by authorities having jurisdiction and deliver certificates approving installations to Owner unless otherwise directed.
- C. Operation and Maintenance Manuals:
1. Refer to Division 01 - Operation and Maintenance Data.
 2. Upon completion of Work but before final acceptance of system, submit to Architect for approval, 3 copies of operation and maintenance manuals in loose-leaf binders. If "one copy" is larger than 2" thick or consists of multiple volumes, submit only one set initially for review. After securing approval, submit 3 copies to Owner.
 3. Organize manuals by specification section number and furnish table of contents and tabs for each piece of equipment or system.
 4. Fire protection system shall be separately bound.
 5. Manuals shall include the following:
 - a. Copies of Shop Drawings and Product Data
 - b. Manufacturer's operating and maintenance instructions. Include parts lists of items or equipment, with component exploded views and part numbers. Where manufacturer's data includes several types or models, designate applicable type or model.
 - c. Electronic versions O&M data with exploded parts lists where available
 - d. Phone numbers and addresses of local parts suppliers and service companies
 - e. Internet/WEB page addresses where applicable
 - f. Wiring diagrams
 - g. Startup and shutdown procedures
 - h. Composite electrical diagrams
 - i. Flow diagrams
 - j. Lubrication instructions
 - k. Factory and field test records (Refer to Test and Balancing in Part 3 of this section.)
 - l. Air and water balance reports
 - m. Valve identification charts as specified in Section 230553 - Mechanical Systems Identification.

- n. Access panel identification charts as specified in Section 230553 - Mechanical Systems Identification.
 - o. Additional information, diagrams or explanations as designated under respective equipment or systems specification sections.
 - 6. Instruct Owner's representative in operation and maintenance of equipment. Instruction shall include complete operating cycle on all apparatus.
 - 7. Furnish O&M Manuals and instructions to Owner prior to request for final payment.
- D. Record Documents:
- 1. Refer to General Conditions of Contract, and Division 01 - Project Record Documents. Prepare complete set of record drawings in accordance with Division 01.
 - 2. Use designated set of prints of Contract Documents as prepared by Architect to mark-up for record drawing purposes.

1.6 JOB CONDITIONS

- A. Building Access:
- 1. Arrange for necessary openings in building to allow for admittance of all apparatus.
- B. Electrical Coordination:
- 1. Refer to Section 230513 - Motors for Mechanical Equipment
 - 2. Contractor shall provide the following items as specified under their respective Division(s):
 - a. Motors
 - b. Electrically powered equipment
 - c. Electrically controlled equipment
 - d. Starters, where specified
 - e. Variable frequency drives, where specified
 - f. Control devices, where specified
 - g. Temperature Control wiring
 - h. Wiring diagrams to Electrical Contractor for apparatus indicating external connection and internal controls.
 - i. Disconnect devices furnished with units (VFDs, chillers, prepackaged control devices, etc.)
 - 1) Devices shall have an interrupting rating not less than that of the upstream overcurrent device as shown on electrical drawings.
 - 2) Equipment electrical connection points shall be labeled with listed electrical short circuit current rating (SCCR). SCCR shall not be less than interrupting rating of upstream overcurrent device as shown on electrical drawings. SCCR shall be marked on equipment control enclosure in accordance with UL 508, or other acceptable, accredited third-party testing agency standards.
 - 3. Electrical Contractor will provide the following devices required for control of motors or electrical equipment, unless noted otherwise.
 - a. Starters
 - b. Disconnect devices

- c. Control devices:
 - 1) Pushbuttons
 - 2) Pilot lights
 - 3) Contacts
 - d. Conduit, boxes and wiring for power wiring.
 - e. Conduit, boxes and wiring for control wiring, except temperature control wiring.
 - 4. Electrical Contractor will make connections, from power source to starter or variable frequency drive and from starter or variable frequency drive, where specified, to motor.
 - 5. Where starters or other similar control devices are furnished by this Contractor, they shall be installed by this Contractor and wired by Electrical Contractor.
 - 6. Should any change in size, hp rating, voltage, or means of control be made to any motor or other electrical equipment after Contracts are awarded, this Contractor shall immediately notify Electrical Contractor of change. Additional costs due to these changes shall be responsibility of this Contractor.
- C. Cutting and Patching:
- 1. Refer to General Conditions of the Contract, and Division 01 - Cutting and Patching.
 - 2. Perform cutting and patching required for complete installation of systems, unless otherwise noted. Patch and restore work cut or damaged to original condition. This includes openings remaining from removal or relocation of existing system components.
 - 3. Provide materials required for patching unless otherwise noted.
 - 4. Do not pierce beams or columns without permission of Architect and then only as directed. If openings are required through walls or floors where no sleeve has been provided, hole shall be core drilled to avoid unnecessary damage and structural weakening.
 - 5. Where alterations disturb lawns, paving, walks, etc., replace, repair or refinish surfaces to condition existing prior to commencement of work. This may include areas beyond construction limits.
- D. Housekeeping and Cleanup:
- 1. Refer to Division 01 - Closeout Procedures.
 - 2. As work progresses and/or as directed by Architect, periodically remove waste materials from building and leave area of work broom clean. Upon completion of Work, remove tools, scaffolding, broken and waste materials, etc., from site.

1.7 WARRANTY

- A. Refer to Division 01 for general warranty requirements.
- B. Refer to technical sections for warranty requirement for each system.
 - 1. Where no warranty requirements are called out, warrant equipment, materials, and workmanship to be free from defect as called out in Division 01.
- C. Warrant that systems will operate without objectionable noise, vibration and uncontrolled expansion.
- D. Repair, replace or alter systems or parts of systems found defective at no extra cost to Owner.

- E. In any case, wherein fulfilling requirements of any warranty, if this Contractor disturbs any work warranted under another contract, this Contractor shall restore such disturbed work to condition satisfactory to Architect and warranty such restored work to same extent as it was warranted under such other contract.
- F. Warranty shall include labor, materials, and travel time.

PART 2 PRODUCTS

2.1 PRODUCT SUBSTITUTIONS

- A. Refer to Division 01 - Product Requirements.

PART 3 EXECUTION

3.1 GENERAL

- A. Verify elevations and dimensions prior to installation of materials.

3.2 DELIVERY, STORAGE, HANDLING, AND PROTECTION

- A. Deliver products to the site under provisions of Division 01.
- B. Store and protect products under provisions of Division 01.
- C. Store in clean, dry space.
- D. Maintain factory wrapping or provide cover to protect units from dirt, water, construction debris, and traffic.
- E. Handle in accordance with manufacturer's written instructions.
- F. Handle carefully to avoid damage to components, enclosure, and finish. Lift only with lugs provided for the purpose.
- G. Provide supplemental heat if required to prevent equipment from moisture contamination.
- H. Protect openings in equipment until connected to system to prevent entry of foreign materials.

3.3 EXCAVATION AND BACKFILL

- A. Refer to Division 31 - Earthwork.
- B. Provide excavation and backfill for underground work unless otherwise indicated. Blasting is not allowed on this project without written permission of Architect and Owner.
- C. Backfill trenches beneath concrete floor and stair slabs within building and beneath concrete slabs, walks, stairs and drives at exterior of building with gravel fill and compact to same density as surrounding area.

3.4 FLOOR, WALL, ROOF AND CEILING OPENINGS

- A. Coordinate location of openings, chases, furred spaces, etc., with appropriate Contractors. Provide sleeves and inserts that are to be built into structure during progress of construction.
- B. Remove temporary sleeves, if used to form openings, prior to installation of permanent materials. Utilize minimum 24 ga galvanized sheet metal for permanent sleeves unless otherwise noted.
- C. Provide Schedule 40 carbon steel pipe with integral water stop for steel sleeves required in interior floor slabs.
- D. Submit to Structural Engineer for review and approval size and location of core-drilled holes prior to execution.
- E. Submit product data and installation details for penetrations of building structure. Include schedule indicating penetrating materials (metal pipe, plastic pipe, conduit, etc.), sizes of each, opening sizes and sealant products intended for use.
- F. Firestopping systems will be provided under Division 07 - Firestopping, unless otherwise indicated.
- G. Submit complete penetration layout drawings showing openings in building structural members including floor slabs, bearing walls, shear walls, etc. Indicate and locate, by dimension, all required openings, including those sleeved, formed or core drilled. Drawings shall be approved prior to preparing openings in structural member.
- H. Provide minimum 1" clearance around penetration openings intended for pipe. Where fire resistant penetrations are required, size openings in accordance with written recommendations of firestopping systems manufacturer.
- I. Openings for underground pipes passing through foundations or under footings shall have minimum clearance of 1-1/2" to concrete. Do not disturb footing bearing soil.
- J. Openings for underground pipe passing through on grade concrete slabs shall have minimum 1/4" clearance to concrete. Seal openings with urethane caulk.
- K. Openings for insulated piping shall be sized based on outside diameter of insulation when it is specified or detailed to be continuous through opening.
- L. Openings for duct penetrations shall be no more than 1/2" larger on all sides than size of duct or duct including duct insulation, if applicable. Where firestopping systems are required at penetrations, size in accordance with recommendations of firestopping systems manufacturer, but opening shall not exceed 1" average clearance on all sides. Openings for ducts with fire dampers shall be in accordance with fire damper installation requirements.
- M. Duct penetrations through concrete floors in mechanical rooms containing liquid heat exchangers and/or pumps shall have 2" high water stopped curbs surrounding openings. This applies to mechanical rooms above the lowest floor level.

- N. Seal non fire-rated floor penetrations with non-shrink grout equal to Embeco by Master Builders, or urethane caulk, as appropriate.
- O. Seal non fire-rated wall openings with urethane caulk.
- P. Where penetrations occur through exterior walls into building spaces, use sleeves with integral water stop. For piping having outer surface temperature less than 150°F, use plastic (HDPE) sleeves, similar to PSI Link-Seal Model CS, rated to 150°F. For piping having outer surface temperature 150°F or higher, or where steel sleeves are shown or walls are fire rated, use steel sleeves with hot dip galvanizing, similar to PSI Link-Seal Model WS. Seal annular space between sleeves and pipe with Thunderline "Link-Seal" modular wall and casing seals, or sealing system by another manufacturer approved as equal by Architect. Where "Link-Seals" are used with insulated pipe, insulation shall be butted against seals on both sides. Sealing system shall utilize Type 316 stainless steel bolts, washers and nuts.
- Q. In lieu of openings as specified herein penetration systems as manufactured by Pro Set may be used, including sleeve couplings and plug.
- R. If total ProSet system with Water Guard "CR" is used, opening shall not need additional water proofing or riser clamps.
- S. Finish and trim penetrations as shown on details and as specified.
- T. Provide chrome or nickel plated escutcheons where piping passes through walls, floors or ceilings and is exposed in finished areas. Size escutcheons to fit pipe and pipe covering for finished appearance. Finished areas shall not include mechanical/electrical rooms, janitors' closets, storage rooms, etc., unless suspended ceilings are specified.
- U. Trim duct penetrations exposed in finished areas with 2" wide galvanized or aluminum trim collars properly sized to fit duct. Collars shall be same gauge as duct, prime finish unless noted otherwise. Finished areas shall not include mechanical rooms, janitors' closets, storage rooms, etc., unless suspended ceilings are specified.

3.5 EQUIPMENT SHUTOFF VALVES

- A. Provide shutoff valves at equipment connected to piping system. Refer to valve section or system section for requirements of valve type.

3.6 EQUIPMENT ACCESS

- A. Install piping, conduit and accessories to permit access to equipment for maintenance. Relocate piping, equipment or accessories to provide access at no additional cost to Owner.
- B. Install equipment with sufficient maintenance space for removal, repair or changes to equipment. Provide ready accessibility to equipment without moving other future or installed equipment (including light fixtures) or system components.
- C. Access doors in walls, chases, or inaccessible ceilings will be provided under Division 08 - Access Doors and Frames, unless otherwise indicated. Access doors for valves, shock stops or other equipment shall provide access for servicing, repairs, and/or maintenance.

- D. Provide necessary coordination and information to the Trade Contractor under Division 08 - Access Doors and Frames. This information shall include required locations, sizes, and rough-in dimensions.

3.7 EQUIPMENT SUPPORTS

- A. Provide supporting steel not indicated on drawings as required for installation of equipment and materials including angles, channels, beams, hangers, etc.

3.8 EQUIPMENT GUARDS

- A. Provide equipment guards over belt driven assemblies, pump shafts, exposed fans, and elsewhere as indicated in this Specification or required by Code.
- B. Paint equipment guards bright yellow.
- C. Equipment guards shall comply with OSHA requirements.

3.9 SUPPORT PROTECTION

- A. In occupied areas, mechanical rooms and areas requiring normal maintenance access, guard certain equipment to protect personnel from injury.
- B. Provide minimum 1/2" thick Armstrong Armaflex insulation or similar product applied with Armstrong 520 adhesive on lower edges of equipment and mechanical supporting devices suspended less than 7 ft above floors, platforms or catwalks in these areas.
- C. Protect threaded rod or bolts at supporting elements as described above. Trim threaded rod or bolts such that they do not extend beyond supporting element and devices.

3.10 MECHANICAL SYSTEMS IDENTIFICATION

- A. Refer to Section 230553 - Mechanical Systems Identification

3.11 TEST AND BALANCING

- A. Tests for equipment, ductwork and piping systems shall be performed as specified in their respective specification sections in accordance with technical requirements noted.
- B. Provide equipment required for testing, including fittings for additional openings required for test apparatus.
- C. All ductwork and piping inspections and testing shall be successfully completed and approved before application of covering materials.
- D. When equipment or systems fail to meet minimum test requirements, replace or repair defective work or material as necessary and repeat inspection and test until equipment or systems meet test requirements. Make repairs with new materials. Caulking of holes or threaded joints is not allowed.

- E. Contractor is responsible for certifying in writing equipment and system test results. Certification shall include identification of portion of system tested, date, time, test criteria, test medium and pressure used, duration of test and name and title of person signing test certification document.
- F. Maintain copies of certified test results, including those for any failed tests, at project site. At completion of project, include copies of test records and certifications in O&M Manuals.
- G. Balancing of various systems shall be in accordance with associated specification sections in addition to requirements noted herein.

3.12 START-UP

- A. Systems and equipment shall be started, tested, adjusted and turned over to Owner ready for operation. This includes "Owner-Furnished, Contractor-Installed" (OFCI) and "Contractor-Furnished, Contractor-Installed" (CFCI) systems and equipment.
- B. Follow manufacturer's pre-start-up check-out, start-up, trouble shooting and adjustment procedures.
- C. Contractor shall provide services of technician/mechanic knowledgeable in start-up and check-out of types of systems and equipment on project.
- D. Provide start-up services by manufacturer's representative where specified or where Contractor does not have qualified personnel.
- E. Coordinate start-up with all trades.

3.13 LUBRICATION

- A. Upon completion of work and before turning over to Owner, clean and lubricate bearings except sealed and permanently lubricated bearings. Use only lubricant recommended by manufacturer.
- B. Contractor is responsible for maintaining lubrication of mechanical equipment under this Contract until Work is accepted by Owner.

3.14 CLEANING

- A. Clean systems after installation is complete.
- B. Clean piping and ductwork both internally and externally to remove dirt, plaster dust or other foreign materials. When external surfaces of piping are rusted, clean and restore surface to original condition.
- C. Clean pipeline strainers to restore them to original condition or replace with new strainer elements.
- D. Clean equipment and plumbing fixtures as recommended by manufacturers.

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- E. Replace throwaway or replaceable media air filters used during construction period with new filters or new filter media after construction has been completed and before building is turned over to Owner. Filter replacement shall be as hereinafter specified.
- F. Blow and clean dirt, plaster dust and other foreign matter from coils, terminal devices, diffusers, registers and grilles.
- G. Thoroughly clean equipment of stains, paint spots, dirt and dust. Remove temporary labels not used for instruction or operation.
- H. Provide additional cleaning of individual piping systems and apparatus as hereinafter specified.

END OF SECTION 230000

SECTION 230513 - MOTORS FOR MECHANICAL EQUIPMENT

PART 1 - GENERAL

1.1 SUBMITTALS

A. Product Data including the following:

1. Manufacturer
2. hp, voltage, phase, hertz, rpm
3. Motor type
4. Enclosure type
5. Frame type
6. Insulation class
7. NEMA design designation
8. Service factor
9. Nominal efficiency at full load
10. Power factor at full load
11. Full load amperes
12. Bearings
13. Mountings
14. Dimensions
15. Weight
16. Shaft grounding brush for motors driven by Variable Frequency Drives (VFD)

1.2 PRODUCT CRITERIA

- A. Motors covered by this Specification shall conform to applicable requirements of NEMA, IEEE, ANSI, and NEC Standards and shall be UL Listed where applicable for service specified.
- B. Motors shall be designed for conditions in which they will be required to perform; i.e., general purpose, splash proof, explosion proof, standard duty, high torque or other special type as required by equipment manufacturers.
- C. Select motors so they do not exceed nameplate rating nor operate into service factor to meet specified duty.
- D. Motors located inside air handling units or exposed located in outdoor or wash down environments shall have totally enclosed fan cooled (TEFC) enclosures.
- E. Motors shall be furnished for starting in accordance with utility requirements and be compatible with starters specified hereinafter or under Electrical sections of Specifications.
 1. Refer to Section 262913 - Enclosed Controllers for reduced voltage starting requirements.
 2. Starters for NEMA rated 200 or 230 V motors, 25 hp and above shall be reduced voltage starting type.

3. Starters for NEMA rated 460 V motors, 60 hp and above to be reduced voltage starting type.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Materials shall be new and guaranteed for service intended.

2.2 ELECTRICALLY COMMUTATED MOTORS (ECM)

- A. Motor assembly shall be designed for use on direct drive fans or pumps and shall be electrically commutated, DC, brushless type, specifically designed for use with 120 V or 208-230/277 V, 60 Hz single-phase electrical input or three-phase, 60 Hz electrical input as scheduled.
- B. Motor speed shall be variable via compatible input signal and shall be complete with and operated by single-phase integrated controller/inverter that operates wound stator and senses rotor position to electronically commutate stator. Motor shall maintain minimum of 70% efficiency over entire operating range.
- C. Motors shall:
 1. have permanently lubricated ball bearings
 2. be designed for synchronous rotation.
 3. be permanent magnet type with near-zero rotor losses.
 4. be able to be mounted with shaft in horizontal or vertical orientation.
 5. be controllable from local and remote speed-control adjustments
 6. be designed to overcome reverse rotation without affecting life expectancy
- D. Provide Power Factor Correction / Harmonic Correction module to limit harmonic distortion to less than 10% THDi at input of the filter.
- E. Speed Control (Drive):
 1. Motor manufacturer shall provide factory installed PWM speed control drive for local (manual) and remote speed adjustment. Local PWM drive shall be field adjustable with standard screwdriver. Drive shall also be capable of receiving 0-10 vdc signal from DDC controller to control fan or pump speed.
 2. Drive shall provide soft start and adjustable speed change ramp rate.
 3. Drive shall provide motor protection consisting of locked rotor, over-current, and thermal overload protection at minimum.

2.3 INDUCTION MOTORS

- A. Voltage Ratings
 1. Refer to equipment schedules and specification sections for voltages required.
 2. Unless otherwise indicated, motors 1/3 hp and smaller shall be rated 115 V for operation on 120 V, 1 Ph, 60 Hz service.
 3. Unless otherwise indicated, motors 1/2 hp and larger shall be rated:

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- a. 460 V for operation on 480 V, 3 Ph, 60 Hz service.
 - b. 200 V for operation on 208 V, 3 Ph, 60 Hz service.
 - c. 230 V for operation on 240 V, 3 Ph, 60 Hz service.
- B. Motors shall be 4 pole (approximately 1750 rpm) unless otherwise noted.
- C. Single-phase motors shall be furnished with built-in thermal overload protection.
- D. Use NEMA Design B motors, normal starting torque with regreasable ball bearings, and Class B insulation unless specified otherwise or unless manufacturer of equipment on which motor is being used has more stringent requirements.
1. Bearings shall be rated for minimum AFBMA 9, L-10 life of 26,280 hours (belted) and 200,000 hours (direct-coupled) at full-load.
- E. Motors shall be rated continuous duty and have 1.15 service factor unless otherwise noted.
- F. Motors Driven by Variable Frequency Drives (VFD)
1. Motors shall comply with the latest NEMA MG 1, Section IV, Part 31.
 2. Motors shall have service factor not less than 1.0 at rated load.
 3. Insulation shall be Class F or H.
 4. Furnish each motor with shaft grounding ring utilizing conductive microfiber similar to AEGIS SGR to protect motor bearings from electrical damage.
- G. Vibration shall not exceed 0.15" per second, unfiltered peak unless otherwise noted.
- H. Motors (180 frames and larger) shall have provisions for lifting eyes or lugs capable of safety factor of 5.
- I. Full load nominal efficiency of motors 1 hp and larger, except special-purpose motors including 2-speed or multi-speed motors, and rewind motors, shall meet or exceed listed values when tested in accordance with IEEE Standard 112 Method B as defined by NEMA MG 1-12.6C. Efficiency values listed are based on NEMA Premium Efficiency Electric Motors of NEMA MG 1-2011, Table 12-12.

	<u>Open Drip-Proof Motors</u>			<u>Totally Enclosed Fan-Cooled Motors</u>		
	1200 rpm	1800 rpm	3600 rpm	1200 rpm	1800 rpm	3600 rpm
(hp)	(6 pole)	(4 pole)	(2 pole)	(6 pole)	(4 pole)	(2 pole)
1 hp	82.5	85.5	77.0	82.5	85.5	77.0
1.5 hp	86.5	86.5	84.0	87.5	86.5	84.0
2 hp	87.5	86.5	85.5	88.5	86.5	85.5
3 hp	88.5	89.5	85.5	89.5	89.5	86.

	<u>Open Drip-Proof Motors</u>			<u>Totally Enclosed Fan-Cooled Motors</u>		
	1200 rpm	1800 rpm	3600 rpm	1200 rpm	1800 rpm	3600 rpm
(hp)	(6 pole)	(4 pole)	(2 pole)	(6 pole)	(4 pole)	(2 pole)
5 hp	89.5	89.5	86.5	89.5	89.5	88.5
7.5 hp	90.2	91.0	88.5	91.0	91.7	89.5
10 hp	91.7	91.7	89.5	91.0	91.7	90.2
15 hp	91.7	93.0	90.2	91.7	92.4	91.0
20 hp	92.4	93.0	91.0	91.7	93.0	91.0
25 hp	93.0	93.6	91.7	93.0	93.6	91.7
30 hp	93.6	94.1	91.7	93.0	93.6	91.7
40 hp	94.1	94.1	92.4	94.1	94.1	92.4
50 hp	94.1	94.5	93.0	94.1	94.5	93.0
60 hp	94.5	95.0	93.6	94.5	95.0	93.6
75 hp	94.5	95.0	93.6	94.5	95.4	93.6
100 hp	95.0	95.4	93.6	95.0	95.4	94.1
125 hp	95.0	95.4	94.1	95.0	95.4	95.0
150 hp	95.4	95.8	94.1	95.8	95.8	95.0
200 hp	95.4	95.8	95.0	95.8	96.2	95.4
250 hp	95.4	95.8	95.0	95.8	96.2	95.8

- J. Single-phase motors for hard starting applications including outdoor applications shall be capacitor start type. Motors for fans and pumps located indoors may be split phase or permanent split-capacitor. Motors shall be equipped with permanently lubricated and sealed ball bearings and shall be selected for quiet operation. Motors 1/8 hp and below may be shaded pole type.
1. Refer to individual equipment section for additional requirements or specific type of motors.
- K. 3 Ph, 2-speed motors shall be one winding, consequent pole, variable torque type and 1 Ph, 2-speed motors shall be capacitor start capacitor run type.

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- L. When submersible pumps are specified, each pump shall include in addition to controls specified, all necessary controls, relays, wiring, etc. that may be required for safety features incorporated in motor design. No submersible motor shall be run or activated until all requirements of motor manufacturer's recommendations have been complied with.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install materials in accordance with drawings, approved Shop Drawings and manufacturer's recommendations.

END OF SECTION 230513

SECTION 230514 - VARIABLE FREQUENCY DRIVE (VFD) SYSTEM

PART 1 - GENERAL

1.1 SYSTEM DESCRIPTION

- A. Provide Variable Frequency Drives (VFD) for each pump, fan or other driven equipment sized to accommodate motors shown on drawings or schedules. Provide all VFDs from same manufacturer.
- B. VFD manufacturer shall review driven equipment and motors for VFD compatibility. Submit written statement from manufacturer of driven equipment along with VFD shop drawing submittals, indicating verification of compatibility.
- C. VFD shall vary speed of its respective fan, pump or other driven equipment motor in response to either 4-20 mA or 0-10 VDC control signal provided by Control Contractor.
- D. VFD system shall consist of the following
 - 1. Variable frequency drive(s)
 - 2. UL Listed disconnect device
 - 3. Electrical noise attenuation device as specified in VFD schedule.
 - 4. Motor starter for bypass mode operation with VFD/OFF/BYPASS selector and drive input and output isolation contactors where VFD bypass starters are scheduled.
 - 5. Internal reactor with minimum 5% impedance or equivalent input line reactor
 - 6. dV/dt Output filter as required to protect motor, based on total length of conductor from VFD to motor(s)
- E. Drives shall have SCCR (short circuit current rating) of equal to or higher than the upstream overcurrent device. kA.

1.2 QUALIFICATIONS

- A. VFD system shall be furnished by a manufacturer with at least 10 yrs experience in design, construction and application of VFD.

1.3 SUBMITTALS

- A. Product Data for each VFD system including the following:
 - 1. Manufacturer's name
 - 2. Identification of system components
 - 3. Type of enclosure, front elevation and plan view, equipment weight, conduit access locations
 - 4. Capacities/ratings/SCCR
 - 5. Warranty
 - 6. System wiring and block diagram showing system components
 - 7. Performance, control and protection data with specified features clearly shown

8. Operating and monitoring devices with specified features clearly indicated
 9. Start-up operation, maintenance, spare parts, and field tests
 10. Manufacturer's installation instructions
 11. Other appropriate data
- B. After quality assurance tests are complete, submit written certification that drive and components have passed factory quality assurance tests.
- C. Submit product and performance data on electrical noise attenuation device if required to meet electrical noise criteria specified. Isolation transformer is not electrical noise attenuation device.
- D. Submit printed list of settings for all items that require setting during startup or list of Factory Default Parameters.
- E. Submit calculations indicating conformance with electrical noise criteria specified. Refer to Electrical Documents for information regarding electrical building distribution system.

1.4 ELECTRICAL NOISE CRITERIA

- A. Provide harmonic mitigation components as scheduled. Refer to VFD schedule for components required.
- B. Definitions:
1. PCC: Point of Common Coupling. Location where Utility can supply service to other customers, typically at the point closest to the facility under evaluation.
 2. ITHD: Total harmonic current distortion
 3. VTHD: Total harmonic voltage distortion
- C. Voltage and current distortion generated by VFD and attenuation devices measured at point of common coupling, shall not exceed the following criteria as referenced by IEEE Standard 519.
1. Voltage total harmonic distortion (VTHD) shall not exceed 8% of fundamental input voltage at full load with 5% maximum RMS value on any single harmonic
 2. Current harmonic distortion (ITHD) shall not exceed 8% with maximum RMS value on any single harmonic based on IEEE 519-2014 Section 5.2 Table 2.
- D. VFD manufacturer shall perform harmonic analysis at point of common coupling to demonstrate that the limits specified in IEEE-519-2014 are satisfied. VFD manufacturer shall perform harmonic analysis at generator supply terminals to demonstrate that harmonic current and voltage distortion limits indicated are not exceeded while system is supplied with generator power.
1. If analysis includes conductor resistance / impedance and separate bus connections, estimated values that are more conservative than the actual installation will be acceptable (it is not necessary to define each conductor).
 2. VFDs provided under other specification sections (chillers, elevators, packaged equipment, etc.) shall also be included in analysis. Contractor shall be responsible for gathering VFD information from other specification sections and providing it to VFD manufacturer performing analysis.

3. Analysis shall be computer generated and perform Fourier analysis of system. Results shall list current and voltage amplitudes of all harmonics up to 50th level at PCC. A summary shall detail percent total harmonic distortion for voltage and total demand distortion for current.
 4. Analysis shall assume maximum transformer loading of 100% of nameplate value. Analysis shall assume maximum generator loading of 100% of nameplate value.
 5. Analysis shall assume motor loading of 100% of nameplate full load amps.
 6. Analysis shall assume 5.5% impedance at service transformer for the purposes of calculating available fault current. Assume infinite utility fault capacity for the purposes of this study only.
- E. Drive type shall be based on findings of the IEEE 519 analysis with minimum configurations based on motor horsepower (horsepower shall include total horsepower connected to given drive, e.g. 4@30 hp = 120 hp), with minimum harmonic mitigation equipment as follows:
1. Less than 50 hp – 6 pulse with input line reactor
 2. 50 hp and larger – 6 pulse with passive harmonic filter, or active front end drive
 3. In lieu of requirements noted above, engineered solution specific to this project that employs multi-pulse drives, passive filtering, active filtering, line reactors, etc. may be used. Proposed solution shall be submitted for Engineer's approval prior to bidding. Where multi-pulse drives or active filters are proposed, submittal must include plan drawing indicating the physical dimensions of the proposed equipment coordinated with other equipment within the project boundary.
- F. Electrical one line diagrams shown on Electrical Drawings include transformer kVA and typical configuration of electrical system. Use this information for evaluation of harmonics for bidding purposes.
- G. Successful contractor must provide required data for VFD manufacturer to complete harmonic analysis. Information shall include utility short circuit amperes capability; distribution transformer kVA and impedance; length, size and number of wires per phase to distribution equipment feeding VFDs; wire data to VFDs from distribution equipment; wire data to motor from VFD; and motor nameplate data.
- H. VFD manufacturer is responsible for cost of all equipment required to meet harmonic limits identified above, based on IEEE-519 standards. Equipment, which can be provided, includes input line reactors, DC bus reactors and harmonic filters.

1.5 START-UP OPERATION AND MAINTENANCE DATA

- A. Provide services of factory trained engineer or technician to approve installation; start-up test and adjust for proper operation; and instruct and train Owner's representative in operation and maintenance of VFD systems. Provide minimum of 4 h of Owner training for VFD system.
- B. Should drive operation be deficient, make changes necessary to bring units into compliance with specified performance requirements. Cost of changes and retest shall be borne by drive manufacturer.

- C. Upon completion of this service, submit report signed by manufacturer's service representative, including start-up and test log. Provide documentation of all setpoints and user adjustable parameters as configured for each drive.
- D. Include additional 2 yr (total 3 yrs) warranty for VFD system, covering parts, labor and travel expenses.

PART 2 - PRODUCTS

2.1 MANUFACTURER

- A. Manufacturers: ABB, Allen Bradley/Rockwell Automation, Emerson, Eaton, Danfoss, GE, Schneider Electric, Yaskawa, or Toshiba

2.2 FABRICATION

- A. VFD shall be variable torque, solid state, microprocessor-based control, modular design for standard induction AC motor.
- B. VFD components shall be factory mounted and wired in NEMA 1 enclosure with lockable door handle.
- C. Circuitry shall be plug-in, plug-out modular. Printed circuit boards shall have protective coating to reduce corrosion.
- D. Unit shall conform to NEMA and NEC standards and be CSA, UL or ETL Listed. Control circuitry shall be electrically isolated from power circuitry. Entire assembly panel shall have UL or equivalent panel sticker.
- E. Inverter section shall be pulse width modulated (PWM) design and most current insulated gate bipolar transistors (IGBTs) technology.

2.3 PERFORMANCE REQUIREMENTS

- A. Input: 460 (+10%, -15%) VAC, 3 Ph, 60 (± 2) Hz
- B. Output: 460 VAC, 3 Ph, 10 to 60 Hz
- C. Operating Environment: VFD Manufacturer shall rate VFDs for specific environment in which they will operate.
 - 1. Ambient temperature:
 - a. Indoor applications: 14°F to 104°F
 - b. Outdoor applications: 14°F to 104°F
 - 2. Relative humidity: 95% non-condensing
 - 3. Elevation above sea level: 0 ft to 3280 ft
- D. Linear acceleration and deceleration adjustable from 5 to 60 seconds. Provide adjustable v/Hz ratio and low speed boost features.

- E. Output Current Rating: Continuous full load output current rating of drive shall not be less than that listed for motor of equivalent horsepower in NEC table 430-150.
- F. Drive overload capacity to be minimum 110% of motor FLA based on NEC ratings for one minute.
- G. Time to Shutdown: Inversely proportional to square of overload current ($t = k/I^2$).
- H. Motor Regeneration Protection: Unit shall have capacity of dissipating regeneration energy up to VFD current rating without damage to or shutdown of drive. Unit shall be capable of starting into rotating load.
- I. Output Frequency Stability: $\pm 0.5\%$ of base frequency in 24 h throughout range of rated operating conditions.
- J. Output Voltage Regulation: $\pm 2\%$ of maximum rated output voltage.
- K. Output voltage rise time shall be no faster than 1000 V/micro sec measured at the motor terminals. If power and control cable between VFD and motor is more than 100 ft, provide dv/dt output filter.
- L. Power Loss Ride-Through: 1 cycle.
- M. Linearity (speed reference to output frequency): $\pm 1.0\%$
- N. Input Power Factor: Minimum of 0.95 regardless of speed and load.
- O. Minimum drive efficiency as percent of input power shall be as follows:

<u>Percent Load</u>	<u>Frequency (Hz)</u>			
	<u>60</u>	<u>50</u>	<u>30</u>	<u>15</u>
100	97	96	95	90

2.4 CONTROL FEATURES

- A. VFD speed control circuit shall accept either 4-20 mA DC or 0-10 VDC isolated ungrounded transmitter signal in automatic mode and from manual speed control keypad in manual mode.
- B. Provide adjustable minimum and maximum speed settings (0 - 100%) for both auto and manual mode. Initial minimum setting shall be 25%.
- C. Provide adjustable automatic reset for fault trips, except short circuit type faults. After selected number of unsuccessful restart attempts, drive shall be shut down. Number of restart attempts and time interval between resets shall be selective.
- D. When unit shuts down due to power outage, unit shall be capable of being restarted manually or automatically.
- E. VFD shall be capable of starting into rotating loads spinning in any direction.
- F. Provide critical frequency avoidance circuit with at least 3 field adjustable bands to avoid operation at speeds, which cause excessive vibration in driven equipment.

- G. Provide isolated ungrounded output signal to indicate drive percent of speed or drive frequency.

2.5 COORDINATION WITH BUILDING AUTOMATION SYSTEM (BAS)

- A. Furnish each VFD with digital communication bus card for BAS use. Coordinate with Control Contractor for specific interface requirement.
- B. Provide contacts (1 NO and 1 NC contact) for remote input control of start/stop function for VFD mode.
- C. Provide three pre-programmed relay/contacts (1 NO and 1 NC contact each) for remote output indication of VFD fault condition, motor run status based on current or torque above minimum threshold, and bypass mode if bypass is specified.

2.6 PROTECTION FEATURES

- A. Power circuits shall be protected by electronic protection circuits. Electronic protection circuits shall provide orderly shutdown without blowing fuses and prevent component loss under the following abnormal conditions.
 - 1. Instantaneous overcurrent and over voltage trip of output
 - 2. Solid state protective circuit shall provide NEC motor running overload protection tested in accordance with UL 991
 - 3. Power line overvoltage or undervoltage
 - 4. Phase sequence detection or insensitivity to incoming power phase sequence
 - 5. Single and 3 Ph short circuit protection
 - 6. Control circuit malfunction
 - 7. Overtemperature
 - 8. Ground fault for all 3 phases
- B. VFD shall protect itself from damage due to phase-to-phase or phase-to-ground faults without fuse blowing or use of isolation transformers. VFDs which require isolation transformers to provide ground fault protection are not acceptable.
- C. In addition, provide the following protection features.
 - 1. Input line-to-line and line-to-ground transient protection up to 3000 V
 - 2. Control circuit transformer fusing
 - 3. Grounded control chassis
 - 4. Diagnostic indication
 - 5. One set of three (3) spare fuses for each size or type of VFD
- D. VFD shall employ adjustable torque limit control, which shall override speed command and decrease frequency while maintaining correct volts/hertz ratio whenever load level surpasses VFD design level or set point.

2.7 OPERATING AND MONITORING DEVICES

- A. The following functionality shall be provided and may be controlled via touchscreen/keypad:

1. Hand-Off-Auto device
 2. Operating mode selector device marked "Hand-Off-Auto"
 3. Manual speed control keypad
 4. Power on indication
 5. Drive run indication
 6. Drive fault indication with testable feature
 7. Fault reset device
- B. Speed indicating meter or digital indication (0 - 100%) calibrated in percent speed or frequency meter with 0 to 90 Hz scale to indicate motor speed.
- C. Integral digital programming and operating display which shows Hz, Percent Output Current, Output Voltage, Percent Output Power, Operating Parameters and their values, and Diagnostic Fault Codes. In addition, Keypads shall be incorporated to facilitate digital programming of drive adjustments. Analog potentiometer adjustments are not acceptable.
- D. Provision shall be included to provide selectable programming security by inhibiting program parameter changes with password security.
- E. Control shall incorporate microprocessors for operator interface, diagnostics, and fault managements, and power management.
- F. Optional programming software, which includes provision for serial communication with drive, shall be available for shipment at time of equipment order placement.
- G. Fault buffers to sequentially store last 4 faults. Parameter and fault information to be stored in non-volatile memory.
- H. VFD with Manual Bypass Starter:
1. Manual selector switch to select power through VFD or bypass line with label marked "VFD/OFF/BYPASS".
 2. Electrically-interlocked VFD/BYPASS contactors with padlocking capability on input side of VFD and bypass starter. Interlock shall be accomplished such that shorting together of any 2 control circuit points cannot cause non-selected device to be energized. Provide electrically-interlocked device that connects only output of selected starting device (VFD or bypass starter) to VFD system output lug. Single shorting of any 2 control circuit points shall not cause both VFD and bypass starter outputs to be interconnected.
- I. Redundant VFDs:
1. Manual selector switch to select power through VFD1 or VFD2 with label marked "VFD1/AUTO/VFD2".
 2. Electrically-interlocked VFD1/VFD2 contactors with padlocking capability on input side of VFDs. Interlock shall be accomplished such that shorting together of any 2 control circuit points cannot cause non-selected device to be energized. Provide electrically-interlocked device that connects only output of selected starting device to system output lug. Single shorting of any 2 control circuit points shall not cause both VFD outputs to be interconnected.

2.8 QUALITY ASSURANCE TESTS

- A. Complete drive assembly shall be factory tested with actual AC induction motor, 100% load and temperature cycled within environment chamber at 104°F. Documentation of test shall be furnished to verify successful completion of test at Engineer's request.

2.9 DISCONNECT DEVICE

- A. Provide integral switch to disconnect incoming electrical power to units. Disconnect device shall be UL Listed devices:
 - 1. Enclosed molded case breaker; ampere rated and providing over current protection
 - 2. Fused switch may be used as option. Fused switch shall be ampere rated and provide overcurrent protection. Non-time delay fuses shall be sized for connected drive and motor.
- B. Disconnect device shall be capable of being padlocked in OFF position and complying with OSHA Requirements. Operating handle shall indicate whether switch is "ON" or "OFF".
- C. Switch shall have cover interlock to prevent unauthorized opening of switch door when handle is in "ON" position and to prevent closing of switch mechanism with door open. Provide defeater mechanism to defeat the interlock for user required access.

2.10 MOTOR CONTROL EQUIPMENT (BYPASS STARTERS)

- A. Bypass starter shall be NEMA or IEC Rated device of the following:
 - 1. Electromechanical across-the-line starter with solid state overload protection for 50 hp or smaller.
 - 2. Solid-state reduced voltage starter consisting of SCR based power section, logic control board and solid state overload protection for 60 hp or larger.
 - 3. Reduced voltage auto transformer - electromechanical starter with solid-state overload protection for 60 hp or larger.
 - 4. Bypass shall include high speed fuses for VFD (not in bypass circuit).
 - 5. Service switch to disconnect power to VFD (not in bypass circuit).

2.11 INPUT LINE REACTORS

- A. Series line reactors shall be designed for harmonic filtering service and shall be UL component recognized. Construction shall be copper wire wound on steel cores. Inductors shall be 3-phase. Series line reactors shall be sized per harmonic analysis and appropriately for total connected load. Design maximum temperature rise for inductors shall be 239°F.
- B. Inductors shall be air-gapped to avoid saturation. Inductance shall be measured under full load and shall be within $\pm 5\%$ of design value.
- C. Line reactor shall be included integral to drive enclosure.

1. Where mounting line reactor in VFD enclosure is not possible, enclosure shall be steel with enamel finish and no knockouts. Enclosure shall match construction of VFD enclosure and shall have hinged lockable cover. Screened openings shall be provided for enclosure ventilation. Enclosure shall be built with integral mounting brackets for platform or wall mounting. Coordinate location with other trades. Provide disconnect switch for line side filters.
- D. Internal DC bus chokes are acceptable when providing equivalent performance to AC line reactors specified.

2.12 PASSIVE HARMONIC FILTER

- A. Tuned passive harmonic filter shall be designed to remove harmonics generated by a 6-pulse VFD in a power distribution system. The filter shall be designed to minimize the possibility of resonance and other system problems associated with power factor correction in the presence of harmonic distortion.
- B. Inductive and capacitive elements shall be arranged in a series configuration and tuned to resonate just below the harmonic frequency for which it is designed to filter. The inductance internal to the filter combined with the series line reactor shall act to limit current surges between the capacitor and other plant electrical equipment, and shall minimize the possibility of equipment or capacitor damage due to such surges.
- C. Capacitors shall be high-endurance cells with a voltage rating capable of handling the nominal system voltage plus 10% over voltage. Capacitors shall be contained in sealed metal cans. The RMS current in each capacitor cell at full load shall not exceed 150% of the current at no load to limit the stress on capacitors.
- D. Both tuning inductors and series line reactors shall be designed for harmonic filtering service and for slowing the rate of rapid current changes. The core shall be made of laminated, magnetic steel. Windings shall consist of copper wire or copper foil. Completed inductors shall be impregnated using solid epoxy resin.
- E. Filter shall be housed internal to drive enclosure.
- F. Filter shall include contactor to disengage circuit capacitor if VFD is operating at 50% electrical power capacity or less. Set point shall be field programmable. Activation of contactor shall leave inductor in circuit for benefits of added circuit impedance. _____

2.13 ACTIVE FRONT END FILTER

- A. Active front end filter shall supply non-linear loads with near sinusoidal current waveform. Filter shall be rated for application at maximum fundamental system frequency of 60 Hz and nominal system voltages up to 600 V.
- B. Unit shall include input protection with minimum kAIC rating to match upstream electrical distribution equipment. Current limiting protection shall also be provided.
- C. Unit shall have ability to communicate via protocol to match Building Automation System.

- D. Multiple units may be installed in parallel as necessary to meet load requirements. Failure of single unit shall not impact other units in parallel.
- E. Unit shall have field configurable relay based fault output.

2.14 DV/DT OUTPUT FILTER

- A. dV/dt motor-protecting output filter shall be a low-pass filter consisting of a gapped, three phase iron core inductor, AC-rated capacitor and wire-wound resistors.
- B. The filter shall be rated for application at a maximum fundamental system frequency of 60 Hz at nominal system voltages up to 600V.
- C. Ambient temperature of operation shall be 104°F.
- D. The combined inductance, capacitance and resistance of the Output Filter shall be specifically designed to reduce voltage waveform dV/dt.

2.15 SPARE PARTS

- A. Additional enclosure cooling fan for each different type of drive.
- B. Additional key pad/touch screen for each different type of drive.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Visually inspect equipment and components at time of delivery. Submit report to Engineer with list of items or deficiencies to be corrected.

3.2 PROTECTION

- A. Protect VFD cabinets from dust/dirt during storage and operation until turned over to Owner.
- B. If VFDs are not furnished with internal air filter racks, provide temporary filter media to protect VFD cabinets and replace filter media as required.

3.3 INSTALLATION

- A. Install VFD system in accordance with details, approved submittals and manufacturer's instructions and recommendations.
- B. Provide field low voltage wiring of VFD system components. Provide field interconnecting wiring between VFD and filters, line reactors and/or by-pass starter if bypass starter is specified and the wiring is not installed at factory. Install wiring in metal conduit and in accordance with Electrical sections of this Specification and applicable Electrical Code.
- C. Provide output dV/dt filter for motor protection where the total conductor length between drive output and motor terminal(s) exceeds 50 ft.

- D. Provide control wiring between interlocks in VFD control circuits and driven motor's disconnect switches. Interlock VFD control circuits with driven motor's disconnect switches where such motor disconnect switches are provided. Disconnecting on-line motor shall shut down VFD. VFD shall restart upon reconnection of motor.
- E. Do not connect ground from one unit to another unit's cabinet.
- F. Use separate conduits for incoming and outgoing power conductors from each unit.
- G. Use separate conduit for control wiring for each unit. Do not combine control wiring with power wiring.
- H. Use minimum 18 ga shielded wiring with ground for control wiring.
- I. Unless otherwise indicated, mount VFD so that display and keypad are at approximately 5'-0" to 5'-6" above floor.
- J. Install floor mounted drives on 3-1/2" high concrete housekeeping pad.
- K. All conduits shall enter the VFD from bottom or lower side to mitigate water intrusion. Top entry is not allowed.

3.4 START UP

- A. VFD manufacturer shall perform field inspection, start-up and testing of VFD in accordance with procedures as defined by manufacturer for proper operation.
- B. Adjust critical frequency avoidance feature to step over frequencies which cause excessive vibration in driven equipment.
- C. Adjust passive harmonic filter capacitor contactor setpoint to ensure drives do not present leading power factor to electrical systems during low-load conditions.

END OF SECTION 230514

SECTION 230529 - MECHANICAL PIPING AND EQUIPMENT SUPPORTING DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Provide all supporting devices not provided as part of building structure or indicated on structural drawings or structural details, as specified and as required for proper supporting, anchoring, and guiding of piping, equipment, materials and systems.
- B. Support for all conditions of operation, including variations in installed and operating weight of equipment, piping and ductwork, to prevent excess stress and allow for proper expansion and contraction.

1.2 SUBMITTALS

- A. Product Data for each piping system for all pipe sizes and all applicable equipment including the following:
 - 1. Manufacturer's name
 - 2. Model numbers
 - 3. Materials of construction and load ratings lbs.
 - 4. Schedule of hangers and support devices with pipe support spacing
 - 5. Insulated pipe supports along with application chart or table including pipe support spacing.
 - 6. Insulation protection saddles and weight bearing insulation table
 - 7. Details and calculations for sizing supplementary steel utilized for trapeze or specially designed supports
 - 8. Structural attachments, inserts, and concrete anchors. Submit ICC-ES Evaluation Report for each type of anchor.
 - 9. Calculations and drawings for concrete inserts and anchors for each application
 - 10. Drawings showing specific locations of any weld attachments to structure, including weight supported by such attachments
 - 11. Drawings showing specific locations of any suspended loads which exceed 100 lbs within joist chord panel to be attached to open web steel joist structural members. Include weight supported by such attachments. (Panel is length of chord between two adjacent diagonal web members at point of connection to chord.)
 - 12. Equipment mounting devices
 - 13. Pipe guides and anchors
 - 14. All other appropriate data
- B. Submittals in PDF format shall be organized using PDF bookmarks per detailed instructions on assembling submittal packages identified under Submittal Requirements section of 230000 - General Mechanical Requirements

- C. Calculations and drawings prepared by the Contractor's structural engineer shall be submitted bearing the stamp of a licensed Structural Engineer registered in project jurisdiction, for approval.

1.3 DESIGN CRITERIA

- A. Materials and application of pipe hangers and supports shall conform to the latest requirements of ANSI B31/ASME B31.1 Code for Pressure Piping and MSS Standard Practice SP-58-2018 (Pipe Hangers and Supports Materials, Design, Manufacture, Selection, Application, and Installation), except as supplemented or modified herein.
- B. Support materials shall be steel or stainless steel unless specifically indicated.
- C. Support devices shall be factory fabricated and have published load ratings.
- D. Unless otherwise indicated, design supports, anchors, and related components with safety factor in accordance with AISC Manual of Steel Construction, but not less than 2.0.
- E. Determine maximum deflection using the following equation.
- F. Maximum deflection of support members, including trapeze supports, shall be in accordance with the following equation, but shall not exceed 0.3":
 - 1. $D = L/240$
D = Max deflection in inches
L = Support member length in inches
- G. Unless otherwise indicated, hangers, support devices and hardware shall be steel and shall have factory standard black, primed, galvanized or electroplated finish for indoor application, and hot-dipped galvanized finish for outdoor application and corrosive atmospheres. Coat cut edges, welds or any damaged finish with galvanized paint.
- H. Materials in contact with pipe shall be galvanically compatible with piping material to eliminate conductive path for galvanic corrosion. Where piping and support materials have galvanic potential, Provide galvanic separation, such as nonmetallic coating or inserts between piping and metallic supports. Pipe insulation is acceptable galvanic separation. Materials in contact with pipe shall be galvanically compatible with piping material to eliminate conductive path for galvanic corrosion. Where piping and support materials have galvanic potential, provide galvanic separation, such as nonmetallic coating or inserts between piping and metallic supports. Pipe insulation is acceptable galvanic separation. Galvanic potential shall be determined by table below:

	Galvanized Steel	Carbon Steel	Stainless Steel (Type 304 or 316)	Copper Brass Bronze
Copper, Brass, Bronze	Yes	Yes	No	NA
Stainless Steel (Type 304 or 316)	Yes Note (1)	Yes Note (1)	NA	
Carbon Steel	No	NA		
Galvanized Steel	NA			

(1) Required where stainless steel surface area near interface is equal or greater than steel surface area

- I. Unless otherwise indicated, steel support devices exposed to ventilation air stream shall be stainless steel or steel with either galvanized finish or paint finish. Paint type shall be approved by Architect.
- J. This Contractor is responsible for proper placement and sizing of supporting devices to accommodate insulation thickness and pitching of pipe. Coordinate with Contractor performing work specified in Section 230700 - Mechanical Systems Insulation.
- K. In addition to hangers specified in this Section, piping connected to pumps, compressors, and similar rotating or reciprocating equipment shall have vibration isolation hangers or supports for specified distance from such equipment. Refer to Section 230550 - Vibration Isolation for required distance.
- L. Piping connected to coils, which are in assembly mounted on vibration isolators, shall have vibration isolation hangers or supports as indicated above. Piping connected to coils, which are in equipment where fan assembly is separately isolated by vibration isolators and flexible connections, does not require additional vibration isolation hangers or supports. Refer to Section 230550 - Vibration Isolation for flexible connections, vibration isolators and additional requirements.
- M. Where piping can be conveniently grouped to allow trapeze type supports, supporting steel shall be by means of standard structural shapes.
- N. Hangers and rods shall be plumb when pipelines are at their normal operating temperatures.
- O. Unless otherwise indicated, continuous insert channels are not allowed.

- P. Punching, drilling, or welding of building structural steel is not allowed unless approved by Structural Engineer.
- Q. Refer to Structural Documents and ICC-ES Evaluation Report for application of concrete inserts and concrete anchors.
- R. Lateral braces shall be designed and detailed to apply loads as directly as possible to structural floor slabs, roof decks, or other building lateral elements. Braces shall not be applied to bottom flanges of steel beams or bottom chords of open web steel joists.
- S. Coordinate with Contractor for any proposed weld attachments to building structure. This may result in use of welding codes or standards, which may apply to "structural work". and may necessitate repair of fireproofing and/or extension of fireproofing to support members. Execution of this work may be assigned to General Trades responsible for building structural steel. Cost for this work, however, will remain the responsibility of this Contractor.
- T. Top or bottom chords of open web steel joists may be used to support loads, provided total load within panel does not exceed 100 lbs and load is placed concentric to joist. (Panel is length of chord between two adjacent diagonal web members at point of connection to chord).

PART 2 - PRODUCTS

2.1 STRUCTURAL SUPPORTS

- A. Unless specifically indicated on structural drawings, design and provide all supporting devices including miscellaneous steel (angles, channels, beams, etc.), required for proper support of piping, equipment and materials.

2.2 PIPE HANGERS AND SUPPORTS (METALLIC)

- A. Manufacturers: Anvil, Erico, Tolco, PHD, National Pipe Hanger Corporation, or B-Line, equal to Anvil figures listed. Corresponding MSS Type is indicated where applicable.
- B. Clevis and Roller Type Hangers:

System	Pipe Size	Clevis	Roller
Ambient Bare Pipes (61°F to 104°F)	2" and smaller	65 (MSS Type-1), 260 (MSS Type-1)	---
	2-1/2" and larger	260 (MSS Type-1), 216 (MSS Type-4)	---
Cold Pipes with Insulation (33°F to 60°F)	2" and smaller	65 (MSS Type-1), 260 (MSS Type-1)	---
	2-1/2" and larger	260 (MSS Type-1), 295 (MSS Type-1)	---

- C. For pipe size 2-1/2" and larger, where there is transverse movement at support points due to thermal expansion/contraction, clevis type hangers similar to Anvil Figure 260 (MSS Type-1) may be used if vertical angle of hanger rod is less than 4°.
- D. Flat Surfaces (Trapeze, Rack Type):
1. Use structural steel members such as struts, angles, channels and beams to support pipes as required. Select members properly for pipe support types and loading conditions. Refer to Part 1 for design criteria. Submit support details with type of members selected and load calculations. Provide straps, clamps, rollers or slides indicated below at each support point.

System	Pipe Size	Straps or Clamps	Rollers	Slides
Hot Pipes with Insulation (105°F and above)	2" and smaller	Anvil Klo-Shure	---	---
	2-1/2" and larger	---	171 or 177(MSS Type-41), 271 (MSS Type-45), 274 (MSS Type-46)	257 or 436 with 212 or 432 clamps, Type 1, 2 or 3 for longitudinal movement only. Type 4, 5 or 6 for both longitudinal and transverse movement
Ambient Bare Steel Pipes (61°F to 104°F)	6" and smaller 8" and larger	B-Line BVT Unistrut Cush-a-Clamp	---	---
Ambient Bare (Copper) pipes (61°F to 104°F)	all sizes	B-Line BVT Unistrut Cush-a – Clump		
Cold Pipes with Insulation (33°F to 60°F)	10" and smaller	137 (MSS Type-24)	---	---
	12" and larger	432	171 or 177 (MSS Type-41), 271	257 or 436 with 212 or 432 clamps, Type 1, 2

			(MSS Type-45), 274 (MSS Type-46)	or 3 for longitudinal movement only and Type 4, 5 or 6 for both longitudinal and transverse movement.
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E. Vertical Pipe within Wall Cavities

1. Use clamps, straps, inserts or channels to support pipes concealed in wall cavity. Select members for pipe support types and loading conditions. Refer to Part 1 for design criteria.
2. Provide clamps, strut channels, insulated supports, or brackets and inserts equal to manufacturer indicated below:

System	Pipe Size	Supports	Clamps, Brackets/Inserts	Pre-insulated Inserts
Hot and Cold Pipes with Insulation	All sizes	Anvil 137	HoldRite 260 series with SBIS bracket, Anvil 262	Anvil Klo-Sure, Pipe Shields A2000
Ambient Bare Steel Pipes (61°F to 104°F)	All sizes	Anvil 137, 138-R	Anvil 262	---
Ambient Bare Copper Pipes (61°F to 104°F)	All sizes	Anvil CT-138R	HoldRite 260 series with SBIS bracket	---

2.3 INSULATION PROTECTION SHIELDS

- A. Anvil Fig. 167 (MSS Type-40) constructed of galvanized carbon steel. Per the latest edition of Standard MSS SP-58, select shield to accommodate outer diameter of insulation. Shield length and gauge for insulation compression strength not less than 15 psi, shall be as follows:

Pipe Size	Length	Gauge
1/4" thru 3"	12"	18
4"	12"	16
5" thru 6"	18"	16
8" thru 14"	24"	14
16" thru 24"	24"	12

2.4 INSULATED PIPE SUPPORTS

A. Description:

1. Products designed specifically for weight-bearing support of insulated pipes. Apply products in accordance with manufacturer's recommendations and requirements indicated below:

2. Refer to PART 3 – EXECUTION for application of Type A, Type B, and Type C Insulated Pipe Supports specified below.

B. General:

1. Supports shall be designed and rated for applied load, including weight of pipe, fluid, insulation, and any other imposed loads, with minimum 1.5 safety factor. Ratings shall be published by manufacturer and included in submittals.
2. Load ratings shall be established by pipe support manufacturer based upon testing and analysis conforming to the latest editions of ASME B31.1 and MSS SP-58.
3. High compressive strength inserts utilized to support loads shall encircle circumference of pipe. Block-style inserts are not allowed.
4. Supports shall be suitable for hot or cold pipe service as applicable.
5. Submit chart or table indicating selected model along with pipe sizes, rated loads, support device types and support spacing for each piping system.
6. Pipe support spacing shall be in accordance with manufacturer's recommendations but shall not exceed maximum spacing indicated under Hanger and Support Spacing in Part 3 of this Section.
7. Testing of insulation for compressive strength properties shall comply with ASTM D1621.
8. Insulation thickness shall match adjacent pipe insulation thickness.
9. Integrity of vapor barrier jacket shall be maintained continuously through support assembly.
10. Insulated pipe support style shall be specifically selected for the application and shall consider the following criteria at minimum:
 - a. Vertical, lateral and axial support design load limits.
 - b. Vertical, lateral, and axial support design travel limits
 - c. Temperature of support, at pipe surface, and ambient conditions
 - d. Test or pre-operational loads that may exceed normal operating conditions
 - e. Material for any items that will be welded directly to the pipe
 - f. Loading and displacements caused by seismic, hydraulic surge, or other forces
 - g. Temperature at support steel
11. All steel components shall have corrosion protection coating consisting of hot-dip galvanizing or zinc-rich primer coating.

C. Type A Insulated Pipe Supports (Light Duty)

1. Description:
 - a. Pipe insulation specified in Section 230700 - Mechanical Systems Insulation with insulation protection shields specified in this Section. Weight-bearing inserts are not required.
 - b. Type B or Type C supports may be utilized in lieu of Type A supports.

D. Type B Insulated Pipe Supports (Standard Duty):

1. Manufacturers:
 - a. SNAPP ITZ insulation inserts by KB Enterprise, Tru-Balance Insulated Saddles by Buckaroos, Inc., Value Engineered Products, or approved equal.

- b. Klo-Shure insulation couplings may be used for cold pipes insulated with elastomeric insulation. Mount shall be 7 Series Strup Mount with metal clamps or Clevis System for clevis hangers.
 - c. Type C supports may be utilized in lieu of Type B supports”
 - d. Contractor may propose to utilize contractor-fabricated insulated pipe supports in lieu of manufactured Type B Supports. Use of contractor-fabricated assemblies is subject to approval of appropriate submittal data. Submit detail drawings of assemblies and product data showing equivalency to specified manufactured products for approval.
2. Description:
- a. Load-rated assembly consisting of high compressive strength insulation material completely encompassing circumference of pipe, vapor barrier jacket, and insulation protection shield.
 - b. Insulation protection shield shall conform to ANSI/MSS SP-58. Shield shall be G90 galvanized steel and shall span full circumference of pipe insulation. Half-shields spanning lower 180° degrees arc of insulation outer circumference will be acceptable when used with clevis hangers.
 - c. Axial length of insulation material shall be not less than 9" or 2" longer than insulation protection shields (1" minimum on each end), whichever is longer.
3. Insulation Materials:
- a. Hot Pipes 105°F to 250°F:
 - 1) Rigid closed cell, polyisocyanurate or phenolic insulation by ITW, Resolco, or Kingspan. Minimum compressive strength shall be 100 psi.
 - b. Hot Pipes 251°F to 1200°F:
 - 1) High-density calcium silicate insulation similar to Johns Manville Thermo-12 Gold. Minimum compressive strength shall be 100 psi.
 - c. Cold Pipes 60°F and below:
 - 1) Rigid closed cell, polyisocyanurate, phenolic insulation similar to ITW, Resolco, Kingspan, or cellular glass insulation similar to Pittsburgh Corning Foamglas.

E. Type C Insulated Pipe Supports (Heavy Duty):

1. Manufacturers:
- a. Pipe Shields, Inc., Bergen Pipe Supports, or Rilco equal to Pipe Shields models listed.
 - b. Unless otherwise indicated, pre-insulated pipe supports shall be as indicated in the following schedule. Model numbers are based on Pipe Shields, Inc.
 - 1) Pipe supported on hangers: Model “A” Series and Model “D” Series
 - 2) Pipe supported on flat surfaces and pipe rollers: Models “A” Series
 - 3) Pipe supported on slides: Model "B" Series with lateral guide or restraint
 - 4) Pipe anchors: Model “C” Series
 - 5) Riser clamps: Model “E” Series with thrust plates. Select proper model for restraint for downward load or upward load.
 - c. Contractor may propose to utilize contractor-fabricated insulated pipe supports in lieu of manufactured Type C Supports. Use of contractor-fabricated assemblies is subject to approval of appropriate submittal data. Submit detail drawings of assemblies and product data showing equivalency to specified manufactured products for approval.

2. Description:
 - a. Load-rated assembly consisting of high compressive strength insulation material completely encircling circumference of pipe, vapor barrier jacket system incorporating structural inserts and insulation protection shield/casing where applicable.
3. Insulation Material:
 - a. Water-resistant high density calcium silicate with minimum density of 208 kg/m³(13 lb/ft³) and compressive strength not less than 100 psi. Thermal conductivity shall be not more than 0.055 W/m°C at 24°C(0.38 Btu·in/(hr·sq ft °F) at 75°F.
 - b. Structural Inserts:
 - 1) Structural inserts used by manufacturer to reinforce between pipe and insulation jacket for clamping devices shall be water-resistant high compressive strength inorganic materials selected by manufacturer for desired combination of structural strength and insulating properties. Structural inserts shall have minimum compressive strength of 600 psi. Thermal conductivity shall be not more than 0.084 W/m°C at 24°C(0.58 Btu·in/(hr·ft²°F) at 75°F.
 - c. Jacket:
 - 1) Jacket shall consist of G90 galvanized steel conforming to ASTM A653/A653M and shall provide complete vapor barrier around insulation and bearing surface for protection of insulation.
 - 2) When recommended by manufacturer, use reinforced insulation protection shield at support bearing surface. Insulation shall extend 1" beyond insulation protection shield to maintain vapor barrier integrity.
- F. Refrigerant Pipes and other systems utilizing elastomeric insulation:
 1. Aerofix-U (or equal) closed cell, lightweight polymeric ridged, high-compressive strength foam insulation pipe support with anti-abrasion surface for contact with piping material. Components shall be UV and weather resistant and be rated to work from -70F to 250F. U-Value requirements shall match adjacent insulation.

2.5 HANGER RODS (METALLIC)

- A. Rods shall conform to the latest MSS Standards except as modified herein. Furnish rods complete with adjusting and lock nuts.
- B. Rods shall have electroplated zinc or hot dip galvanized finish.
- C. Unless otherwise indicated, size rods for individual hangers and trapeze support as indicated in the following schedule. Rod size may be reduced one size for double rod hangers. Total weight of equipment, including valves, fittings, pipe, pipe content and insulation, shall not exceed limits indicated.

Max. Pipe Size With Single Rigid Rod	Rod Diameter	Max Load of Hanger Rod (Not exceeding 650°F Service Temp.)
2"	3/8"	730 lbs
3"	1/2"	1350 lbs
5"	5/8"	1350 lbs

Max. Pipe Size With Single Rigid Rod	Rod Diameter	Max Load of Hanger Rod (Not exceeding 650°F Service Temp.)
8"	3/4"	3230 lbs
12"	7/8"	4480 lbs
18"	1"	5900 lbs
30"	1-1/4"	9500 lbs

D. Threaded rods are not allowed in clean rooms.

2.6 BOLTS, NUTS, STUDS AND WASHERS

A. ASTM A307, electroplated zinc finish

2.7 ROD ATTACHMENTS

A. Anvil Fig. 290 (MSS Type-17), galvanized finish

2.8 U-BOLTS

A. Anvil Fig. 137 (MSS Type-24), galvanized finish

2.9 BEAM CLAMPS

A. Beam Clamps: Anvil Fig. 133/134 (MSS Type-21), 218 (MSS Type-30), 228 (MSS Type-28 or 29) and 292 (MSS Type-28 or 29)

B. Top Beam Clamps: Anvil Fig. 227 (MSS Type-25)

C. C-Clamps: Anvil Fig. 86, 92 or 93 (MSS Type-19 or 23) with set screw and lock nut

2.10 ADJUSTABLE PIPE SADDLE SUPPORTS

A. Anvil Fig. 264 (MSS Type-38), galvanized finish. Provide Anvil Fig. 63 Type T stanchion with base, galvanized finish, where applicable.

2.11 RISER CLAMPS (BARE PIPE)

A. Anvil Fig. 261 (MSS Type-8), galvanized finish

B. B-Line B3373C, PVC coated carbon steel, in area at pipe contact, for bare copper tubing

C. Proset system, proseal plug and fire-fill for sleeved and cored holes.

2.12 RISER CLAMPS (INSULATED PIPE)

A. Unless otherwise indicated, insulated pipe riser clamps shall be Type C insulated pipe supports. Refer to Insulated Pipe Supports in Part 2.

- B. Contractor may propose to utilize contractor-fabricated riser supports. Use of contractor-fabricated riser supports is subject to approval of appropriate submittal data. Submit support detail drawings, bearing stamp of Structural Engineer registered in project jurisdiction, for approval. Supports shall be engineered to withstand static and dynamic forces with minimum safety factor of 2.0. Submit insulation details addressing thermal break from building structure and vapor barriers.

2.13 CONCRETE INSERTS (METAL DECK FORMED CONCRETE)

- A. Anvil Fig. 284, Tolco No. 109DD, B-Line Fig. B3019, DeWalt/Powers "Bang-It+", Hilti HCI-MD, or MSCO No. MX34.

2.14 CONCRETE ANCHORS

- A. Manufacturers: Hilti, DeWalt/Powers or Red Head
- B. Anchors shall be selected, sized, and detailed by Contractor's structural engineer registered in project's jurisdiction, based on project conditions and in accordance with project building code. Calculations and drawings shall be submitted.
- C. Anchors shall meet ICC Acceptance Criteria, and ICC-ES Evaluation Reports (ESRs) shall specifically list the current applicable codes.
- D. Anchors installed in hardened concrete for purpose of transmitting structural loads from one connected element to another, or for safety related elements such as sprinkler pipes, heavy suspended pipes, and barrier rails shall have ICC-ES report demonstrating anchors have met requirements of AC 193 for mechanical anchors in concrete elements.
- E. Post-installed expansion anchors and undercut anchors installed in hardened concrete shall be qualified for strength design and tested according to ACI 355.2. Designs shall be per the requirements of ACI 318, Appendix D.
- F. Anchors for seismic load application shall be approved by ICC-ES Evaluation Reports to resist seismic loads and selected to meet project seismic design requirements. Refer to Section 230548 - Mechanical Seismic Anchorage and Restraints and Structural drawings.
- G. Anchors shall be zinc plated in accordance with ASTM B633.
- H. Select anchors with load ratings based on cracked concrete conditions.

2.15 METAL FRAMING SUPPORT SYSTEM (STRUT SYSTEM)

- A. Manufacturers: Unistrut, B-Line Strut Systems, Anvil-Strut, Power-Strut, Erico, Superstrut, Kindorf, Hilti, and Hydra-Zorb
- B. Channels shall have epoxy paint or electroplated zinc finish.
- C. Channels shall not be lighter than 12 ga.

2.16 EQUIPMENT RAILS

- A. Manufacturers: Roof Products & Systems, ThyCurb, Custom Curb, Inc. or Vent Products equal to Roof Products & Systems Model ER-4 with raised cant style. Mounting rails shall be galvanized steel with integral base plate, continuous welded corner seams, factory installed 2" x 4" wood nailer and 18 ga galvanized steel counter flashing.
- B. Mounting rail gauge shall be selected to support equipment adequately but shall be not less than 18 ga.
- C. Height shall be as detailed, but not less than 12" above finished roof.
- D. Equipment rails shall span minimum of 2 joists and not cantilever more than 6") where joists are used. Rails shall be level at top with pitch built in when deck slopes 1/4" per ft or greater.

2.17 PIPE ROOF PENETRATION PROTECTIONS

- A. Manufacturers: Roof Products & Systems, ThyCurb or Vent Products equal to Roof Products & Systems "RPS-Pipe Portals" consisting of 12" OD prefabricated roof curb, laminated acrylic coated ABS plastic curb cover with EPDM protective rubber cap and stainless steel clamp.

2.18 PIPE GUIDES

- A. Unless otherwise indicated, guides shall be equal to Pipe Shields "B" Series, selected by load and movement. Refer to Insulated Pipe Supports in Part 2.

2.19 PIPE ANCHORS

- A. Unless otherwise indicated, anchors shall be Type C Insulated Pipe Supports. Refer to Insulated Pipe Supports in Part 2.
- B. Contractor may propose to utilize contractor-fabricated anchors. Use of contractor-fabricated anchors is subject to approval of appropriate submittal data. Submit anchor system detail drawings, bearing stamp of Structural Engineer registered in project jurisdiction, for approval. Anchors shall be engineered to withstand static and dynamic forces with minimum safety factor of 3.0. Submit insulation details addressing thermal break from building structure and vapor barriers.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install supports to allow for free expansion of piping. Support piping from building structural members using concrete inserts, beam clamps, ceiling plates, wall brackets, or floor stands. At no time shall hangers and supports overload building structural members. Fasten ceiling plates and wall brackets securely to structure and test to demonstrate adequacy of fastening.
- B. Select and size building attachments properly in accordance with MSS Standards and manufacturer's published load rating information.

- C. Coordinate hanger and support installation to properly group piping of all trades.
- D. Suspend piping hangers by means of hanger rods. Perforated band iron and flat wire (strap iron) are not allowed.
- E. Piping and ductwork shall be supported independently from other piping or ductwork.
- F. Pipe hangers and supports shall not penetrate vapor barrier of pipe insulation.
- G. Do not support equipment, or piping from metal roof decking or ceiling grid.
- H. Install adequate supports so as not to over stress either piping or equipment to which piping is connected.
- I. Refer to Section 230000 - General Mechanical Requirements for requirements of personnel injury protection guards for supporting devices.

3.2 HANGER AND SUPPORT SPACING

- A. Space pipe hangers and supports for horizontal pipe accordance with the following schedule, with exceptions as indicated herein:

- B. Steel Pipe (Standard Weight and Extra Strong):

Pipe Size	Max Spacing
1-1/4" and smaller	7 ft
1-1/2"	9 ft
2"	10 ft
2-1/2"	11 ft
3"	12 ft
4"	14 ft
6"	17 ft
8"	19 ft
10" and larger	20 ft

- C. Steel Pipe (Standard Weight and Extra Strong):

Pipe Size	Max Spacing
1-1/4"	7 ft-0"
1-1/2"	9 ft-0"
2"	10 ft-0"
2-1/2"	11 ft-0"
3"	12 ft-0"

- D. Copper Tube (Unless Otherwise Noted):

Pipe Size	Max Spacing
3/4" and smaller	5 ft
1" 1-1/4"	6 ft
1-1/2" 2-1/2"	8 ft

Pipe Size	Max Spacing
3" and larger	10 ft

- E. Maximum spacing shown above may be restricted by strength of attachment to building structure. Submit data with calculations with published load ratings showing attachment to be utilized and maximum spacing allowable for that type of attachment and pipe size.
- F. Spacing less than indicated above may be required to conform to building structure design or loading limitations.
- G. Spacing less than indicated may be required depending on compressive strength of pipe insulation and insulated pipe supports.
- H. If pipe size changes between support points, maximum spacing shall be based on the smaller pipe size.
- I. If trapeze hangers are used to support multiple services, spacing shall be based on the most restrictive pipe size and material on trapeze hanger.
- J. For non-metallic pipe, follow manufacturer's installation recommendations in addition to requirements noted herein.
- K. Install supports for vertical piping and anchors as recommended by pipe manufacturer.
- L. Place hangers and supports to meet requirements of Section 232116 - Pipe and Pipe Fittings or specific pipe system sections, with regard to pitch for drainage and venting and clearance between services.
- M. Hangers and supports shall bear on outside of insulation when pipes are to be insulated.
- N. Place hangers and supports within 1 ft of each fitting, such as elbows and tees, and at each valve, strainer, and other piping specialty for piping 4" and larger.
- O. Place hanger or support at first elbow upstream of pump inlet and first elbow downstream of pump outlet.

3.3 RISER SUPPORTS

A. Insulated Piping:

- 1. Unless otherwise indicated, support vertical piping as indicated below:
- 2. Support vertical piping at bottom of riser, secured and anchored to building structure. Provide guides on vertical piping. Use spring hangers at _____ of riser and at take offs from riser at each floor. Use spring hangers for minimum 3 hangers away from top and bottom elbows and from each take off at riser.
- 3. Guide vertical piping 2-1/2") and smaller at every floor. Guide 2-1/2" and larger at every other floor. Spring hangers (Type 6) and guides (Type VSG) are specified in Section 230550 - Vibration Isolation.

B. Bare Piping:

- 1. Unless otherwise indicated, maximum vertical support spacing for ambient bare steel and cast iron pipes shall be 15 ft.

2. Maximum vertical support spacing for other piping including copper tubing and plastic piping shall be 10 ft.
3. Install riser clamps and intermediate supports as required.
4. Rest riser clamps on floor or on pipe sleeve.
5. Bare piping above 120°F such as steam vents shall be supported per insulated piping requirements.

3.4 INSULATED PIPE SUPPORTS APPLICATION

- A. Install insulated pipe support at each support point of insulated pipe.
- B. Pipe Size 1-1/2" and Smaller:
 1. Use Type A insulated pipe support. Pipe insulation specified in Section 230700 - Mechanical Systems Insulation shall be continuous through support points.
 2. Use one shield (bottom) for clevis hanger.
 3. Use 2 shields (top and bottom) for roller hanger/support or strap/clamp support. Apply 2 metal straps to hold top and bottom shields onto insulation jacket.
 4. Type B or Type C insulated pipe supports may be used in lieu of Type A support.
 5. Refrigerant Pipes and other systems utilizing elastomeric insulation:
 - a. Use pre-insulated pipe supports. Refer to Part 2 for acceptable products.
- C. Pipe Size 2" through 5":
 1. Use Type B insulated pipe supports. Refer to Part 2 for acceptable products.
 2. Type C insulated pipe supports may be used in lieu of Type B supports.
 3. Refrigerant Pipes and other systems utilizing elastomeric insulation:
 - a. Use pre-insulated pipe supports. Refer to Part 2 for acceptable products.
- D. Pipe Size 6" and Larger:
 1. Use Type C insulated pipe supports. Refer to Part 2 for applicable products.

3.5 PIPE FLOOR SUPPORTS

- A. Unless specifically shown otherwise, use adjustable pipe saddle supports with associated stanchion similar to Anvil Fig. 264/63. Select supports properly for weight and height of pipe stand.

3.6 CONCRETE INSERTS

- A. Concrete insert application, size, loading, and placement shall be this Contractor's responsibility.
- B. Coordinate placement of inserts before concrete pour. Minimize use of inserts and anchors after concrete pour.

3.7 BEAM CLAMPS

- A. Provide locknut for hanging rod at clamp.

- B. C-clamps are allowed for rod size 3/8" or smaller and only for static loading such as air piping, cold water piping, fire protection piping and, other similar piping. C-clamps are not allowed for hot water piping and steam and steam condensate piping, except hot water runouts to terminal heating devices.
- C. C-clamps are not allowed for open web steel joist application.
- D. C-clamps are not allowed for seismic application.

3.8 TRAPEZE SUPPORTS

- A. Construct trapeze supports with struts, angles, or channels and hang them by inserts or welded beam attachments and rods.
- B. If trapeze supports are used to support multiple services, support spacing shall be based on the most restrictive pipe size and material on trapeze supports.
- C. Refer to Part 1, Design Criteria for maximum deflection allowed for trapeze supports.

3.9 PIPE MOUNTING PEDESTALS

- A. Use for all piping on roof. Install bottom of pedestal flat on roof deck, insulate exterior of pedestal, flash and counter flash.

3.10 EQUIPMENT RAILS

- A. Use for all roof-mounted equipment, which is not curb mounted. Install bottom of equipment rail flat on roof deck. Insulate exterior of equipment rail.
- B. Flashing will be by General Contractor. Provide counter flashing as specified and secure to wood nailer with stainless steel truss head screws.

3.11 CONCRETE ANCHORS

- A. Anchor application, size, and placement shall be this Contractor's responsibility.

3.12 PIPE ROOF PENETRATION PROTECTIONS

- A. Install at points where pipes are penetrating roof. Install as shown and according to manufacturer's installation instructions.

3.13 PIPE GUIDES

- A. Install where shown on drawings.
- B. For manufactured expansion devices, install minimum of 2 pipe guides at each side of manufactured pipe expansion device. Locate first guide no more than 4 pipe diameters from expansion device and second guide at 14 pipe diameters from first guide. Install intermediate guides in accordance with guide spacing data recommended by manufacturer or the following table, whichever is more stringent.

MAXIMUM DISTANCE BETWEEN INTERMEDIATE GUIDES				
Pipe Size	Pipe Operating Pressure			
	0-50 psig	51-100 psig	101-150 psig	151-200 psig
3"	21 ft	19 ft	17 ft	16 ft
4"	35 ft	29 ft	25 ft	22 ft
6"	57 ft	44 ft	37 ft	32 ft
8"	66 ft	52 ft	45 ft	40 ft
10"	91 ft	69 ft	58 ft	51 ft
12"	107 ft	79 ft	66 ft	58 ft
14"	115 ft	85 ft	71 ft	62 ft
16"	127 ft	94 ft	78 ft	68 ft

- C. If anchor is located within 4 pipe diameters from expansion joints, guides need not be installed on anchor side.

3.14 PIPE ANCHORS

- A. Install anchors where shown on drawings or in conjunction with expansion joints, loops and swing joints as required to allow proper expansion and contraction of piping without damage to structure, equipment or piping.
- B. Do not anchor piping to concrete block walls, wood, or partition walls.

END OF SECTION 230529

SECTION 230550 - VIBRATION ISOLATION

PART 1 - GENERAL

1.1 DESIGN CRITERIA

- A. Isolate motor driven mechanical equipment, unless otherwise noted, from building structure, and from systems that they serve, to prevent equipment vibrations from being transmitted to structure. Unless specifically indicated, follow the latest edition of ASHRAE Handbook HVAC Applications - Sound and Vibration Control, or manufacturer's recommendations for isolator selection whichever is more stringent.
- B. Select and locate isolators to produce uniform loading and deflection. Use minimum of 4 isolators to support each piece of equipment.
- C. Select vibration isolation devices based on the lowest operating speed of equipment.
- D. Vibration Criteria:
 1. All rotating equipment shall operate at speeds less than 80% of their true critical speed. Unless otherwise required, equipment shall be balanced according to recommendations given in the following schedules.
 2. Vertical vibration of rotating equipment shall not be greater than levels indicated. Vibration shall be measured on equipment. If equipment has inertia base, allowable vibration level is reduced by ratio of equipment weight alone to equipment weight plus inertia base weight.

<u>Equipment Speed</u>	<u>Maximum Allowable</u>
<u>rpm</u>	<u>Vibration Displacement</u>
	<u>Peak-to-Peak (mil)</u>
100 to 200	10
200 to 300	6
300 to 600	4
600 to 1000	3
1000 or 2000	2
over 2000	1

- E. Following field installation, each fan and pump over 25 hp shall be balanced in accordance with the following maximum rms velocity levels:

1. Fans: 0.15"/sec

2. Pumps:

0.16"/sec	for 30 hp and smaller
0.18 "/sec	40 through 60 hp
0.20"/sec	75 through 100 hp
0.22"/sec	125 and Larger hp

- F. Allowable field pump vibration values above are based on HI 9.6-2000, Figure 9.6.4.12.
- G. Final in-field balance shall be measured with each fan over 25 hp installed on springs specified for unit. Fans shall be loaded with design static pressure. Measurement shall be carried out in vertical, horizontal and axis planes at impeller shaft bearing location.

1.2 SUBMITTALS

- A. Submit Shop Drawings and product data including the following:
 - 1. Manufacturer's name
 - 2. Isolator type and model number
 - 3. Materials of construction and finish
 - 4. Dimensional data
 - 5. Load ratings lbs
 - 6. Isolator free and operating heights
 - 7. Static deflections
 - 8. Isolation efficiency based on lowest operating speed
 - 9. All other appropriate data
- B. Provide seismic restraints for all vibration-isolated equipment. Restraints shall not be in contact with the equipment during its normal operation but shall be capable of withstanding loads imposed by seismic acceleration of the equipment in any direction during seismic event.
- C. Refer to Section 230548 - Mechanical Seismic Anchorage and Restraints for additional requirements.

1.3 SUPERVISION, INSPECTION AND CERTIFICATION

- A. Vibration isolation manufacturer or qualified representative shall provide supervision to assure correct installation and adjustment of isolators. Upon completion of installation and after system is put into operation, manufacturer or manufacturer's representative, shall make final inspection, adjustment, and submit report to Engineer in writing, certifying correctness of installation and compliance with Specifications.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Materials used shall retain their isolation characteristics for life of equipment served. Elastomeric materials shall comply with ASTM D2240 and shall be oil-resistant industrial grade neoprene.
- B. Isolators shall be treated to resist corrosion.
- C. Isolation devices subject to weather shall have either hot-dip or cold-dip galvanized, cadmium plated, or neoprene coated finish after fabrication and be furnished with limit stops to resist wind.

- D. Vibration isolator springs shall have minimum additional travel to solid equal to 50% of rated deflection.
- E. Ratio of lateral to vertical stiffness of vibration isolators shall not be less than 0.8 or greater than 2.0.
- F. Coordinate selection of devices with isolator and equipment manufacturer.

2.2 MANUFACTURERS

- A. Mason Industries, Amber/Booth Co., Aeroflex-VMC-Korfund. Vibration Eliminator, Vibro-Acoustics, Kinetics, or equal to manufacturer's model listed, except flexible pipe connections.
- B. Mason, Metraflex, Proco, Twin City Hose, Engineered Flexible Products (EFP) or Flex-Weld/Keflex for flexible pipe connections.

2.3 TYPE 1 MOUNTS (NEOPRENE PAD)

- A. Mason Type Super W, neoprene waffle pads, 50 durometer. Select number and size of pads as required to accept equipment operating weight evenly.

2.4 TYPE 2 MOUNTS (NEOPRENE PAD)

- A. Mason Type ND or rails Type RND, double deflection neoprene mounts with cast-in metal inserts for bolting to equipment.
- B. Both surfaces shall be rib molded for skid resistance. On equipment such as small vent sets and close coupled pumps, steel rails shall be used above mountings to compensate for overhang.

2.5 TYPE 3 MOUNTS (UNHOUSED SPRING WITH NEOPRENE)

- A. Mason Type SLF, combination spring and neoprene with rib molded base. Spring type isolators shall be free standing and laterally stable without any housing and complete with 1/4" neoprene acoustical friction pads between baseplate and support.
- B. Mountings shall have leveling bolts rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of compressed height of spring at rated load.

2.6 TYPE 4 MOUNTS (RESTRAINED SPRING WITH NEOPRENE)

- A. Mason Type SLR, combination spring and neoprene with rib molded base similar to Type 3 above, but shall have rigid housing with hold-down bolts to limit vertical as well as horizontal movement.
- B. Installed and operating heights shall be the same. Maintain minimum clearance of 1/2" around restraining bolts and between housing and spring so as not to interfere with spring action. Limit stops shall be out of contact during normal operations. Use height saving brackets.

2.7 TYPE 5 HANGERS (SPRING HANGER WITH NEOPRENE)

- A. Mason Type 30N, vibration hangers with steel spring and neoprene element in series. Neoprene element shall be molded with rod isolation bushing that passes through hanger box. Spring diameters and hanger box lower hole sizes shall be large enough to permit hanger rod to swing through 30° arc before contacting hole and short circuiting spring.
- B. Mason Type DNHS may be used where load rating and specified deflection cannot be accommodated by Type 30N.

2.8 TYPE 6 HANGERS (PRECOMPRESSED SPRING HANGER WITH NEOPRENE)

- A. Mason Type PC30N, vibration hangers similar to Type 5, but precompressed to rated deflection so as to keep piping or equipment at fixed elevation during installation. Design hangers with release mechanism to free spring after installation complete and hanger is subjected to its full load.

2.9 TYPE 8 HANGERS (SPRING HANGER WITH NEOPRENE)

- A. Mason Type 30, W30, or PC30 steel spring located in neoprene cup manufactured with grommet to prevent short-circuiting of hanger rod. Neoprene cup to contain steel washer designed to properly distribute load on neoprene and prevent its extrusion. Spring diameters and hanger box lower hole size to be large enough to permit hanger rod to swing through 30° arc before contacting hole and short-circuiting spring. Provide hangers with rod attachments or eyebolts on spring end.

2.10 FLEXIBLE PIPING CONNECTORS

- A. Flexible connectors shall be suitable for pressure, temperature and fluid involved, but not less than 215 psig working pressure at 250°F for 14" and smaller and 150 psi working pressure at 250°F for 16" and larger.
- B. Flexible connectors shall be straight pipe configuration and shall not be used to replace pipe fittings such as elbows.
- C. Refrigerant System:
 - 1. Seamless corrugated bronze liner and bronze wire braided cover with standard copper tube ends suitable for brazing for copper piping. Seamless corrugated stainless steel flexible connector with braided cover for steel piping.
 - 2. Seamless corrugated stainless steel liner with stainless steel braided cover and carbon steel butt weld ends for steel piping

Nominal Pipe Diameter (in)	Minimum Live Length (in)
2-1/2" and smaller	12"
3" and 4"	18"
5" and larger	24"

- D. Do not provide flexible piping connectors for gas piping.

2.11 PERFORMANCE

- A. When floors are lighter than 4" concrete or location is in a particularly sensitive area and the mass described above cannot be introduced, select deflection requirements for the next longer span. Unless otherwise noted, select vibration isolation devices to achieve either minimum 95% isolation efficiency or minimum static deflection and mounting requirements listed in Table below, whichever is greater. For floor spans between increments indicated, use longer floor span indicated in table. Minimum static deflections listed below are not nominal but certifiable minimums with actual installed load. Unless otherwise indicated, apply requirements listed for floor mount for roof-mounted equipment.

Type of Equipment	Ground Supported Slab		Floor Span							
			Up to 20 ft		Up to 30 ft		Up to 40 ft		Up to 50 ft	
	Type	Min Defl in	Type	Min Defl in	Type	Min Defl in	Type	Min Defl in	Type	Min Defl in
Condensing Units										
Air Cooled Condensers	-	-	4	0.75	4	1.5	4	1.5	4	2
Air Cooled Condensing Units	-	-	4	0.75	4	1.5	4	2.5	4	3.5
Piping Connected to Rotating or Recipro-Equipment										
	Use flexible piping connections, and spring hangers for distance 4 hangers or 50 ft away from equipment, whichever is greater. First 3 spring hangers shall be Type 6 hangers providing same deflection as equipment isolators with maximum limitation of [2"] ([50 mm]) deflection. Remaining spring hangers shall be Type 5 with minimum deflection of 0.75". For piping less than 2" in diameter, neoprene or felt pad inserted between pipe or pipe covering and clamp or hanger may be used in lieu of Type 5 hangers. Where piping is floor-supported, above requirements shall apply, but use Type 3 mounts instead of hangers.									
	Flexible piping connection shall not be used for unit heaters and in-line pumps with 3 hp and smaller motors that are supported by connected pipes. Type 6 hangers with 1" minimum deflection shall be applied within one foot of both sides of in-line pump and for distance of 100 pipe diameters or 50 ft away from first hanger at in-line pump, whichever is greater.									
Ductwork in Mechanical Equipment Rooms										
	Use Type 8 hangers with 0.75" minimum deflection for ducts with cross sectional area greater than 2.0 sq ft and where air velocity is greater than 2000 fpm for distance 50 ft from fan.									

BLOWER MINIMUM DEFLECTION GUIDE					
When blowers are 60 hp or larger, select deflection requirements for next larger span, but not less than 2-1/2".					
When floor span dimensions differ in two directions (e.g., north-south vs east-west), choose the larger dimension.					
Fan Speed (rpm)	Required Deflection inches				
	On Grade	Up to 20 ft Floor Span	Up to 30 ft Floor Span	Up to 40 ft Floor Span	Up to 50 ft x Floor Span
Up to 300	2.5	3.5	3.5	3.5	3.5
301-500	1.5	1.5	2.5	2.5	3.5
501 and over	0.75	1.5	1.5	2.5	3.5

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install and adjust vibration isolation devices as specified, as shown on drawings and according to manufacturer's recommendations.
 1. Adjust isolators after piping system is at operating weight.
 2. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
 3. Adjust active height of spring isolators.
 4. Adjust restraints to permit free movement of equipment within normal mode of operation.
 5. Adjust air-spring leveling mechanism.
- B. In no case shall installation short circuit isolation devices.

3.2 INERTIA BASES (TYPE I BASES)

- A. Provide required concrete for inertia bases. Refer to Section 230000 - General Mechanical Requirements for concrete work.
- B. Raise inertia bases to final elevation with temporary blocking prior to making piping connections to pumps or ductwork connections to fans. After connections are complete, install vibration isolators in accordance with manufacturer's installation instructions.

3.3 PACKAGED AIR HANDLING UNITS

- A. Install Type T thrust restraints at fan sections when fan section is isolated from remainder of air handling unit.

3.4 FLEXIBLE PIPING CONNECTIONS

- A. Provide flexible connections for piping connected to rotating or reciprocating equipment, equipment such as coils mounted on vibration isolators, and as indicated on plans and details.

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- B. Piping connected to coil which is in assembly where fan is separately isolated by vibration isolators and duct flexible connections does not require flexible piping connectors or piping vibration hangers.
- C. Piping connected to steam heating coils in floor mounted air handling units where coils are supported without vibration isolation shall have flexible piping connections and piping vibration hangers to prevent thermal stress in piping system from damaging the coils.
- D. Install flexible connections on equipment side of shut off valves and horizontal and parallel to equipment shafts where applicable.
- E. For non-metallic flexible piping connections, 2-1/2") and larger, use flange type recommended by manufacturer. Flanges for mechanical grooved connections are not allowed.

END OF SECTION 230550

SECTION 230553 - MECHANICAL SYSTEMS IDENTIFICATION

PART 1 - GENERAL

1.1 SUBMITTALS

- A. Product Data: For identification materials and devices
- B. Valve Schedules: For each piping system
- C. Samples: Of color, lettering style, and graphic representation required for each identification material and device.

PART 2 - PRODUCTS

2.1 IDENTIFYING DEVICES

- A. Stencil Paint:
 - 1. Oil-based, alkyd enamel, black color
- B. Marker System:
 - 1. Manufacturers: Brady USA, Marking Services Inc. (MSI), Kolbi, or Seton
 - 2. Manufacturer's standard, preprinted with color coding, lettering size and length of color field according to ASME A13.1 .
 - 3. Use pressure-sensitive type or "snap-on" type.
 - 4. "Strap-on" type may be used for piping over 6" size including insulation.
- C. Valve Tags:
 - 1. Minimum 1-1/2" diameter, 0.032" thick, polished brass or 316 stainless steel.
- D. Laminated Plastic Nameplates:
 - 1. Nameplates shall be approximately 1-1/2" x 4", 1/16" thick, and have 1/2" high lettering. Face of plastic nameplates shall be black with white letters.
 - 2. Fasteners shall be self-tapping, stainless steel screws or contact type with permanent adhesive.

PART 3 - EXECUTION

3.1 GENERAL

- A. After painting and/or covering is completed, identify equipment and piping as indicated. Locate identification as conspicuously as possible except where such would distract from finished area.
- B. Where markers are used in high heat applications or exposed to harsh chemical or acid environments, specifically select marker materials for those applications.

- C. Coordinate, obtain and confirm mechanical systems identification criteria and requirements from Owner.

3.2 PIPING SYSTEM IDENTIFICATION

- A. Install pipe identification on each system.
- B. Place flow directional arrows at each pipe identification location.
- C. Identify all piping not less than once every 25 ft, not less than once in each room, at each branch, adjacent to each access door or panel, at each valve and where exposed piping passes through walls and floors.
- D. Identify piping by stenciling. Height of lettering shall be same as pipe diameter up to maximum of 1" in height. When finished color of piping is dark, stenciling shall be on white background.
- E. Identify piping with marker system.
 - 1. For "strap-on" type, ensure marker is fitted snugly to pipe or pipe insulation surface with sufficient straps.
- F. In addition to marker system, piping systems shall be identified by continuous colored PVC jacket according to the color chart below. Painting shall be under applicable sections of Division 09 - Finishes. Colored PVC jackets are to be provided under Section 230700 - Mechanical Systems Insulation.

Piping System	System Abbreviation	Pipe Jacket Color
Cooling Coil Condensate	CCC	White
Non-Potable Cold Water	NPW	Green
Refrigerant Suction	RS	N/A
Refrigerant Liquid	RL	N/A

- G. Piping specified Section 230700 - Mechanical Systems Insulation to have aluminum or stainless steel jacket shall not be painted.

3.3 VALVE IDENTIFICATION

- A. Identify valves with brass tags bearing system identification and valve sequence number in 1/2" black characters. Attach tag to valve body with brass jack chain and "S" hook for brass tag and SS jack chain or SS braided wires with swag sleeves and "S" hook for stainless steel tag. Non-metallic fasteners are not allowed.
- B. Valve numbers shall be prefixed with corresponding piping system identification in 1/4" black letters.
- C. Valve tags are not required at terminal devices unless valves are greater than 10 ft from device or located in another room not visible from terminal unit.
- D. Furnish typewritten valve schedule indicating valve number, fixtures, equipment or areas served by each numbered valve and incorporate in O&M Manuals.

3.4 DUCT SYSTEM IDENTIFICATION

- A. Install duct identification for each supply, return and exhaust air system.
- B. Identify all ductwork not less than once every 25 ft and not less than once in each room.
- C. Identify duct system by stenciling exterior of duct or insulation jacket by name as either "Supply Air (AHU-x)", "Return Air (RF-x)", or "Exhaust Air (EF-x)". "-x" shall indicate system number (e.g. AHU-1).
- D. Stencils shall be 2" (min) lettering, shall include direction arrow and shall be on bottom of duct or insulation jacket such that it is visible from floor below.
- E. Do not identify systems exposed in architecturally "finished" spaces.
- F. Hazardous ductwork shall have appropriate warning signs posted to protect personnel from exposure.

3.5 EQUIPMENT IDENTIFICATION

- A. Identify major equipment, including air handling units, fans, boilers, chillers, heat exchangers, air terminal devices, pumps, tanks, etc.
- B. Identify equipment by stenciling equipment number and service in 2" high letters.
- C. Identify equipment with marker system.
- D. Identify equipment with laminated plastic nameplates.
- E. Identify control equipment and panels with laminated plastic nameplates.
- F. Nameplate Markings:
 - 1. Identify model number, size, capacity, electrical characteristics, serial number, along with other items scheduled for equipment on drawings.
 - 2. Indicate motor horsepower, voltage, phase, cycles, RPM, full load amps, locked motor amps, frame size, manufacturer's name and model number, Service Factor, Power Factor, efficiency, minimum circuit amps, minimum feeder conductor size, disconnect or fuse size, refrigerant, and other pertinent information.
- G. Locate motor nameplates for easy reading. Relocate or provide new nameplates on motors if original nameplates are not located for easy reading.

3.6 ACCESS PANEL IDENTIFICATION

- A. Identify each service opening or access opening for fire, smoke, and fire/smoke damper with minimum 1/2" high letters indicating type of damper.
- B. Furnish typewritten charts with identification and location of all access panels serving equipment and valves and incorporate in O&M Manuals.

END OF SECTION 230553

SECTION 230595 - AIR SYSTEMS TEST ADJUST BALANCE

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This Contractor shall be responsible for providing complete testing, adjusting and balancing (TAB) work for air systems, such as air handling units, return fans, exhaust fans, air terminal devices, diffusers, grilles and other air moving processes included in this project.
- B. Work required shall consist of setting volume flow rates and adjusting speed controls, recording data, making tests, and preparing reports, as specified herein.
- C. Scope of work includes TAB of new work specified herein and includes all equipment, distribution systems, and terminal units connected.
- D. Scope of work also includes TAB of existing air systems as defined by drawings, schedules, or specified in this Section.
- E. All existing air systems within scope of demolition/renovation areas shall be rebalanced as necessary to provide new air flows as indicated on drawings. This shall include measurements of existing system air flows prior to demolition and confirmation that air flows to all spaces served by systems being modified are equal to air flows that existed prior to work being started.
- F. Work is limited to new areas within the construction boundaries and does not include central fan equipment or other areas. Make attempts to balance flows to values indicated. If flow is low, attempt to proportional balance flows to the same percentage below design.
- G. TAB work shall be performed by persons trained in TAB work and certified by Associated Air Balance Council (AABC), National Environmental Balancing Bureau (NEBB), or Testing, Adjusting and Balancing Bureau (TABB). Procedures shall be in accordance with the latest edition of AABC, NEBB or TABB Standards, ASHRAE (HVACA)-2015 Chapter 38, and as detailed herein.
- H. Mechanical Contractors who are members of AABC or NEBB and who have qualified personnel available to perform work may submit Quality Assurance Submittal for approval. Mechanical Contractors who cannot meet these requirements shall subcontract with independent TAB Contractor who meets these requirements. TAB subcontractor shall prepare Quality Assurance Submittal for Contractor to submit for approval.
- I. Upon direction of Architect/Engineer or TAB subcontractor, Mechanical Contractor shall provide at no additional cost to Owner, any additional work and/or devices necessary to properly balance system, including fan sheaves, motor sheaves and/or drive belts.
- J. TAB work shall not proceed until assigned personnel have been approved by Architect/Engineer via Quality Assurance Submittal. Coordinate each phase of TAB work with overall project schedule. Each phase of TAB work shall be done in timely manner as detailed herein. Fieldwork must be completed before occupancy. Certificate of Substantial Completion shall not be issued until after Final Report is accepted by Architect/Engineer.

1.2 SUBMITTALS

A. General:

1. Make submittals in accordance with project submittal procedure. Submittals shall be in electronic Portable Document Format (pdf) utilizing NEBB, AABC, or TABB Reporting Forms. Embed bookmarks for each system and each terminal device to assist navigation.
2. Submit Final Report in pdf format..
 - a. PDF files shall include bookmarks to facilitate navigation.
 - b. Final Report shall be assembled electronically including the Project Name and location on coversheet 8-1/2" x 11". Use preprinted forms of NEBB, AABC or TABB wherever possible. Final Report shall be a searchable PDF electronic version. Provide electronic bookmarks for each system. Assemble report in the following order:
 - 1) Transmittal letter
 - 2) Cover sheet with Project title, location, submittal date, and name and addresses of Owner, Mechanical Contractor, TAB subcontractor, Architect, and Engineer
 - 3) Index of numbered tabs listing major systems
 - 4) Data organized by system in the following order:
 - a) Equipment data and measurement summary
 - b) Equipment measurement data
 - c) Branch main measurement data
 - d) Terminal device measurement data arranged by room or zone

B. Quality Assurance Submittal:

1. Within 30 days of signing contract, Contractor shall submit the following information:
 - a. Firm resume
 - 1) AABC or NEBB active membership certificate
 - 2) Names of 3 recent relevant completed projects along with project address, Owner's contact person, supervising design professional
 - b. Supervisor resume
 - c. Balance technician(s) resume
2. Architect/Engineer and/or Owner reserves the right to contact previous project representatives and to reject persons whom Architect/Engineer and/or Owner feel are not qualified for this project due to lack of relevant experience or problems on previous projects.

C. Planning Report:

1. Submit Planning Report as detailed in Part 3 of this Section to demonstrate to Architect/Engineer and Owner that proper procedures are being followed. Planning Report shall be submitted after Quality Assurance submittal and 30 days before any fieldwork starts.

D. Initial Test Report:

1. Prior to starting Final Balance Phase, submit Initial Test Report as detailed in Part 3 of this Section to indicate to Architect/Engineer and Contractor incomplete work or problem areas to be resolved before final balance is completed.

E. Final Report:

1. Within 30 days after fieldwork is completed, submit Final Report as detailed in Part 3 of this Section to assure design objectives are met and to assist Owner in future maintenance.

1.3 REFERENCE STANDARDS

- A. Refer to the latest publications of NEBB, AABC, TABB, ASHRAE, and Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) publications for establishing required procedures.

PART 2 - PRODUCTS

2.1 INSTRUMENTATION

- A. Provide all required instrumentation to obtain proper measurements. Application of instruments and accuracy of instruments and measurements shall be in accordance with requirements of NEBB, AABC or TABB Standards and instrument manufacturer's specifications.
- B. Instruments used for measurements shall be accurate, and calibration histories for each instrument to be available for examination by A/E upon request. Calibration and maintenance of instruments to be in accordance with requirements of NEBB, AABC or TABB Standards.

2.2 INSTRUMENT TEST HOLE PLUGS

- A. Center-pull plugs similar to CPW Series by Mocap. Plug material shall be low-density polyethylene.

PART 3 - EXECUTION

3.1 GENERAL

- A. TAB work shall be done in separate phases as outlined herein. TAB schedule shall allow ample time to complete TAB work before occupancy. Follow procedures outlined herein and as described in Planning Phase narratives.
- B. Unless otherwise specified, maximum acceptable offset tolerance is plus or minus 10% of the design flow rates as indicated on drawings and/or as scheduled.

3.2 PLANNING PHASE

- A. Procedure:

1. Obtain the latest Contract Documents including addenda, applicable construction bulletins and change orders. Obtain product data, shop drawings and performance curves from Mechanical Contractor for fans, flow measuring devices, and all terminal devices. Prepare Planning Report as detailed herein. Make adjustments in Planning Report and/or measuring instrument calibration.
- B. Planning Report:
1. Planning Report shall contain the following minimum requirements.
 - a. Samples: Provide copies of all forms to be used.
 - b. General narratives: Furnish written narratives of all procedures used. Include separate narratives for each fan and air handling system. Identify flow-measuring devices to be used at each fan, air terminal device, and air outlet. Narrative shall include statement that every air outlet shall be measured and adjusted. Provide different narratives for constant and variable flow systems. Narratives shall include references to published standards of NEBB or AABC. Narratives shall include measuring instruments to be used and ranges required for each procedure. Narratives shall include specified adjustment tolerances.
 - c. Air system narratives: Provide narratives for each air system which shall include procedures for measuring static pressures at each component of air handling system to generate a static pressure profile. Measurements shall be made to measure performance of system in all operating modes including economizer mode using 100% outside air where applicable. Differentiate between constant and variable flow systems.
 - d. Non-standard air system narratives: Include narratives on how to measure and adjust for different air densities for systems with static pressures greater than 8" WG or temperatures greater than 140°F.
 - e. Air terminal narratives: Narratives shall describe procedures for measuring flows and adjusting controls to meet specified minimum and maximum flow rates based on actual field installed conditions.
 - f. Branch duct and air outlet measurements: Indicate on preprinted forms all measurements to be taken in field. Include branch duct or air outlet identification, system, space served, location, and design flow rates (include zone and system summaries). Indicate duct or air outlet neck size, make, model number, and design velocities.
 2. Prebalance Checklist - to include:
 - a. Check for completeness of work
 - b. System cleaning if required
 - c. Check fire, smoke and balancing damper positions
 - d. Place system into normal operation without economizers.
 - e. Install test openings where required.
 - f. Indicate type of test holes to be used and installation procedure.
 - g. Note condition of filters.
 - h. Provide temporary blankoffs to simulate design pressure drops of filters.
 - i. Chisel holes and duct tape are not allowed.
 - j. Wet cooling coils

- k. Fan wheels, blades, bearings, alignment, starters, vibration isolators, and rotation
 - l. Drive belt tension and alignment
 - m. Setting of automatic dampers to proper position including shutoff and bypass dampers
 - n. Set up of controls and control devices
3. Measuring Instrument List - list what measuring instruments will be used for each procedure. Indicate ranges required for each procedure. Provide data on each measuring instrument to be used. This data shall include:
- a. Manufacturer name and model number
 - b. Measurement range
 - c. Pressure/temperature limits
 - d. Date put into service
 - e. Date of last calibration
 - f. Include certificate from calibration firm
4. Architect/Engineer reserves the right to request adjustments in any procedure and/or ask for recalibration of any measuring instrument, which has not been recalibrated within past year.

3.3 SET-UP PHASE

- A. Procedure:
 - 1. Perform prebalance checkout as per Planning Phase narrative.
- B. Initial Test:
 - 1. Measure fan data and flows in "as found" condition after initial damper settings are made.
- C. Initial Test Report:
 - 1. Submit report to Architect/Engineer and Mechanical Contractor indicating all measurements made and make notes of all items, which are not complete or are not within design tolerance.

3.4 FINAL BALANCE PHASE

- A. Procedure:
 - 1. Perform all procedures as per Planning Phase narrative. Correct all deficiencies and redo procedures as required before submitting Final Report.
- B. Final Report:
 - 1. Submit report to Architect/Engineer and Mechanical Contractor indicating all data and measurements as per requirements herein and per Planning Phase narrative. Do not submit partial or incomplete reports.
- C. Final Report Adjustments:

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1. Architect/Engineer reserves the right to check any measurement made and to reject any portion of work not within required tolerance of design flow. TAB Contractor shall resubmit all or portions of Final Report as directed by Architect/Engineer.

END OF SECTION 230595

SECTION 230700 - MECHANICAL SYSTEMS INSULATION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Provide insulating materials and accessories as required for mechanical systems as specified below.
- B. Insulating products delivered to construction site shall be labeled with manufacturer's name and description of materials.

1.2 DEFINITIONS

- A. Concealed areas, where indicated in this Section, shall apply to shafts, furred spaces and space above finished ceilings, inaccessible tunnels and crawl spaces. All other areas, including walk-through tunnels, shall be considered as exposed.
- B. Unless otherwise indicated, unit of thermal conductivity is BTU in(h ft²F).

1.3 SUBMITTALS

- A. Product Data for each piping system for all pipe sizes, each ductwork system but not limited to, the following:
 - 1. Manufacturer's name
 - 2. Schedule of insulating materials
 - 3. Insulation material and thickness
 - 4. Jacket
 - 5. Adhesives
 - 6. Fastening methods
 - 7. Fitting materials
 - 8. Intended use of each material
 - 9. Manufacturer's data sheets indicating density, thermal characteristics, temperature ratings
 - 10. Insulation installation details (manufacturer's installation instruction/details, Contractor's installation details, MICA plates where applicable)
 - 11. All other appropriate data

1.4 DELIVERY, STORAGE AND HANDLING

- A. Insulation material shall be delivered to project site in original, unbroken factory packaging labeled with product designation and thickness. Shipment of materials from manufacturer to installation location shall be in weather-tight transportation. Protect insulation materials from moisture and weather during storage and installation. Protect insulation material against long exposure to UV light from sun.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Insulation:

1. Owens Corning, Johns Manville, Manson, Knauf or CertainTeed similar to product indicated except where product of manufacturers not listed above is specifically identified for special type of insulation.

B. Coatings, Mastics, Sealants and Adhesives:

1. Foster, Childers, Design Polymerics, Vimasco, Miracle or Pittsburgh Corning

2.2 MATERIALS

- A. Products used for or related to air conditioning and ventilating systems shall conform to NFPA 90A possessing flame spread index of not over 25 and smoke developed index no higher than 50.
- B. Unless otherwise indicated, all products, material itself or on composite basis, shall have flame spread index not more than 25 and smoke developed index not more than 50, when tested in accordance with ASTM E84 or UL 723.
- C. Pipe insulation installed outdoors may have smoke developed index not exceeding 450.
- D. Insulation shall not contain formaldehyde.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in manufacturing process.
- F. Insulation applied on stainless steel shall meet requirements of ASTM C795 and NRC 1.36.

2.3 INSULATION

- A. Insulation materials shall be fire retardant, moisture and mildew resistant, vermin proof, and suitable to receive jackets, adhesives and coatings as indicated.
- B. Glass fiber insulation shall be of inert inorganic material, non-corrosive to mechanical surfaces.
- C. Insulating cement shall be Quick-Cote by PK Insulation MFG Co. or Ryder GP, with dry density of no more than 38 lb/ft³ thermal conductivity of 0.96 at 400°F mean temperature, and service temperature to 1200°F.
- D. Filling and finishing cement shall be Super-Stik by PK Insulation MFG Co., or Ryder MW, with dry density of no more than 24 lb/ft³, thermal conductivity of 0.74 at 500°F mean temperature, and service temperature to 1900°F.
- E. Type A Insulation (Flexible Elastomeric):
 1. Flexible, closed-cell, elastomeric cellular insulation.
 - a. ASTM Standard: ASTM C534/C534M, Type I (tube form) or Type II (sheet form), Grade I

- b. Thermal Conductivity: Maximum 0.28 at 75°F mean temperature
 - c. Water Vapor Permeability: Maximum 0.08 perm-inch
 - d. Water Absorption: Maximum 0.2 % by volume
 - e. Service Temperature: -297 to 220°F
 - 2. Manufacturers/Products:
 - a. Armacell, AP Armaflex or AP Armaflex FS
 - b. Aeroflex, Aerocel
 - c. K-Flex, Insul-Tube
- F. Type F Insulation (Flexible Fiberglass Blanket):
- 1. Flexible fiberglass blanket insulation, faced with specified jacket.
 - a. ASTM Standard: ASTM C1290
 - b. Density: Minimum 0.75 lb/ft³
 - c. Thermal Conductivity: Maximum 0.30 at 75°F mean temperature
 - d. Service Temperature: Maximum 250°F.
 - 2. Manufacturers/Products:
 - a. Johns Manville, Microlite EQ FSK
 - b. Owens Corning, All Service Duct Wrap
 - c. Knauf, Atmosphere Duct Wrap
- G. Type R Insulation (Rigid Mineral Fiber Pipe Insulation):
- 1. Mineral fiber (fiberglass) preformed pipe insulation faced with specified jacket.
 - a. ASTM Standard: ASTM C547, Type I
 - b. Density: Minimum nominal 3 lb/ft³
 - 1) Thermal Conductivity: Maximum 0.23 at 75°F and 0.29 at 200°F
 - 2) 0.29 at 200°F mean temperature
 - c. Service Temperature: To 850°F
 - 2. Manufacturers/Products:
 - a. Johns Manville, Micro-Lok HP
 - b. Owens Corning, ASJ Max Fiberglass Pipe Insulation
 - c. Knauf, Earthwool 1000° Pipe Insulation
- H. Type R Insulation (Rigid Mineral Fiber Board Insulation):
- 1. Mineral fiber (fiberglass) duct and equipment insulation faced with specified jacket.
 - a. ASTM Standard: ASTM C612, Type IA and IB
 - b. Density: Minimum nominal 3 lb/ft³
 - c. Thermal Conductivity: Maximum 0.23 at 75°F mean temperature
 - d. Service Temperature: To 450°F
 - 2. Manufacturers/Products:
 - a. Johns Manville, 800 Series Spin-Glas, Type 814
 - b. Owens Corning, Fiberglass Fiberglass 700 Series, Type 703

- c. Knauf, Earthwool Insulation Board

2.4 JACKETS

- A. Jacket puncture resistances shall be based on ASTM D781 test methods. Vapor barrier permeance ratings shall be based on ASTM E96/E96M Procedure A.
- B. Type A-1 Jacket (Aluminum Roll Jacketing):
 - 1. Factory fabricated 0.016" thick, ASTM B209/B209M, Type 3003 or 3105, stucco embossed aluminum jacket with integrally bonded moisture barrier/retarder consisting of 3 layers of polymer films with total thickness of 3 mil.
 - 2. Fitting covers shall be factory fabricated from not lighter than thick, Type 3003 or 1100 aluminum. For large pipes, where factory fabricated fitting covers are not available, Contractor shall fabricate fitting covers from like sheet materials.
 - 3. Manufacturers/Products:
 - a. Johns Manville, Aluminum Jacketing
 - b. RPR Products, Insul-Mate
- C. Type D-1 Jacket:
 - 1. Heavy-duty, fire retardant material with glass fiber reinforcing. Jackets shall have neat, white Kraft finish suitable for painting, with beach puncture resistance of 50 units minimum. Vapor barrier shall be adhered to inner surface of jacket. Permeance shall not exceed 0.02 perm.
 - 2. Manufacturers/Products:
 - a. Owens Corning, ASJ Max
 - b. Johns Manville, ASJ-4535
 - c. Knauf, ASJ+
- D. Type P-1 Jackets:
 - 1. Heavy-duty, fire retardant material with glass fiber reinforcing and self-sealing lap. Jacket shall have neat, white Kraft finish suitable for painting, with burst strength of 1.5 Joules(50 beach units) minimum and tensile strength 45 lbs/in minimum. Vapor barrier shall be adhered to inner surface of jacket. Permeance shall not exceed 0.02 perm.
 - 2. Manufacturers/Products:
 - a. Owens Corning, ASJ-SSL
 - b. Johns Manville, ASJ
 - c. Knauf, ASJ+

2.5 ADHESIVES, MASTIC, COATINGS, SEALANTS, AND REINFORCING MATERIALS

- A. Adhesives and sealants shall comply with the South Coast Air Quality Management District SCAQMD 1168; VOC limits shall comply with Indoor Environmental Quality Section, Credit IEQ-4.1.
- B. Coatings and mastics shall comply with VOC limits set forth by Green Seal BS-11 and comply with the South Coast Air Quality Management District SCAQMD 1113; VOC limits shall comply with Indoor Environmental Quality Section, Credit IEQ-4.2.

- C. Products shall be compatible with surfaces and materials on which they are applied and shall be suitable for use at operating temperatures of systems to which they are applied.
- D. Products shall be fire retardant, moisture resistant and mildew resistant and vermin proof.
- E. Vapor Barrier Mastic: Below ambient insulation. Water vapor permeance shall be less than 0.08 perms at 45 mils dry film thickness per ASTM F1249.
 - 1. Foster 30-33
 - 2. Childers CP-33
 - 3. Vimasco 749
- F. Weather Barrier Breather Mastic: Above ambient insulation. Permeance shall be greater than 1.0 perms at 1/16" dry film thickness per ASTM E96/E96M.
 - 1. Foster 46-50 Weatherite
 - 2. Childers CP-10/CP-11 Vi Cryl
 - 3. Vimasco WC-5
- G. Lagging Adhesive/Coatings: Indoors applications used in conjunction with canvas/glass cloth.
 - 1. Foster 30-36
 - 2. Childers CP-50 AMV1
 - 3. Vimasco 713
- H. Metal jacketing sealant for aluminum jacketing:
 - 1. Foster 95-44 Elastolar
 - 2. Childers CP-76 Chil Byl
 - 3. Pittsburgh Corning 727
- I. Insulation joint sealant for Type P, Type PP, and Type G insulation:
 - 1. Foster 95-50 Flextra
 - 2. Childers CP-76 Chil Byl
 - 3. Pittsburgh Corning CW Sealant
- J. Glass fiber fabric reinforcing shall be 10 x 10 mesh similar to Childers Chil Glas #10 or Foster Mast A Fab.
- K. Wire mesh reinforcing shall be 22 ga, 1" galvanized.
- L. Insulation cement shall be ANSI/ASTM C195, hydraulic setting mineral wool.
- M. Finishing cement shall be ASTM C449.
- N. Butt joint and longitudinal joint adhesive for Type A insulation shall be Armstrong 520, Rubatex 373, Childers CP-82 or Foster 85-75.
- O. Weather-resistant protective finish for Type A insulation shall be equal to Armstrong WB Armaflex finish or Foster 30-64 elastomeric coating.

2.6 METAL BANDS AND WIRES

- A. Aluminum bands shall be 0.5 x 0.20" up to 48" diameter and 0.75 x 0.020" over 48" diameter.
- B. Stainless steel bands shall be 0.5 x 0.015" or 0.75 x 0.015".
- C. Stainless steel wires shall be 16 ga.

2.7 INSULATION FASTENERS

- A. Insulation fasteners shall be cup head weld pins, galvanized low carbon steel, minimum 12 ga (0.105") pins.
- B. Washer edge shall be beveled.
- C. Fasteners shall be stainless steel for stainless steel ductwork application.
- D. Insulation fasteners using adhesive are not allowed.

2.8 REMOVABLE INSULATING BLANKETS

- A. Custom designed removable, reusable, flexible, blanket thermal insulation system.
- B. Acceptable Manufacturers: Thermal Energy Products, Inc., Advanced Thermal Corp., Temptec, Remco Technology, Inc., or approved equal.
- C. Removable insulation system shall be custom designed for each individual item to provide close contour fit. Overlapping seams and gaps are not acceptable.
- D. Removable insulation shall be designed to overlap adjoining pipe insulation by .
- E. Insulation: Minimum 2" thick, 2.4 lb/ft³ density, 1000°F continuous service temperature thermal insulating wool; Owens Corning Fiberglass or equal.
- F. Interior and Exterior Fabric: Minimum weight 0.59 kg/m² silicone rubber coated fiberglass cloth.
- G. Securement: Blanket seams shall be closed with buckle and strap assembly (D ring closure).
- H. Identification/Tagging: Label each removable insulation device with plastic or 304 stainless steel tag with raised letters. Tag as directed by Owner.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Provide insulation and jackets with minimum insulation thickness as indicated in the following schedule. The schedule applies to both exposed and concealed applications unless noted otherwise:

Piping System		
		Minimum Insulation Thickness According to Pipe Size

INDOOR PRACTICE FACILITY
EAST CAROLINA UNIVERSITY, GREENVILLE, NC
SCO ID# 23-26345-01A
AIM # 1752

Service	Jacket Type	Insulation Type	3/4" and Smaller	1" - 1-1/4"	1-1/2" - 3"	4" - 6"	8" and Larger
Refrigerant Suction Lines and Hot Gas By-pass Line if Used (Interior)	---	A	1"	1"	1"	1"	1-1/2"
Refrigerant Suction Lines and Hot Gas By-pass Line if Used (Exterior)	P-2	A	1"	1"	1"	1"	1-1/2"
Cooling Coil Condensate Drain	---	A	3/4"	3/4"	3/4"	3/4"	3/4"
Insulated Exterior Piping	Unless otherwise indicated, provide protective insulation shield (Type A-1 jacket) in addition to pipe insulation and jacket specified in this schedule.						
Ductwork/Equipment & Systems							
Service	Jacket Type		Insulation Type		Insulation Thickness		
OA Ducts Exposed	D-1 or D-2		R		2"		
Mixed Air (Outside Air & Return Air Ducts & Plenum)	D-1		R		1-1/2"		
Supply Ducts Exposed	D-1		R		1-1/2"		
Return and Relief Ducts in Equipment Rooms	D-1		R		1-1/2"		

- B. Type F insulation with Type D-2 jacket may be used in lieu of Type R insulation with Type D-1 jacket for ductwork located 6 ft or higher above floor in mechanical equipment rooms. Horizontal ducts that are not completely 6 ft above floor shall be insulated with Type R insulation as specified for its entirety.

3.2 INSTALLATION - GENERAL

- A. All insulation installation methods shall be performed in accordance with the latest edition of National Commercial and Industrial Insulation Standards published by MICA (Midwest Insulation Contractors Association) and manufacturer's installation instructions, except as modified in this Section of specifications.
- B. Install products with good workmanship, with smooth and even surfaces. Use full-length factory-furnished material where possible. Do not use scrap pieces.
- C. Apply insulation only on clean, dry surfaces, after all rust and scale have been removed and testing of systems has been completed. Do not insulate any section of system that must be pressure tested until after it has been successfully tested. Any removal and reinstallation to correct system defects prior to end of guarantee period shall be accomplished at no expense to Owner.

- D. Install insulating materials with necessary joints and terminations, to permit easy access and removal of equipment sections where inspection, service or repair is required, and to allow for expansion.
- E. Where possible longitudinal joints in jackets shall face toward wall or ceiling.
- F. Apply insulation to each pipe or duct individually. Common insulation applied to adjacent pipes or ducts will not be accepted.
- G. Unless otherwise indicated, pipe and duct insulation shall be continuous through walls and floors.
- H. Where multiple layers of insulation are used, stagger and secure each layer with metal bands.
- I. Where penetrations occur through fire-rated walls, partitions, or floors, provide fire seal as specified in Section 230000 - General Mechanical Requirements and Section 078400 - Firestopping.
- J. Insulate the following systems for complete vapor barrier protection:
 - 1. Refrigerant
 - 2. Cooling coil condensate drain
 - 3. All insulated ductwork
 - 4. All piping and/or equipment with surface temperature below 60°F
- K. Apply Type A insulation for insulation and jackets requiring vapor barrier protection where specified insulations are cut for mounting sensors, control devices, parts of valves, devices or components which extend out from specified insulation to prevent condensation.

3.3 PIPING, VALVE AND FITTING INSULATION

- A. Apply insulation to pipe, unions, flanges, fittings, valves and piping specialties with butt joints and longitudinal seams closed tightly. Valve insulation shall cover entire valve body including bonnets and packing nuts.
- B. Laps on factory-applied jackets shall be 2" minimum width firmly cemented with lap adhesive, or shall be pressure sealing type lap.
- C. Cover joints with factory furnished tape 3" minimum width) to match jacket. Cement firmly with lap adhesive. On systems requiring a vapor barrier (ASJ), vaporseal all longitudinal and butt joints ASJ/Saran seams with 4"wide coat of vapor barrier mastic or 3" minimum tape.
- D. Where staples are used, they shall be on 6" maximum centers. When used for systems requiring vapor barrier, cover lap and staples with finish coat of vapor barrier mastic or 3" minimum tape.

- E. For finishing of insulated pipe fittings and valves where surface temperature of insulation is not higher than 125°F, use one piece PVC fitting covers, minimum thickness of 0.05 mm(20 mil), Fitting cover shall be Johns Manville Zeston 2000 PVC, PROTO Fitting Covers, or similar by other manufacturers listed. Where fitting and valve insulation requires vapor barrier, seal joints of PVC covers with vapor barrier adhesives. Insulation type, R-value and density of insulation used at fittings shall match insulation of adjacent piping. Install insulation at pipe fittings and valves completely prior to applying PVC covers.
 - 1. For Type R (Rigid glass fiber) pipe insulation, PVC fitting covers with flexible mineral fiber blanket insulation inserts are acceptable, except those located in mechanical rooms within 6 ft above floor. For fitting covers located in mechanical room within 6 ft above floor, insulation inserts shall be pre-molded rigid fiber glass type wrapped around elbows.
- F. Stove pipe style insulation on elbows (Detail A on Plate 2-200 of MICA 8th Edition) is not allowed. It may be used for closed cell elastomeric insulation.
- G. Where terminations of pipe insulation are required, insulation shall have tapered ends, built up and finished as specified for fittings.
- H. For pipes 1" and smaller, install specified pipe insulation and jacket continuous through hanger or support locations. Install insulation protection shields to protect insulation from compressing.
- I. For pipes 1-1/2" and larger, where manufactured pre-insulated pipe supports are used at hanger or support locations, extend insulation to insulated pipe supports. Where vapor barrier is required, this Contractor shall be responsible for continuity of vapor barrier at insulated pipe supports. 3" wide vapor barrier tape on hot and cold systems at pipe supports.
- J. For pre-insulated pipe supports and insulation protection shields, refer to Section 230529 - Mechanical Piping and Equipment Supporting Devices.
- K. For Contractor-fabricated anchors, secure insulation directly to pipe surface and extend insulation up anchor for distance of 4 times insulation thickness. For pre-insulated anchors, cover entire surface of anchors with Type A insulation. Where applicable, take special care to assure vapor seal at anchor.
- L. Where mechanical grooved pipe connections are used in piping system, insulate couplings as specified for pipe.
- M. Piping, fittings, and valves not to be insulated:
 - 1. Heating hot water piping inside fin tube radiation enclosures
 - 2. Control valves and balancing valves for heating terminal devices
 - 3. Valves and steam traps furnished with removable insulation/jacket

3.4 EQUIPMENT INSULATION

- A. Install removable insulation where access is required for cleaning, repair and inspection. Construct removable insulation with Type A insulation for cold equipment and Type R insulation with V-1 jacket for hot equipment. Do not apply bonding adhesive to equipment surface.

- B. Provide removable insulating blankets on expansion joints.
- C. Do not insulate over equipment nameplates or ASME stamps. Bevel and seal insulation at these locations.
- D. Equipment not to be insulated:
 - 1. Equipment furnished with factory insulation.

3.5 DUCTWORK AND COMPONENTS

- A. Apply duct insulation evenly over duct surface. Unless otherwise indicated, insulation and jacket shall run continuously between duct and duct supports. Maintain insulation thickness specified over duct reinforcing members.
- B. For support points of rectangular or oval ducts supported by trapeze hangers, place weight-supporting insulation at bottom of duct over trapeze. Weight supporting insulation inserts shall be minimum 6" long with same thickness as insulation specified and shall be Type G, H, P or PP insulation. Size inserts based on compression strength and weight being supported.
- C. For support points of round ducts smaller than 16" diameter, weight-supporting insulation is not required for either rigid or flexible glass fiber insulation.
- D. For support points of round ducts 16" diameter and larger, place weight-supporting insulation between duct and strap or trapeze. Weight-supporting insulation shall be minimum 6" long with same thickness as insulation specified and shall be Type G, H, P or PP insulation. Size inserts based on compression strength and weight being supported.
- E. Securing glass fiber insulation (Type F, R, and RR) for rectangular or oval ductwork:
 - 1. Horizontal ductwork:
 - a. Secure to bottom of duct where duct width is 24" diameter or greater.
 - b. Secure to sides of duct where duct side is 24" diameter or greater.
 - 2. Vertical ductwork:
 - a. Secure to all sides where duct width is 18" diameter or greater.
 - 3. Install fasteners as required to secure, but not over 18" on center and within 3" of butt joint or edge.
 - 4. Fastener shall be weld pin mechanical type.
- F. Fastening insulation anchors to ductwork with adhesives is not allowed. Where weld pin fasteners are used, install them without damage to interior galvanized surface. Where weld pin fasteners cannot be used, use other type of fasteners such as metal bands.
- G. Where insulation is required for ductwork, provide insulation over entire ductwork system, including system components such as filters, mixing air chambers, sound attenuators, air measuring stations, reheat coils, etc. For fire dampers, smoke dampers and combination F/S dampers in ductwork requiring insulation, install insulation and jacket to wall and apply vapor barrier sealant to prevent condensation.

- H. Provide insulation over back pan or plenum of supply air diffusers, registers, or grilles primary air plenums of active chilled beams, and unlined boots after termination point of flexible ducts or rigid duct insulation to prevent sweating.
- I. Where vapor barrier jackets are specified, pins and staples if used shall be jacketed over with matching material using 4" tape. Vaporseal insulation seams, punctures, and tears with two 4" wide tape.
- J. Insulation without factory jacket shall be cut and mitered to suit surface. Build up voids, seams and joints with insulating cement, cover with glass fabric as specified herein and finish to smooth surface.
- K. D-1 jackets:
 - 1. Butt together joints and seams firmly, cover with glass fiber fabric 4" minimum width.
- L. Acoustical Barrier Materials:
 - 1. Provide 2" thick Type R insulation with Type D-1 jacket as inner layer. Over insulation install acoustical barrier materials as outer layer in accordance with manufacturer's installation instruction.
 - 2. For ductwork specified with Type F insulation, replace it with insulation specified above.
 - 3. Refer to plans for ductwork requiring acoustical barrier materials.
- M. Ductwork not to be insulated:
 - 1. Internally lined ductwork
 - 2. Ductwork components with factory installed insulation

3.6 PROTECTIVE INSULATION SHIELD (A-1 JACKET) FOR PIPE JACKETS EXTERIOR TO BUILDING

- A. Unless otherwise indicated, install shields (A-1 jacket) around insulated pipe and fittings exterior to building. Seal water and vapor tight at terminations.
- B. Longitudinal overlap shall be at least 2" wide with vapor barrier sealant.
- C. Secure jacketing with 3/4" wide .015" stainless steel or 3/4" wide .020" aluminum bands and wing seals on maximum 18" centers.

END OF SECTION 230700

SECTION 230901 - CONTROL SYSTEMS INTEGRATION

PART 1 - GENERAL

1.1 DEFINITIONS

- A. The following abbreviations, acronyms, and definitions may be used in addition to those found elsewhere in Contract Documents.

Actuator:	Control device to provide motion of valve or damper in response to control signal.
AI:	Analog Input
AO:	Analog Output
Analog:	Continuously variable state over stated range of values
Auto-Tune:	Software routine used to adjust tuning parameters based on historical data.
BAS:	Building Automation System
BMS:	Building Management System
DDC:	Direct Digital Control
DDCP:	Direct Digital Control Panel
Discrete:	Binary or digital state
DI:	Discrete Input (Sometimes referred to as Binary Input BI)
DO:	Discrete Output (Sometimes referred to as Binary Output BO)
EMCS:	Energy Management and Control System (Typically interchangeable with BAS or BMS)
E/P:	Voltage to pneumatic transducer (Often solenoid valve is referred to as an E/P transducer)
FA;	Field Adjustable
FC:	Fail Closed position of control device or actuator. Device moves to closed position on loss of control signal or energy source.
FLP:	Fail Last Position
FMS:	Facility Management System linking two or more BAS
FO:	Fail Open position of control device or actuator. Device moves to open position on loss of control signal or energy source.
I/P:	Current to pneumatic transducer
Instrument:	Device used for sensing input parameters or used for actuation.
Modulating:	Movement of control device through an entire range of values proportional to an infinitely variable input value
Motorized:	Control device with actuator
NC;	Normally Closed position of switch after control signal is removed or normally closed position of manually operated valves or dampers.
NO:	Normally Open position of switch after control signal is removed or normally open position of manually operated valves or dampers.

Node:	DDCP, operator workstation, or other control device connected to communications network.
Operator:	Same as actuator for motorized devices. Also refers to an individual who physically "operates" facility.
PC:	Personal Computer
Peer-to-Peer:	Mode of communication between controllers in which each device connected to network has equal status and each share its database values with other devices connected to network.
P:	Proportional control, control mode with continuous linear relationship between observed input signal and final controlled output element.
PI:	Proportional - Integral control, control mode with continuous proportional output plus additional change in output based on both amount and duration of change in controlled variable (reset control).
PID:	Proportional - Integral - Derivative control, control mode with continuous correction of final controlled output element versus input signal based on proportional error, its time history (reset), and rate at which its changing (derivative).
Point:	Analog or discrete instrument with addressable database value.
Self-Tune	Same as Auto-Tune
Solenoid:	Electric two-position actuator. (See E/P.)
TCC:	Temperature Control Contractor (Same as Control Contractor)
TCP:	Temperature Control Panel

1.2 ACCEPTABLE CONTROL CONTRACTORS

- A. Control Contractor shall have full service office within 100 miles of project site. Full service office is defined as being home office of applications engineers, supervisors, and field technicians, having complete parts inventory, and having required test and diagnostic equipment. Control Contractors shall be factory authorized agent or dealer of controllers and control hardware as manufactured by:
1. Johnson Controls
 2. Siemens Building Technologies
 3. Trane Company
- B. Bids will be accepted only from prequalified Control Contractor per "Instruction to Bidders".

1.3 SYSTEMS DESCRIPTION

- A. System shall be electric and/or electronic.
- B. Control system shall be Direct Digital Control (DDC).

- C. New BAS shall seamlessly integrate with existing site web server operator interface of the same company. Existing web server shall be able to access and read all input, output and calculated points and issue commands to all output points in new BAS by means of a standard web browser. Contractor shall provide necessary hardware and software components to accomplish this interface.
- D. Provide modular designed stand-alone controllers capable of future BAS architecture with peer-to-peer and/or low/medium speed communication networks. Upgrade to full BAS architecture shall not require removal of existing controllers, sensors, actuators, etc.
- E. BAS network architecture shall be based on an Open implementation of BACnet using ASHRAE 135-2016 exclusively as the communications protocol for communication between DDC Hardware devices, including BAS Web Server, to allow multi-vendor interoperability.
- F. Building Automation System (BAS) shall control building's HVAC components and provide interface with Lighting Control System.
- G. BAS Ethernet/IP controllers shall reside on the building enterprise network on an Owner configured VLAN.
- H. Provide BAS architecture consisting of communication network, operator workstations, web servers and modular designed controllers with all points addressable and modifiable from operator workstations or from master controller using laptop computer. BAS shall be fully expandable with addition of hardware and/or software. Expansion shall not require removal of existing controllers, sensors, actuators, or communication networks.
- I. System shall support operator workstations as specified and shall be capable of additional workstations, limited only by systems maximum node capacity.
- J. Operator workstations connected to building Ethernet network shall be able to access BAS information as determined by Graphical User Interface (GUI) software through standard web browsing software (Internet Explorer, Mozilla Firefox, Opera, or Google Chrome). GUI software shall allow transparent access to each building component/system for control and/or monitoring.
- K. System intelligence shall be such that operator workstation(s) can be used for programming controls, performing analysis on filed data, generating maintenance and operation reports and providing permanent storage for programs and data.
- L. Safety devices shall function in both auto and hand modes on starter, and on VFD in auto, hand or bypass modes.
 - 1. Dampers interlocked with fans shall operate in both auto and hand modes to prevent dead-head of fans.
 - 2. Valves interlocked with pumps shall operate in both auto and hand modes of operation to prevent dead-head of pump.
 - 3. All safeties shall be hardwired through starter/VFD safety circuit to prevent unsafe operation when in either auto or hand modes.

1.4 SCOPE OF WORK

- A. Provide all labor and materials for complete fully functioning control systems in accordance with Contract Documents included in this Section plus:
 - 1. Section 230902 - Control Valves and Dampers
 - 2. Section 230903 - Control Instrumentation
 - 3. Section 230905 - Instrument Point List
 - 4. Section 230923 - Direct Digital Controllers and Networks
 - 5. Section 230924 - Graphical User Interface Integration
 - 6. Section 230993 - Control Sequences
- B. Engineering services shall be performed by Factory Trained Engineers. System shall be installed either by trained mechanics directly employed by Control Contractor or by subcontractors who are under direct supervision of Control Contractor's representative. Engineer reserves right to exclude Project Managers, Engineers, Field Supervisors, or Technicians whose past experience is not sufficient to meet needs of Project.
- C. Control Contractor's Project Managers, Engineers and Digital System Programmers shall have previously performed in capacity that qualifies them to successfully engineer system of scope and magnitude similar to this Project.
- D. Submit qualification of Project Managers, Engineers, Programmers, Field Supervisors, and Technicians to be assigned to this Project within 30 days after contract award. Use Qualification Form attached at end of this Section.
- E. Labor shall include, but not be limited to:
 - 1. Engineering services to size unscheduled valves and dampers based on design criteria specified in Section 230902 - Control Valves and Dampers, and confirm sizing of scheduled valves and dampers.
 - 2. Engineering services to produce requested submittals and working construction drawings and record drawings as specified here within.
 - 3. Engineering services for required software programming.
 - 4. Engineering services for graphics programming specified.
 - 5. Engineering services for BAS Ethernet network design.
 - 6. Project management services as single point contact to coordinate construction related activities.
 - 7. Field mechanics for installation of control wiring and related control devices.
 - 8. Field technicians to startup, calibrate, adjust, and tune control loops.
 - 9. Field technicians to perform system checkout and testing, and to complete required reports.
 - 10. Field supervisor during controls installation and startup.
 - 11. Field technicians to assist Mechanical Contractor and Testing and Balancing (TAB) Contractor in adjusting controls and determining setpoints related to TAB work.
 - 12. Field representatives and/or classroom instructors to provide Owner training as specified.

- F. Control Contractor shall be responsible for complete installation of control devices (except as noted), wiring, and pneumatic terminations at controller locations to accomplish control sequences specified in project manual or on drawings. Control Contractor is required to provide power for air terminal controllers and other field mounted devices that require 24 VAC, 60 Hertz and shall be powered from 120 to 24 VAC transformer panels provided by Control Contractor. Control Contractor shall also be responsible for additional instrumentation described in point schedules found in Contract Documents, which may not be directly related to specified control sequences.
 - 1. Control contractor shall provide unique tag numbers for all devices under this specification and reference those tag numbers in control sequences and control diagrams.
- G. Control Contractor shall be required to install instrumentation and control devices furnished with packaged equipment to be field installed as indicated on control drawings.
- H. Control Contractor shall be required to install instrumentation and control devices furnished with fume hood controllers to be field installed and provide control wiring from fume hood monitors and sash sensors to fume hood controllers.
- I. Mechanical Contractor shall provide wells, taps, and other mechanical interfaces required for control equipment mounting into piping systems. Mechanical Contractor shall install in-line mounted devices, such as valves, dampers, flow meters, static pressure probes, etc., furnished by Control Contractor. Control Contractor shall be responsible for installation of other control devices, such as actuators, linkages, sensors, air terminal controllers, flow transducers, remote mounted control devices, control panels, control transformers, etc.
- J. Electrical work required as integral part of control work is responsibility of Control Contractor. Control Contractor shall be responsible for providing final power connections, including conduit, wire, and/or disconnect switches, to control devices from appropriate electrical distribution panels.
 - 1. Electrical Contractor will provide distribution panel circuit breakers required to provide electrical power to BAS control & power distribution panels.
 - 2. 120 to 24 VAC transformer panels shall be provided by Control Contractor and mounted adjacent to controller panels or in Electrical Rooms, Telecommunications Rooms and/or (IDF/EIDF) rooms, or as indicated on plans and powered from dedicated electrical circuit.
 - 3. Quantity and location of BAS 120VAC power circuits shown on Electrical Power Plans are to be confirmed by Control Contractor. Should any change occur in location or quantity of power circuits required for BAS after Contracts are awarded, Control Contractor shall immediately notify Electrical Contractor of change. Additional costs due to these changes shall be responsibility of Control Contractor.
 - 4. Coordinate with Electrical Contractor for additional power requirements.
- K. Provide temporary Ethernet network for communications between Ethernet-based controllers and BAS servers (Web & Data Historian) until building IT network is available for use by BAS. Temporary Ethernet network and all other communications required for BAS shall be installed as required for specified operation of mechanical equipment to allow check out and commissioning of equipment in timely manner.

- L. Additional BAS data drops (from telecommunication room patch panel to field jacks/patch panels) that are not accounted for in contract documents shall be provided by Control Contractor in one of two ways:
 - 1. Option 1:
 - a. Control Contractor shall sub-contract at control contractor's expense the project's Structured Cabling Contractor to install additional data drops.
 - 2. Option 2:
 - a. Control Contractor can provide their own data drops but must exactly match all cabling and hardware installed by Structured Cabling Contractor as indicated in the following spec sections:
 - 1) 270000 - General Communications Requirements
 - 2) 270528.33 - Raceway and Boxes for Communications Systems
 - 3) 271000 - Structured Cabling
 - 4) 271300 - Communications Backbone Cabling
 - 5) 271500 - Communications Horizontal Cabling
 - 6) 271600 - Communications Connecting Cords, Devices And Adapters
 - 3. If Control Contractor chooses Option 2, submit to EOR a separate control submittal including all material and proposed locations for data jacks for approval prior to installation.
 - 4. Coordinate final Telecommunications room patch panel connections with network installation Contractor.
- M. Control Contractor shall be responsible for maintaining master IP address list for all BAS devices throughout project to be handed over to Owner upon completion.
 - 1. Master IP address list should include but not be limited to the following:
 - a. Device serial number
 - b. Firmware version
 - c. MAC address
 - d. IP address
 - e. Subnet mask
 - f. Static or dynamic IP address
 - g. VPN assignment
 - h. VLAN assignment
 - i. TCP and UDP port(s) the device uses
 - j. Default gateway
- N. Materials shall be as specified unless approved through procedures for product substitution specified in Division 01. Control Contractor shall provide components not specifically indicated or specified, but necessary to make system function within the intent of specification.

- O. If during the installation period any of the factory equipment or material provided in the system is found to be defective in material or workmanship, it shall be replaced or repaired by Contractor at no additional cost to the Owner within 24 hours from the time the problem was reported/discovered.
- P. Any part/device or equipment installed as part of this contract found to be malfunctioning or defective during the warranty period shall be replaced by Contractor within 24 hours from the time the problem was reported.
- Q. Electrical products shall be listed and labeled by UL and comply with NEMA Standards.
- R. All controls and wiring used for smoke control/life safety shall be UL 864 UUKL rated.
- S. Provide weather protection cover or weatherproof control devices where required for control devices located outdoors.
- T. Provide tamper resistant screws and fasteners for equipment located in accessible and/or public areas.
- U. Contractor is responsible for integration of the following independent systems into BAS:
 - 1. Fire Alarm System (FAS) Monitoring:
 - a. FAS provider will provide contact termination points and/or addressable relays for connection to BAS for Smoke Control and Equipment Shutdown. Contractor shall supply cabling, conduit, and hardware necessary to make connections from BAS to FAS. Contractor and FAS provider are responsible for coordination of testing point connections between systems, and joint commissioning of systems. Contractor to refer to P&IDs, DDC Point Schedules and Control Sequences for programming and monitoring requirements.
 - 2. Variable Frequency Drives (VFD):
 - a. VFD provider will provide a termination point for a single point communication connection to the BAS utilizing BACnet MS/TP protocol. Contractor shall provide cabling and conduit to make an interface connection from the BAS to the VFD. Contractor and VFD provider responsible for translation of network protocols, testing of communications between systems, and joint commissioning of systems. Contractor to refer to P&IDs, DDC Point Schedules, and Section 230514 - Variable Frequency Drive (VFD) System for programming and monitoring requirements.

1.5 SUBMITTALS

- A. Technical Proposal:
 - 1. Submit, directly to Engineer on bid day, 3 copies of technical proposal. Technical proposal shall include written and/or graphic representation of proposed BAS architecture including quantity and types of controllers to be used at each location. Show or describe routing of communication networks. Include product data sheets for proposed controllers and sensors. Provide complete, detailed description of software packages to be used. Use pre-printed shop drawing materials with technical details in lieu of sales literature whenever they are available.

2. Submit resumes of subcontractors to be used for project. List projects of similar size and scope. List shall include name and location of project, dollar value of control contract, date completed, and references. References shall include name and phone number of contact person.
 3. Technical proposals shall not intentionally deviate from specification, but explain how proposed system meets or exceeds specification. Deviations and/or exceptions must be clearly stated in executive summary. Technical proposals will be evaluated based on completeness, conformance, and value (performance versus Bid price).
- B. Extended Service Agreement:
1. Control manufacturer shall, upon completion of warranty period, make available to Owner annual service agreement covering all labor and material required to effectively maintain control system after warranty period. Owner reserves the right to accept or reject any such offers and to cancel on-going agreements with 30-day written notice.
 2. During extended service period, Contractor shall maintain Operation and Maintenance manuals to reflect all changes made to BAS.
- C. ShopDrawings:
1. Submit manufacturer's printed product data sheets for control devices and materials listed in bill of material in Control Contractor's control drawings. Datasheets shall be submitted electronically in pdf format with programmed bookmarks. When a manufacturer's data sheet refers to a series of devices rather than a specific model, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Data sheets shall include sufficient technical data to describe instrument parameters required as specified.
 - a. All submitted PDF documents shall have electronic bookmarks setup to quickly and easily locate documents and submitted information. Bookmarks shall be set up as follows:
 - 1) Shop Drawings:
 - a) Each major system (Network Architectures, AHUs, Heating systems, Cooling systems, etc.) shall have a master bookmark programmed with all documentation for the system grouped in order under a single bookmark for that system. Subgroups under the main bookmark should be divided in a minimum of: flow diagram/bill of material, wiring detail, control sequence, point list.
 - b) Each minor system (Air Terminals, FCUs, Plumbing systems, Electrical systems etc..) shall have a master bookmark programmed for the type of system with bookmarks under the master for each type of minor system. All documentation for the system shall be grouped in order under a single bookmark for equipment type but subgroups for flow diagrams, control sequences, point list etc. are not required.
 - 2) Device Data Sheets:
 - a) Device Data Sheets for all equipment specified in 230902 - Control Valves and Dampers, 230903 - Control Instrumentation and 230923 - Direct Digital Controllers and Networks shall have bookmarks organized in alpha numerical order by part number. Part numbers can and should be grouped by major category such as Valves, Dampers, Temperature sensors, Actuators, etc.

- 3) Hyperlinks:
 - a) Hyperlinks can be used to enhance the bookmark tools but are not an acceptable substitute for electronic bookmarks.
 - b) If hyperlinks are used, they should be clearly identifiable as a hyperlink but using a different color text similar to how MS Office documents identify hyperlinks.
2. Submit data concerning type of signal wiring and installation methods including raceway types and grounding methods.
 - a. Submit voltage drop calculations for all low voltage DDC circuits. Voltage drop to include number of devices and wiring run lengths, calculated voltage available at each device.
3. Submit control drawings in pdf format with bookmarks provided for each system and table of contents with links to each page. Control drawings shall include, but are not limited to, the following:
 - a. Overall system/network architecture drawings:
 - 1) Submit block diagram(s) showing relationship of each controller, control panel and other network devices relative to each other.
 - 2) Submit overall building Ethernet network architecture.
 - 3) Submit individual floor level architectures.
 - 4) Label room location of each controller/network device.
 - 5) Number and indicate model number of each device.
 - 6) Indicate network & communication protocol types.
 - b. Control Drawings:
 - 1) Including graphic representation of systems with major in-line components to properly locate all control devices.
 - 2) Identify controlled devices with their software designation on drawings, including unique valve and damper tag numbers.
 - 3) Include point input/output labels adjacent to each device corresponding to panel wiring diagrams.
 - c. Detailed wiring and piping diagrams showing point-to-point hookup details of transducers, relays, outputs, inputs and subsystem components. Label pneumatic lines and control wires with field ID numbers/colors.
 - d. Layout Design Drawing for each control panel:
 - 1) The layout drawing shall be to scale with all devices shown in their proposed positions.
 - 2) All control devices shall be identified by name.
 - 3) All terminal strips and wire channels shall be shown.
 - 4) All control transformers, power supplies and UPS modules shall be shown.
 - 5) All 120 VAC receptacles shall be shown.
 - 6) All IP connection points shall be shown.
 - 7) All fieldbus connection points shall be shown.
 - 8) Provide bill of material table.

- e. Wiring Design Diagram for each control panel:
 - 1) The control voltage wiring diagram shall clearly designate devices powered by each control transformer. If the control devices use half wave power, the diagram shall clearly show the consistent grounding of the appropriate power connection. All wire identification numbers shall be annotated on the diagram.
 - 2) If shielded communication wiring is used, the grounding of the shield shall be shown.
 - 3) The terminal strip wiring diagram shall identify all connections on both sides of the terminal strip. Wiring label numbers for all wiring leaving the control panel shall be annotated on the diagram.
 - 4) Provide controller wiring diagram showing each point wired to the controller with points identified by labels used on submitted control diagrams.
 - f. Floor level control transformer panels:
 - 1) The layout drawing shall be to scale with all devices shown in their proposed positions.
 - 2) Provide bill of material table.
 - 3) Provide Power Loop Schedule including transformer tag, transformer circuit #, devices & controllers power from circuit and total design power consumption for each circuit.
 - 4) Identify 120VAC power panel and circuit breaker serving each panel.
 - g. Bill of material identifying actual product model number used for each control device for each schematic control drawing.
 - 1) Bill of material shall be included on flow diagrams for each system and on panel layouts showing panel components.
 - 2) Bill of material shall include device name/tag, type of device, manufacturer and model number.
 - h. Floor Plan Drawings:
 - 1) Show proposed locations of sensors and flow meters in ductwork and piping systems.
 - 2) Show proposed locations of transformer panels, control panels, network equipment, lab equipment monitoring wall jacks and BAS components.
 - i. Sequence of operation: Provide written narrative describing each control sequence indicating method of control. Identify sensors, controllers, and actuators used with references to tag number of controlled device. Include set points of each control loop.
 - j. Point list for each system controller including, as a minimum, both inputs and outputs (I/O), point name, point description, point number, I/O type, scaled range, the controlled device associated with the I/O point, and the location of the I/O device. Configuration settings, alarm points, etc.
 - k. BACnet Compliance Documentation: The Protocol Implementation Conformance Statement for each component.
4. Control Instrumentation (230903) and Direct Digital Controllers and Networks (230923) submittals can be submitted as separate submittals from control shop drawings but must be submitted simultaneously with control shop drawings.

5. Submit a sample graphic page for each type of page described in Section 230924 - Graphical User Interface Integration.

D. Completion Checklist:

1. Submit with product data, shop drawings, detailed completion checklist including written procedures for adjusting and calibrating each type of instrument and sensor. Engineer reserves the right to request modifications to any procedure, which is incomplete or not adequate to prove system performance.
2. Checklist shall include references to the following additional requirements:
 - a. Instruments and sensors shall be calibrated by comparison to known device, which is traceable to National Institute of Standards and Testing.
 - b. Each point shall be checked for calibration, connection to correct control loop, and proper setting of limit and alarm values.
 - c. Transducers and other output devices shall be properly zeroed and calibrated at both minimum and maximum output.
 - d. Document settings for discrete instruments and set points for analog instruments shall include minimum and maximum positions for safe operating conditions where applicable (max. pump speed or max. frequency of fan drive, etc.).
 - e. Calibrate temperature, pressure, level and flow switches to make or break contacts as required. Document final switch make/break and reset setpoints.
 - f. Stroke and adjust control valves and dampers to assure full closed seating and full opening.
 - g. Control loops shall be tuned to maintain controlled process variable at set point through seasonal conditions without operator intervention. Provide multiple sets of tuning parameters if necessary. Controller shall automatically use tuning parameters appropriate to existing ambient conditions. Maintain record on completion checklist, of control loops that require tuning at alternate times of year. Instruct technicians to supply default parameters that can approximate stable control until actual load conditions allow proper tuning of control loops.
 - h. Performance tests of analog control loops shall be performed by changing set points and verifying that sequences can come into stable control within reasonable time period appropriate for each sequence. Simulate load changes for pressure and flow control loops.
 - i. Performance tests of discrete control loops shall be performed by adjusting set point and verifying sequence action.
 - j. Alarms, including network failures, shall be tested for each controller and device connected to network. Ensure that alarms are properly acknowledged at operator's workstation.
 - k. Schedules for each system/device shall be verified.
 - l. Graphics shall be verified for functionality including password protection, floor plan displays, system displays, alarm messaging, historical trends, report generation and HVAC schedules.
 - m. Contractor shall verify all building systems operate per the submitted sequence of operation.

- n. BAS Ethernet network testing and benchmarking documentation showing network performance from switch to switch.
 - o. Validation that IP networking configuration and programming has been completed as specified.
 - p. Testing of specified IP networking configuration and programming to ensure specified performance. Coordinate testing with Owner's IS/IT staff.
 - q. Testing of BAS to ensure cyber security. Coordinate testing requirements with Owner.
 - r. Post as-built sequences of operation on the BAS page for easy access by ECU controls technicians.
- E. Control Contractor and Mechanical Contractor shall walk proposed static pressure sensor and flow meter locations and mark up drawings for review and approval by Owner and Engineer prior to installation.

1.6 WARRANTY

- A. Warranty period shall begin as authorized by the Owner's representative in writing. Authorization will not be given before the following conditions are met:
- 1. All verified completion checklists provided to Owner.
 - 2. Completion of all punch list items.
 - 3. Conduction of a preliminary training session for personnel. The training shall consist of an orientation session at the job site to familiarize the personnel with the location and type of controlled equipment and controls on the project, a discussion of the control sequences, and a review of the control drawings.
 - 4. Completion and distribution of the as-built control drawings, including correction of all items noted by Owner and Engineer after review of the documents.
- B. Warranty shall cover all costs for parts, labor, associated travel, and expenses for a period of one year from completion of system acceptance.
- C. Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the vendor. A telephone number where the service supervisor can be reached at all times shall be provided. The maximum acceptable response time to provide this service at the site shall be 24 hours Monday through Friday, 48 hours on Saturday and Sunday.
- D. This warranty shall apply equally to both hardware and software.
- E. Service personnel shall be qualified to accomplish work promptly and satisfactorily. Owner shall be advised in writing of the name of the designated service representative, and of any changes in personnel.
- F. Scheduled Inspections:
- 1. Two inspections shall be performed prior to warranty expiration and all work required shall be performed. Inspections shall be scheduled 6 months after Owner acceptance and one month prior to end of warranty period.
 - 2. These inspections shall include:
 - a. Visual checks and operational tests of equipment.

- b. Clean control system equipment including interior and exterior surfaces.
 - c. Check and calibrate each field device. Check and calibrate 50 percent of the total analog inputs and outputs during the first inspection. Check and calibrate the remaining 50 percent of the analog inputs and outputs during the second major inspection. Certify analog test instrumentation accuracy to be twice the specified accuracy of the device being calibrated. Randomly check at least 25 percent of all digital inputs and outputs for proper operation during the first inspection. Randomly check at least 25 percent of the remaining digital inputs and outputs during the second inspection.
 - d. Run system software diagnostics and correct diagnosed problems.
 - e. Resolve any previous outstanding problems.
 - f. Install software upgrades, patches and fixes. Contractor to provide verification to facility personnel that all upgrades, patches and fixes to be installed have been tested in accordance with site testing and deployment procedures.
- G. Scheduled work shall be performed during regular working hours, Monday through Friday, excluding holidays.
- H. Dated records and logs shall be kept of each task, with cumulative records for each major component, and for the complete system chronologically. A continuous log shall be maintained for all devices. The log shall contain initial analog span and zero calibration values and digital points. Complete logs shall be kept and shall be available for inspection onsite, demonstrating that planned and systematic adjustments and repairs have been accomplished for the control system.
- I. Each service call request shall be recorded as received and shall include its location, date and time the call was received, nature of trouble, names of the service personnel assigned to the task, instructions describing what has to be done, the amount and nature of the materials to be used, the time and date work started, and the time and date of completion. A record of the work performed shall be submitted within 5 days after work is accomplished.
- J. Recommendations for system modification shall be submitted in writing. No system modifications, including operating parameters and control settings, shall be made without prior approval of the Owner. Any modifications made to the system shall be incorporated into the Operations and Maintenance Instructions, and other documentation affected.
- K. During the warranty period, the Contractor shall maintain a backup of all software installed in the system. The backup shall be updated monthly or whenever the Contractor makes a change to the software. A reload of backup software into the system shall be performed by the Contractor immediately upon notification by the Owner. The reload shall be free of charge.
- L. At the end of the warranty period, the Contractor shall provide updated copies of the latest versions of all project record documentation as described in Paragraph 1.10, Record Documents. This includes final updated drawings, software documentation, and electronic media backups that include all changes that have been made to the system during the warranty period.

1.7 COORDINATION WITH TAB CONTRACTOR

- A. Control Contractor shall allow sufficient time to provide assistance and instruction to TAB Contractor in proper use and setting of control components such as, Operator Workstation computers, static pressure controllers, "K" Factors for VAV boxes, or any other devices that may need set points changes so that TAB work can be performed.
- B. Provide required hardware and software related to control system to TAB Contractor to allow testing of systems and continued operation.

1.8 OPERATION AND MAINTENANCE MANUALS

- A. Refer to Division 01 - General Requirements.
- B. Operation and Maintenance manuals shall provide descriptions of maintenance on all system components, including sensors and controlled devices. Descriptions shall include:
 - 1. Product manuals for the key software tasks.
 - a. Operating the system
 - b. Administering the system
 - c. Engineering the Operator workstation
 - d. Application programming
 - e. Engineering the network
 - f. Setting up the web server
 - g. Report creation
 - h. Graphics creation
 - i. Data backup & Archiving
 - 2. List of recommended maintenance tasks associated with the system, controllers, instruments, operator workstations, data servers, web servers, and web clients.
 - a. Define the task.
 - b. Recommend a frequency for the task.
 - c. Reference the product manual that includes instructions on executing the task.
 - 3. Licenses, guarantees, and warranty documents for equipment and systems.
 - 4. Master IP address list for all network devices including but not be limited to the following:
 - a. Device serial number
 - b. Firmware version
 - c. MAC address
 - d. IP address
 - e. Subnet mask
 - f. Static or dynamic IP address
 - g. VPN assignment
 - h. VLAN assignment
 - i. TCP and UDP port(s) the device uses
 - j. Default gateway

5. System architecture diagram for components within the building annotated with specific location information.
6. As-built drawing for each control panel
7. As-built wiring design diagram for each control panel
8. As-built system flow diagram for each system
9. Sequence of control for each system
10. Binding map for the building
 - a. A list of the device to device data flow. This shall not include the flow of data from devices to the presentation system.
 - b. Include:
 - 1) Description of the variable
 - 2) Sending device
 - 3) Receiving device
11. Product data sheet for each component
12. Troubleshooting guide
13. Repair parts list
14. Calibration instructions
15. Control Contractor's completion checklist
16. Manufacturer representative's name, address, and phone number
17. Refer to SUBMITTALS, Shop Drawings above for electronic bookmark requirements for electronically submitted Operation and Maintenance manuals.

1.9 RECORD DRAWINGS

- A. Refer to Division 01 - General Requirements.
- B. Submit revised as-built shop drawings indicating changes made during Project.
 1. Refer to SUBMITTALS, Shop Drawings above for electronic bookmark requirements for electronically submitted record drawings
- C. Record drawing submittals shall be inclusive of BAS as installed and commissioned.
- D. Update control diagrams to include tuning parameters and set points applicable to systems depicted as of date of system completion. This information shall be incorporated with sequence of operation for each system.
- E. Include floor plans showing location of control panels and routing of BAS network cabling.
- F. BACnet systems and devices:
 1. Submit finished device addressing documentation.
 2. Submit finished hardcopy of device binding database.
- G. Provide passwords, if used, for back-up and restore functions for each controller.
- H. List of all BACnet IP devices installed with their network IP addresses, BACnet Device Instance numbers and associated BACnet network numbers.

- I. Software (as installed and commissioned)
 - 1. All software submittals shall be provided in a format suitable for restoration of the programming and configuration of respective digital controllers, servers, workstations and peripheral devices, etc. provided as part of the BAS.
 - 2. Submit a copy of all software installed on the servers and workstations.
 - 3. Submit all licensing information for all software installed on the servers and workstations.
 - 4. Submit a copy of all software used to execute the project even if the software was not installed on the servers and workstations.
 - 5. Submit all licensing information for all of the software used to execute the project.
 - 6. All software revisions shall be as installed at the time of the system acceptance.
- J. Firmware Files (as installed and commissioned)
 - 1. All firmware files shall be provided in a format suitable for restoration of the programming and configuration of respective digital controllers, servers, workstations and peripheral devices, etc. provided in the BAS.
 - 2. Submit a copy of all firmware files that were downloaded to or pre-installed on any devices installed as part of this project. This does not apply to firmware that is permanently burned on a chip at the factory and can only be replaced by replacing the chip.
 - 3. Submit control listing of firmware version for all firmware that is permanently burned on a chip at the factory.
 - 4. Submit a copy of all application files that were created during the execution of the project.
 - 5. Submit a copy of all graphic page files created during the execution of the project.
 - 6. Submit a copy of all secondary graphic files such as bitmaps, jpegs, etc. that were used in the creation of the graphic pages.

1.10 OWNERSHIP OF PROPRIETARY MATERIAL

- A. Owner shall retain all rights to software for this project.
- B. Owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to the Owner as defined by the manufacturer's license agreement, but shall protect the manufacturer's rights to disclosure of Trade Secrets contained within such software.
- C. Licensing agreement shall not preclude the use of the software by individuals under contract to the Owner for commissioning, servicing, or altering the system in the future. Use of the software by individuals under contract to the Owner shall be restricted to use on the Owner's computers and only for the purpose of commissioning, servicing, or altering the installed system.
- D. All project developed software, files and documentation shall become the property of Owner. These include but are not limited to:
 - 1. Server and Workstation software
 - 2. Application Programming Tools
 - 3. Configuration Tools
 - 4. Addressing Tools

5. Application Files
6. Configuration Files
7. Graphic Files
8. Report Files
9. Graphic Symbol Libraries
10. All Documentation.

PART 2 - PRODUCTS

2.1 CONTROL WIRING

- A. Control wiring shall be in accordance with National Electrical Code and Local Electrical Codes. Final connection points at devices and panels shall be made either at terminal blocks integral to device or at separate terminal blocks mounted inside of control panel enclosures. Use of wire nuts and crimped connections are not allowed for terminating control wiring unless approved by Engineer.
- B. Refer to Division 26 for specification requirements for conduits and conductors, except as noted.
- C. Terminal Blocks:
 1. Terminal blocks which are not integral to other equipment shall be insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, shall be suitable for rail mounting, and shall have end plates and partition plates for separation or shall have enclosed sides.
- D. Signal and Power Conductors (24 V and Under):
 1. Wires smaller than #18 AWG shall not be used, except for manufacturer supplied instrument specific wire, or where otherwise specified. Use 2-wire stranded twisted/shielded pair 24 VDC for analog and discrete input and 24 VAC/VDC output devices. For 3-lead RTD signal wiring, use #18 AWG stranded, tinned copper twisted/shielded 3-conductor. Provide isolated instrument grounding system as per manufacturer's recommendations.
 2. Conductors not concealed in raceway shall have UL Listed plenum rated Teflon or low-smoke PVC jacket and insulation. Conductors not concealed in raceway used in high temperature applications or harsh environments shall have UL Listed plenum rated Teflon jacket and insulation.
 3. Provide 250 ohm, 5 watt, 0.1% tolerance dropping resistors in 4 - 20 mA circuits as required to generate 1 to 5 volt signals in 24 VDC powered instrument loops.
 4. 24 VAC Power Conductors shall be #18 AWG 2 wire twisted pair or larger. Provide Metal Oxide Varistors (MOVs) on 24 VAC/VDC discrete outputs connected to inductive loads to reduce noise levels (i.e., solenoid valves, motor contactors, relays, damper/valve electric actuators, etc.).
 5. Stranded twisted/shielded control conductors are required with shields to be terminated within variable frequency Drive enclosures to reduce effects of noise from VFD. Follow VFD manufacturer's installation instructions for wiring control conductors to VFD.

6. Intrinsic safe instrument signal wiring, used in NEC rated area, shall be concentric stranded, tinned copper, twisted, shielded pair with shield drain wire per ISA RP12.6.
- E. Communication Cable:
1. Cable not concealed in raceway shall have UL Listed plenum rated insulation.
 2. Floor Level Network Communication Cable (Twisted Pair): Use control system manufacturer's standard communications cable or #22 AWG to #24 AWG twisted, shielded pairs, coaxial cable, or fiber optics for communications between remote controllers/devices
 3. IP Network and Telephone Cable:
 - a. Refer to specification 271500 - Communications Horizontal Cabling
- F. Transient Voltage Surge Suppression Devices:
1. Devices shall be designed for 120 V power conditioning devices for electronic equipment. Devices shall be designed, manufactured, tested, and installed in compliance with ANSI/IEEE C62.41 and IEEE C62.45 Federal Information Processing Standards Publication 94 (FIPS PUB 94), NEMA, NFPA 70, NFPA 75, and NFPA 78, and UL 1449 and UL 1283. Devices shall be labeled for UL 1449.
 2. Clamping voltage for 120 V power systems shall be 400 V.
 3. Provide visual indicator of when surge device has been used.
- G. Uninterruptible Power Supply
1. Manufacturers: MGE UPS Systems, Eaton Powerware, Vertiv Liebert or approved equal
 2. Provide UPS for backup power for Operator Workstations, Building Level Controllers, Floor Level Controllers and field panels required for control of emergency/standby powered equipment, UPS shall maintain control upon loss of normal power and until emergency/standby power supply is brought on line.
 3. Select UPS for minimum of 5 minutes backup time for load connected. This will allow emergency/standby power sources to come on line and provide backup power to emergency/standby powered equipment.
 4. Upon sensing loss of normal power, transfer time shall be 8 milliseconds maximum.
 5. Operating Parameters:
 - a. Operating Temperature: 32°F to 104°F.
 - b. Relative Humidity: 0 to 95% rh, non-condensing
 - c. Recharge Time: 8 hours, typical
 6. UPS shall have self-diagnostic capability with alarm contact to BAS to allow remote monitoring/alarming of UPS trouble or alarm conditions.
- H. Uninterruptible Power Supply (Servers):
1. Manufacturers: MGE UPS Systems, Eaton Powerware, Vertiv Liebert or approved equal
 2. Provide rack mounted dual/double conversion UPS for backup power for each rack-mounted Server. UPS shall maintain power to Server upon loss of normal power and until emergency power supply is brought on line.
 3. Select UPS for minimum of 20 minutes backup time for load connected. This will allow emergency power sources to come on line.

4. UPS shall be provided with power management software and communication cable for interfacing with respective Server.
5. Upon sensing loss of normal power, transfer time shall be 8 milliseconds maximum.
6. Operating Parameters:
 - a. Operating Temperature: 32°F to 104°F.
 - b. Relative Humidity: 0 to 95% rh, non-condensing
 - c. Recharge Time: 8 hours, typical

2.2 LOCAL CONTROL PANELS

- A. Control panels shall meet the following minimum requirements:
 1. Outdoors: Control panels located outdoors shall comply with NEMA 3R or 4X requirements.
 2. Mechanical Rooms: Control panels located in mechanical or electrical rooms shall comply with NEMA 4 requirements.
 3. Other Locations: Control panels in other locations, including occupied spaces, above ceilings, and plenum returns shall comply with NEMA 1 requirement.
- B. Provide panels of adequate size to accommodate instruments for future expansion of approximately 25% beyond space required for this scope of work.
- C. DIN Rail Circuit Breakers:
 1. Manufacturer: Allen Bradley, Entelec, WAGO, Phoenix Contact or approved alternate.
 2. Circuit breakers for switching panel power shall be magnetic, energy limiting, handle style, single-pole finger safe type DIN rail mounted with visual fault trip indication and capable of accepting #16 to #6 AWG wire.
- D. Terminal Blocks:
 1. Manufacturers: Wago, Allen Bradley, Entelec, Phoenix Contact, Weidmuller or approved alternate.
 2. Terminal blocks shall be IEC style double density feed through finger safe type rated for 15A, UL listed, DIN style rail mounted, and capable of accepting #22 to #12 AWG wire. Insulation shall be rated for 32°F to 185°F continuous operating temperature. Voltage rating shall be greater than or equal to voltage rating of cables served by terminal block.
- E. Panel Power Terminal Blocks:
 1. Terminal blocks shall be IEC style single density feed through finger safe type rated for 20A/600 VAC, UL listed, DIN style rail mounted, and capable of accepting #18 to #10 AWG wire. Insulation shall be rated for 194°F continuous operating temperature.
- F. Push Buttons:
 1. Manufacturer and Type: Allen Bradley, IDEC, Square D, or approved alternate.
 2. Heavy-duty nonilluminated flush push buttons with same or better NEMA rating as panel enclosure shall be used for control panel operator interface switching.

- a. Contact Type: Contractor shall select based on drawings or as required to meet intended control function.
 - b. Current: 5 amp continuous.
 - c. Mechanical Switch Actuation Life: 500,000 cycles minimum.
 - d. Dielectric Strength: 2000 V for 1 minute.
 - e. Vibration: 6 G minimum without false trip or switch damage.
 - f. Shock: 1/2 cycle sine wave for 8 milliseconds without switch actuation.
3. Provide legend plate for each pushbutton for indication of depressed state.
4. Selector Switches:
5. Manufacturer and Type: Allen Bradley Bulletin 800T, IDEC, Square D, or approved alternate.
6. Heavy-duty nonilluminated 24VAC/60Hz or 24VDC, 10A continuous selector switches with same NEMA rating as panel enclosure shall be used for control panel operator interface switching.
 - a. Contact Type: Contractor shall select based on drawings or as required to meet intended control.
 - b. Current: 5 amp continuous.
 - c. Mechanical Switch Actuation Life: 500,000 cycles minimum.
 - d. Dielectric Strength: 2000 V for 1 minute.
 - e. Vibration: 6 G minimum without false trip or switch damage.
 - f. Shock: 1/2 cycle sine wave for 8 milliseconds without switch actuation.
7. Provide legend plate for each switch indicating each switch position.

PART 3 - EXECUTION

3.1 GENERAL

- A. Install control equipment, and wiring in neat and workmanlike manner.
- B. Coordinate timely delivery of materials and supervise activities of other trade contractors to install devices such as immersion wells, pressure taps, any associated shut-off valves, flow switches, level switches, flow meters, air flow stations, valves, dampers, and other such items furnished by Control Contractor, which are to be installed by Mechanical Contractor.
- C. Install control devices in accessible location.
- D. All BAS associated 120 VAC power wiring (including all input and output power supplies) shall originate from clearly-marked, BAS-dedicated circuit breakers. All system control devices shall be powered from the same circuit that supplies power to the associated BAS controller. All BAS equipment shall be fused in accordance with manufacturer's recommendations.

- E. 120 VAC power shall not be allowed inside BAS controller panels. All 120 VAC to 24 VAC transformers and 120 VAC to 24 VDC power supplies shall be located in enclosures adjacent to the control panel being served. Each BAS system controller (AHU, EF, chilled water, HHW, etc) and building controller shall be provided 120 VAC power from a dedicated power circuit/circuit breaker. Provide disconnect means on the line-side of each transformer.
- F. Control Contractor provided 120 VAC distribution panels shall be provided with circuit breakers on 120 VAC power entering panel and provide individual circuit breakers or fusible switches on 120 VAC power feeding each instrumentation/device or valve actuator.
- G. Terminal unit controls shall be served by consolidated 24 VAC transformer panels. Provide disconnect means on the line-side of each transformer.
- H. BAS controllers and transformer panels shall be labeled with the source of electrical power including panel number, circuit breaker number, and room number where electric panel is located.
- I. Devices containing mercury are not allowed.
- J. Coordinate mounting height and location of control devices so that NEC workspace clearances are maintained.
- K. During construction, Contractor shall take necessary precautions to ensure all panels, wiring, instrumentation, etc. are kept clean and dry. Upon Project completion, control panels shall be clean of wire nuts, trash, and wire stripping. All excess material is to be turned over to Owner BAS group.
 - 1. Mechanical systems that are used during construction for heating and/or cooling shall have all air sensors (pressure and flow), humidity sensors, and any sensor that construction dust/dirt could inhibit sensor performance, wrapped with filter material to prevent construction dust/dirt from fouling the sensor.
 - a. When construction is complete and before building is turned over to the owner, filter material shall be removed, and sensor calibration shall be re-verified.
- L. BAS floor level network to room/equipment controllers shall be confined to the same floor the respective building level controller is located on.
 - 1. In applications where the floor level network must transition between floors, the transition shall be located in a clearly marked junction box on each floor of appropriate size to accommodate a screw terminal strip. Network cabling shall be labeled to indicate the previous connection prior to entering the junction box with the terminal strip. Terminal strip shall be used as a transition point from one floor to the next. Terminal strip shall be large enough to accommodate transitions to and from the floors below and above if floor transitioning is required.

- M. Labels and tags shall be keyed to unique identifiers shown on As-Built drawings. Enclosures and DDC Hardware and controllers shall be labeled. Sensors, valves and actuators shall be tagged. Airflow measurement arrays shall be tagged to show flow rate range for signal output range, duct size, and pitot tube AFMA flow coefficient. Duct static pressure taps shall be tagged at location of pressure tap. Tags shall be plastic or metal and shall be mechanically attached directly to each device or attached by a metal chain or wire. Labels exterior to protective enclosures shall be engraved plastic and mechanically attached to enclosure or DDC Hardware. Labels inside protective enclosures may be attached using adhesive, but shall not be hand written.

3.2 CONTROL WIRING

- A. Provide electrical wiring required for complete functional control systems, including power circuit to control panels, both line and low voltage, in accordance with applicable local codes, and latest version of National Electrical Code and NFPA.
 - 1. Voltage drops for all low voltage circuits shall be calculated prior to installing low voltage circuits. Voltage drop calculations shall be made available to Engineer on demand.
- B. Control panels serving equipment fed by emergency/standby power shall also be served by emergency/standby power. Equipment fed by emergency/standby power is so indicated on mechanical equipment schedules and electrical motor schedules. Control panels shall be powered by local UPS (Uninterruptible Power Supply) to ensure continued control of equipment powered by site standby power sources when primary power source is lost. Devices such as Operator Workstations, Floor Level and Building Level Controllers, Advanced Application Controllers, Application Specific Controllers, routers, gateways and fume hood controls shall be provided with UPS power.
- C. Where multiple controllers reside in a single control panel, provide a separate control transformer and disconnect (or fuse) for each controller.
- D. Install control wiring in metal conduit or raceway system. Refer to Division 26 - Electrical for additional requirements.
- E. Wiring concealed inside walls shall be run in conduit with stub to above ceiling. Plastic bushing shall be installed where the sensor wire exits the conduit to prevent damage.
- F. Where penetrations of fire-rated assemblies are involved, seal penetrations with appropriate firestopping systems as specified in Section 260000 - General Electrical Requirements.
- G. Color-code each junction box cover plate as to signal type using 1/2" self-adhesive color dot or enamel spray paint. Use green for low voltage signal wiring, blue for pneumatic tubing, and yellow for line voltage wiring used for signal wiring or dedicated power wiring.
- H. Tag each wire termination at control panels, junction boxes, and remote control devices with unique wire ID number.

- I. Low voltage wiring concealed above accessible ceilings does not require raceway. Cables not in raceway shall be routed along building structure lines using Bridal Rings, J-hooks or other mounting methods as approved by Engineer. Use of wire-ties for attaching cabling to duct brackets, piping or structure is not acceptable. Diagonal routing is not allowed. Label each cable not in raceway with unique wire ID number every 50 ft.
- J. Terminate low voltage DC instrument signal cable with black terminated on positive terminal and white terminated on negative unless otherwise noted.
- K. Run direct current instrument conductors separately from alternating current conductors. Where allowed by NEC wiring classification, AC-DC route crossings shall be at 90 degrees. Install special sensor to transmitter cables in accordance with manufacturer's installation drawings or in compliance with manufacturer's instructions. Extra precautions shall be taken when pulling and shortening these "vendor furnished" cables. Any extra length on these cables shall be neatly coiled into minimum 3" diameter coils and installed into junction box.
- L. All wiring terminating in a control panel/enclosure shall be landed on terminal strips, with one wire per terminal. All I/O points on a DDC/BAS controller shall be wired to panel-side of terminal strip, including all spare I/O points. This requirement does not apply to terminal unit controllers
- M. All communication/power/signal wiring terminating in a control panel/enclosure/junction box shall be provided with a minimum of 3" – 6" extra wiring length. Extra cable shall be loosely folded/looped and stored neatly in wireways or cable tray/headers above control panel.
- N. Route intrinsic safe wiring separately from other conductors. These conductors shall not be run with, nor cross, conductors of other NEC classifications and shall require intrinsic barrier if run in the same path with wiring of other classifications.
- O. Follow Control Contractor's Company standard cabling color codes.
- P. Electric Signal Cables:
 - 1. Analog electric signal cables from electronic transmitters to controllers/receivers and from controllers to other analog devices shall be continuously shielded to reduce effects of EMI on control signals residing on those cables. Electric signal cables to discrete devices typically do not require shielding, but for better noise immunity use twisted/shielded pairs.
 - 2. Shields shall be grounded at power source end only and floated at other end. Pay particular attention to floating shields through termination points, maintaining only one single grounding point, and insulating from ground at other points.
 - 3. Provide 250 ohm, 5 watt, 0.1% tolerance, dropping resistors as required to generate 1 - 5 VDC signals or 500 ohm, 5 watt, 0.1% tolerance, dropping resistors as required to generate 2 - 10 VDC signals from 4 - 20 mA control loop powered by 24 VDC power supply.
- Q. BAS Network Communication Cable:
 - 1. Typically, #22 AWG, but no smaller than #24 AWG, twisted pairs, twisted shielded pairs, coaxial cable, fiber optics or manufacturer's standard cabling for communications between remote control devices and BAS controllers.
 - 2. BAS Network communication cable shall not be spliced.

3. Provide isolated instrument grounding system as necessary per manufacturer's recommendations.

3.3 LOCAL CONTROL PANELS

- A. Provide local control panel for each system where more than one control device requires field mounting, (air handling units, exhaust fans, miscellaneous control systems including pump controls, heat exchanger controls, etc.). Single devices may be mounted on piping, wall or ductwork. Install local control panel where indicated on drawings or suitable location adjacent to system served.
- B. Mount panels on wall with suitable brackets or on self-supporting stand. Mount top of panels no higher than 6 ft above floor. Install panels so front cover door can swing fully open without interference.
- C. Label local control panels with respective unique ID numbers in accordance with Section 230553 - Mechanical Systems Identification.
- D. All control panels located in accessible areas be provided with keyed locks. Locks shall utilize a single master key. Provide 2 spare key sets to Owner.
- E. Provide a pouch or other containing method inside each non-terminal unit control panel and insert a copy of the corresponding system record control drawings and record panel wiring diagrams.
- F. Panel Layout:
 1. Locate controllers in lower half of panel first and upper half second.
 2. Locate terminal strips either horizontally in upper half of back panel or vertically. Do not locate terminal strips below 2 ft-0" or above 6 ft above finished floor.
 3. Provide separate enclosure for 120 VAC power transformer and circuitry.
 4. Enclose wire and cable in wireways or bundle w/ wire ties and secure to back-panel. This does not apply to wire exiting wireways to terminal strips or panel mounted devices.
 5. Space controllers according to manufacturer's requirements with 3" minimum between controllers and other devices on panel and 6" between controller front and door mounted devices. Ensure adequate space is allowed for device heat dissipation.
 6. Do not place controller or control devices on enclosure sides.
 7. Do not use any control panel as wire or cable pass-through to adjacent panel.
 8. All panel mounted devices and accessories shall be fastened to panel with mechanical fasteners or DIN-rail. Double-sided tape is not acceptable.
- G. Provide separate enclosure for 120 VAC power distribution, 24VAC transformer(s) and related accessories.

3.4 BAS ETHERNET NETWORK TESTING AND BENCHMARKING

- A. Test and document connectivity, latency, and integrity of network from each switch to each BAS controller and BAS server switch and from switch-to-switch.
 1. Latency between any ports shall be equal to or less than 1 millisecond.

2. Packet loss shall be less than 0.5% between any ports when tested with frame sizes between 64 and 1518 frames for duration of 60 seconds.
- B. Test and document all telecommunication protection/security techniques employed on system including access control into BAS Ethernet network from other building networks and access control to other building networks from BAS Ethernet network. Coordinate testing procedures with Owner.

3.5 ADJUSTMENT AND COMPLETION CHECKLIST

- A. After completion of installation, follow checklist procedure defined in checklist submittal to adjust and calibrate thermostats, control valves, control actuators, controllers, sensors, and other equipment provided in this Contract. Include signed and dated, completed checklist in Operation and Maintenance Manuals.
- B. Control Contractor shall provide all diagnostic and test instruments required for calibration and adjustment of system.
- C. Upon completion of Work but before final acceptance of systems, Engineer or Owner's representative will verify performance of system controls. Control Contractor shall immediately remedy any deficiencies found. Corrective measures may include modification or addition of equipment and devices, control strategies and/or software program. Corrective modifications made by Control Contractor during warranty period shall be incorporated and updated in Operation and Maintenance Manuals.
- D. After final acceptance of system, Contractor shall work with Owner to remove all existing user names and passwords for all software and hardware used on project and create new user names and passwords as required.

3.6 OWNER TRAINING

- A. Provide minimum of 8 hours of on-site training to Owner's representatives. Conduct training sessions during normal business hours after system start-up and acceptance by Owner. Scheduling of training session(s) will be established by Owner. Portions of training may be performed before system is completely operational, but no sooner than one month before system is planned to be fully operational. Final training session shall be held after systems are complete including all graphics programming.
- B. Course content shall include, but not be limited to, the following topics:
 1. Explanation of control sequences. Include which sensors are used and how output device operates.
 2. Explanation of control drawings and manuals, including symbols, abbreviations, and overall organization.
 3. Walk-through of Project to identify controller locations and general routing of network cabling.
 4. Review of operation and maintenance of hardware devices including air compressor, air dryers, controllers, instruments, and sensors. Include schedule for routine maintenance.
 5. Review of operation of operator's workstation; include hardware (PC's, printers, etc.).
 6. Review of operator's workstation software using specific examples of operating hardware.

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7. Review of portable operator's workstation software using specific examples of operating hardware.
 8. Any additional item(s) specifically requested by Owner.
- C. Provide listing of regularly scheduled factory classroom training sessions concerning advanced topics covering proper operation and maintenance of control systems, sensing, monitoring and control equipment. Additional classes travel and lodging will be arranged and paid by Owner.
- D. Provide minimum of 4 hours of additional on-site training to Owner's Representatives, 6 months after initial training is completed.
- E. Scheduling of training session(s) will be established by Owner.

END OF SECTION 230901

SECTION 230902 - CONTROL VALVES AND DAMPERS

PART 1 - GENERAL

1.1 GENERAL

- A. Devices containing mercury are not allowed.

1.2 SUBMITTALS

- A. Submit manufacturer's printed product data sheets for all valves, dampers, actuators and accessories included in Contractors submitted valve and damper schedules. Product data sheets shall include construction materials and assembly methods, maximum design parameters (temperature, pressure, velocity, etc.), and performance data for full range of actuator stroke. Product data sheets shall include charts, graphics or similar items used in making selections, including damper to duct area ratio and free area ratio. Damper product data sheets shall indicate certified leakage rates for given pressure differentials.
 - 1. Device data sheets shall be submitted with electronic bookmarks as specified in Section 230901 - Control Systems Integration. Refer to PART 1 – GENERAL, subsection SUBMITTALS.
- B. Valve and damper Shop Drawing submittals will not be processed unless supporting data and sizing calculations are included.
- C. Submit damper schedules with Shop Drawings, indicating unique tag numbers for each device, equipment or system served, device model numbers, duct sizes, damper sizes, flow rates, pressure differentials, calculation of actual damper pressure drops, approach velocities, leakage rates, torque requirements, actuator model number, actuator torque capacities, actuator fail positions and pilot positioner locations.
- D. Select dampers to meet their intended service with respect to maximum approach velocities and maximum pressure differential. Damper materials shall match duct construction materials of systems in which they are installed (galvanized steel, aluminum, 304 or 316 stainless steel, etc.).
- E. Aluminum dampers may be used in galvanized steel ductwork.

PART 2 - PRODUCTS

2.1 CONTROL DAMPERS

- A. General:
 - 1. If control damper sizes are not shown or scheduled, refer to Part 1 of this Section for sizing criteria.
 - 2. Unless otherwise indicated, modulating control dampers shall be opposed blade or parallel blade type and 2-position (open/close) dampers shall be parallel blade type.
 - 3. Blade linkage hardware shall have corrosion-resistant finish and be readily accessible for maintenance.

4. AMCA Leakage Classification of Control Dampers

Class	Static Pressure Inches Water Column			
	1	4	8	12
Leakage Rate L/s/m ² (cfm/ft ²)				
IA	3	NA	NA	NA
I	4	8	11	14
II	10	20	28	35
III	40	80	112	140

B. Standard Modulating and Two-Position Dampers:

1. Manufacturers and acceptable model numbers:
 - a. Johnson Controls VD-1630 (airfoil type)
 - b. Honeywell D2
 - c. Ruskin CD50/CD60
 - d. Air Balance AC-525/526
 - e. Greenheck VCD-43/VCD-33
2. Damper frames shall be minimum of 16 ga galvanized steel or 14 ga extruded aluminum. Blades shall be minimum of 16 ga galvanized steel or 14 ga aluminum. Blades shall have maximum blade width of 8" with steel trunnions mounted in bronze sleeve, nylon or ball bearings.
3. Furnish dampers with blade seals and stainless steel side seals. Dampers and seals shall be suitable for maximum system temperature, pressure differential and approach velocity, but not less than temperature range of -40 to 200°F, pressure differential of 6" WC, and approach velocity of 4000 fpm based on 4 ft damper section width.
4. Leakage rate shall meet AMCA Leakage Class IA or I.
5. Testing and ratings shall be per AMCA 500-D.

C. Air Flow Measuring Dampers:

1. Manufacturers and Models: Ruskin Airflow-IQ or Greenheck AMD-TD.
2. Dampers shall have integral thermal dispersion air flow measuring sensors with honeycomb air flow straighteners (as needed) for measuring minimum outside air flow at air handling units.
3. Air flow sensors consist of velocity sensors mounted within the damper frame. Measurement range shall be from 250 fpm (minimum) to 5,000 fpm (maximum). Provide transmitter programmed to provide 4-20 mA or 2-10 VDC output scaled to volumetric flow to the BAS. Transmitter shall display real-time volumetric airflow.
4. Damper frames shall be at minimum of 16 gauge galvanized steel or 14 gauge extruded aluminum. Blades shall be at minimum 16 gauge galvanized steel or 14 gauge aluminum. Blades shall have maximum blade width of 8" with steel trunnions mounted in bronze sleeve, nylon or ball bearings.

5. Furnish dampers with blade seals and stainless steel side seals. Dampers and seals shall be suitable for maximum system temperature, pressure differential and approach velocity, but not less than temperature range of -20 to 140°F, pressure differential of 6" WG, and approach velocity of 4000 fpm.
6. Dampers, when closed, shall be guaranteed by manufacturer not to leak air in excess of 8 cfm per sq ft at 4" WG differential static pressure or 3 cfm per sq ft at 1" WG differential static pressure.

2.2 DAMPER AND VALVE ACTUATORS

A. General:

1. Actuators shall have an electronic cut off or other means to provide burnout protection if stalled.
2. Actuators shall have a visible position indicator and provide position feedback to the controller as shown.
3. Actuators located outdoors or located in outside air stream shall be provided with internal heaters.
4. Actuators located outdoors or located in outside air stream should operate in the ambient temperature range of -40°F to 120°F.
5. Actuators installed outdoors shall be NEMA 4X or IP66 rated or shall be provided with weatherproof NEMA 4X stainless steel enclosures (Belimo ZS-300 or equal) that have removable covers that have clasps or machine screws (no sheet metal screws) and that do not require removing fasteners from the ductwork.
6. Provide spring return or electronic fail-safe feature for fail open or closed positions, as required by design documents. Fail-last-position actuators do not have spring return feature. Mechanical spring return shall drive the controlled device to an end position upon loss of power. Electronic fail-safe shall incorporate an active balancing circuit to maintain equal charging rates among the Super Capacitors. The electronic fail-safe shall be adjustable in 10 degree increments with a 2-second operational delay.
7. Actuators installed on smoke or smoke/isolation dampers shall be UL 555S listed.
8. Actuators requiring 120VAC or greater control power shall be provided with a means to disconnect power at each actuator.
9. Stroke time for actuators associated with emergency generators (outside air intake, generator radiator discharge) or actuators called-out as "High Speed" shall be 5 seconds or less for 90° rotation.

B. Analog Electronic:

1. Manufacturers: Belimo, Honeywell, Johnson Controls, Siemens Building Technologies or Schneider Electric
2. Actuators shall be electric motor/gear drives that respond proportionally to analog voltage or current input, or digital floating control signals.
 - a. Floating control actuators shall only be allowed for terminal hot water or chilled water control where valve position feedback is not required for system reset control (refer to control sequences).
 - b. Analog control actuators shall be used for all other modulating applications.
3. Actuators shall have a minimum 90% intermittent duty rating or rated for continuous duty.

4. Maximum full stroke time for major equipment shall be 90 seconds or less. Stroke time for terminal equipment shall be compatible with associated local controller, but no more than 6 minutes.
 5. Provide spring return or electronic fail-safe feature for fail open or closed positions, as required by control documents, for critical applications such as outside, return, or exhaust dampers, heating and cooling coils on major air handling units, humidifiers, heat exchangers, flow control for major equipment items such as chillers, cooling towers, boilers, etc. Fail-last-position actuators do not have spring return feature.
 6. Provide position feedback potentiometers connected to controller for closed loop control on major equipment analog control loops.
 7. Actuators for terminal heating/cooling equipment do not require spring return feature unless indicated otherwise in design documents.
- C. Discrete Two-Position Electric:
1. Manufacturers: Belimo, Honeywell, Johnson Controls, Siemens Building Technologies or Schneider Electric
 2. Actuators shall be electric motor/gear drives for two-position control. Maximum full stroke time shall be 90 seconds or less for 90° rotation.
 3. Provide spring return or electronic fail-safe feature for fail open or closed positions as required by control documents. Fail-last-position actuators do not have spring return feature.

PART 3 - EXECUTION

3.1 CONTROL DAMPERS

- A. Furnish control dampers as shown on drawings and/or as required to perform control sequences specified, except those furnished with other equipment.
- B. Control dampers furnished by Control Contractor shall be installed by Mechanical Contractor under coordinating control and supervision of Control Contractor.
- C. Blank-off plates or transitions required to facilitate dampers shall be provided by Mechanical Contractor.

3.2 ACTUATORS AND PILOT POSITIONERS

- A. Provide actuator for each automatic damper or valve with sufficient capacity to operate damper or valve under all conditions. Select actuators to provide tight shut-off against maximum system temperatures and pressure encountered. Each actuator shall be full-modulating or two-position type as required or specified, and shall be provided with spring-return for fail open or fail closed position for fire, freeze, moisture, occupant safety, equipment protection, heating or cooling system protection on power interruption as indicated and/or as required. Smoke dampers and steam valves serving pressure rated heat exchangers or convertors shall fail-closed.

- B. Valve and damper operating speeds shall be selected or adjusted so that actuators will remain in step with controllers without hunting, regardless of load variations. Actuators acting in sequence with other actuators shall have adjustment of control sequence as required by operating characteristics of system.
- C. Provide speed control valves for On/Off actuators for adjustment of actuator speed to prevent water hammer or excessive stress on large valves and dampers.
- D. Provide proper linkage and brackets for mounting and attaching actuators to devices. Design mounting and/or support to provide no more than 5% hysteresis in either direction (actual movement of valve stem or damper shaft versus ideal movement) due to deflection of actuator mounting.
- E. Provide single actuator on damper section not exceeding torque capacity of actuator.
- F. Multiple damper sections where used shall be connected together via jackshaft or other coupling device, not by internal pinned connections at blade shafts of individual damper sections. Where multiple damper sections are connected together via jackshaft or other coupling device, damper actuator shall be mounted directly to jackshaft or other coupling device for operating damper sections. For instances where damper actuator cannot be mounted to jackshaft or other coupling device, damper actuator shall be provided for each damper section.
 - 1. Mounting multiple actuators to common damper jackshaft or valve stem to meet torque requirements is not allowed.
- G. Position feedback potentiometers shall be provided where floating control actuators are sequenced with other floating control actuators in terminal hot water control (i.e., reheat valve, fin tube radiator valve, radiant ceiling panel valve, etc.).
- H. Calibrate position feedback potentiometers, where specified, with range and gain factors as required for proper operation per manufacturer's recommendations.
- I. Integral damper actuator end switches or feedback potentiometers shall not be used. Provide separate end switches/feedback potentiometers that provide actual damper position.
 - 1. Integral actuator end switches or feedback potentiometers can be used if damper shaft is keyed or directly affixed to the actuator such that the shaft cannot slip and provide false position. U-clamp type actuator mounting always requires separate end switches/feedback potentiometers.
 - 2. Limit/position switches used on dampers and valves shall be set at approximately 95% of full stroke (opened and closed).
- J. Actuators installed outdoors shall be NEMA 4X or IP66 rated or shall be provided with weatherproof NEMA 4 stainless steel enclosures (Belimo ZS-300 or equal) that have removable covers that have clasps or machine screws (no sheet metal screws) and that do not require removing fasteners from the ductwork.

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- K. Damper actuator mounting bolts/screws shall be tightened per manufacturer recommended torque requirement and provided with lock washers or blue threadlocker to ensure bolt will not loosen due to vibration.

END OF SECTION 230902

SECTION 230903 - CONTROL INSTRUMENTATION

PART 1 - GENERAL

1.1 SUBMITTALS

- A. Device data sheets shall be submitted with electronic bookmarks as specified in Section 230901 - Control Systems Integration. Refer to PART 1 – GENERAL, subsection SUBMITTALS.
- B. Device data sheets shall be submitted simultaneously with Control Systems Integration submittal. Refer to submittals section in 230901 - Control Systems Integration.
- C. Thermostat/Room Temperature Sensor Schedules:
 - 1. Submit thermostat/room temperature sensor schedule with shop drawings.
Thermostat/room temperature sensor schedule shall have detailed listing of which type is used for each room, including data concerning service and model numbers, sizes, cover types, and engineering data sheets for each control device.
- D. Warranty
 - 1. Provide 1 year warranty on all materials and labor.
 - 2. Warranty requirements shall include furnishing and installing software upgrades issued by the manufacturer during the 1 year warranty period.

1.2 FCC COMPLIANCE

- A. Digital equipment furnished under this Contract shall be tested and made to comply with limits for Class A computing devices pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against interference when operated in commercial environments. Literature shall so note and equipment shall be so labeled.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Instruments of same type shall be by same manufacturer, for instance, pressure transmitters, gauge, absolute, and differential pressure shall be of same manufacturer.
- B. Pressure and temperature ratings of devices indicated in Part 2 - of this Section are minimum required. Devices shall be designed to withstand maximum pressures and temperatures encountered in respective systems.
- C. No devices containing mercury will be allowed under this Specification.
- D. All instrumentation located outdoors shall be NEMA 4X rated.

2.2 GENERAL INSTRUMENTATION

- A. Pressure Gauges:
 - 1. Refer to Section 232120 - Piping Specialties

B. Thermometers (Dial-Type):

1. Refer to Section 232120 - Piping Specialties

C. Analog Electronic Instrument Indicators:

1. Electronic indicators, used for displaying sensor and/or output values as measured by current or voltage, shall be panel mount type and at least 2" square. Output may be either analog needle type or digital with 1/2" high LED or backlit LCD displays.
2. Electronic indicators shall be marked in appropriate units (degrees, psi, % rh, gpm, cfm etc.) and with appropriate range of values. Panel mounted indicators shall have minimum accuracy of 1% of scale range. Digital units shall be scaled to show 3 digits plus 1 decimal point.

2.3 DISCRETE ELECTRIC INSTRUMENTATION

A. General:

1. Electrical devices, switches, and relays shall be UL listed and of type meeting current and voltage characteristics of project. Terminal connections shall be made at terminal blocks inside of NEMA 1 enclosures unless otherwise specified. Outdoor units shall be NEMA 4 with concealed adjustment.
2. Ratings of normally open and normally closed contacts shall be adequate for applied load (minimum 5 amps at 240 Volts).
3. Accuracy of devices shall be $\pm 1\%$ of scale with adjustable offset unless otherwise specified.

B. Temperature Low Limit Switches (Freezestats):

1. Electric 2 position type with temperature sensing element and manual reset. Controls shall be capable of opening circuit if any 1 ft length of sensing element is subject to temperature below setting.
2. Sensing element shall not be less than 1 lineal ft per sq ft of coil surface areas. Unless otherwise indicated, calibrate temperature switch setpoint to 38°F.
3. Specifications:
 - a. Range Cutout: 35 to 45°F
 - b. Differential: 12°F

C. Relays:

1. Manufacturers: IDEC, Potter Brumfield, Schneider Electric, or Allen Bradley
2. Equal to IDEC Type RH2B-U, miniature 8 blade pilot relay with DPDT silver cadmium oxide contacts rated at 10A, 30 VDC, or 120 VAC. Coil shall match control circuit characteristics. DDC outputs shall be 24 VDC with maximum current burden of 50 milliamps. Rectangular base socket mount with blade type plug-in terminals and polycarbonate dust cover.
3. Provide DIN rail mountable (Snap type) mounting sockets equal to IDEC SH2B-05.

D. Enclosed Relay (Relay-in-a-Box):

1. Manufacturers: Veris Industries, Functional devices, Inc. or approved equal

2. 1 or 2 SPDT relays in NEMA 1 or better enclosure. Coil shall be selected for control circuit characteristics.
 3. Contacts rated at 10A, 28 VDC or 120 VAC. Conduit nipple is 1/2" NPT. Maximum coil current burden 50 milliamps.
- E. Pressure Differential Switches (Air Systems):
1. Manufacturers: Cleveland Controls, Dwyer Instruments Inc, Honeywell, Johnson Controls/Penn, Siemens Building Technologies, or Schneider Electric
 2. Adjustable set point, differential pressure type. Select switches for accuracy, ranges (20 to 80% of operating range) and dead-band to match process conditions, electrical requirements and to implement intended functions.
 3. Pressure differential switches for air systems shall have pressure rating of at least 10" WC.
 4. Pressure switches shall be automatically reset or manually reset. Refer to 230993 - Control Sequences
 5. Pressure indicating differential switches for air systems shall be equal to Dwyer Series 3000 photohelic gauge.
 - a. Maximum Temperature Rating: 180°F
 - b. Repeatability: $\pm 1\%$
 6. Provide pitot tubes on tubing ends that penetrate housings or ductwork.
- F. Position Switches (End Switches):
1. Manufacturers: Allen Bradley, Johnson Controls/Penn, Honeywell, Ruskin, Greystone Energy Systems, NAMCO, Omron or Westlock
 2. Provide damper position switches, as required to meet specified sequence. Rotary switches shall be cam action, lever, or proximity type. Provide damper brackets and connecting rods for connecting position switch actuation levers to damper blades or jackshafts.
 3. "Tip Switches" or other position switches that contain mercury shall not be used for damper end switch applications.
- G. Current Switches - Constant Load, Constant Speed:
1. Manufacturers: Veris Industries, NK Technologies, Absolute Process Instruments, R-K Electronics, Setra or approved equal
 2. These shall be Induction type sensors clamped over single phase conductor of AC electrical power and shall be solid-state sensors with adjustable threshold and normally open contacts. Each current switch shall be selected for proper operating range of current.
 - a. Output: Solid state relay or relay contacts
 - b. Trip Setpoint: Adjustable by multi-turn potentiometer
 - c. Operating Temperature: 32 to 131°F
 - d. Response Time: < 0.5 seconds
- H. Indicator Lights:
1. Manufacturers: Allen Bradley, GE, Schneider Electric, or Idec
 2. 1/4", 1/4" minimum size or 1-1/4" maximum size, push-to-test type. Use green for normal, yellow for warning (low/high values), and red for alarm or fail (low-low or high-high conditions). AC or DC type with voltage matched to control circuit without transformers.

I. Drain Pan Moisture Detector:

1. Manufacturers: Kele and Associates, DiversiTech or approved alternate.
2. Moisture detector is small, electronic control relay for detecting rising water levels, within drain pans or other containments. Moisture detector shall alarm when water levels reach 0.43" to prevent damage from overflow of drain pans. Relay shall reset when water levels decrease to 0.31" and relay re-energizes.
3. Relay is normally energized upon powering up and no water is present. When water level reaches the trip point the relay de-energizes for alarming in BAS.
4. Moisture Detector Relay Module (Model LD1-24):
 - a. Supply Voltage: 24 VAC, 60 Hz
 - b. Power Consumption: 1 W
 - c. Cable Length: 18"
 - d. Relays Contacts:
 - 1) Type: SPDT
 - 2) Rating: 2.5A at 24 VDC; 5.0A at 120 VAC
 - e. Enclosure Rating: Hermetically Sealed
 - f. Dimensions: 0.87" H x 2.0" W x 1.25" L

2.4 ANALOG ELECTRONIC INSTRUMENTATION

A. Space Temperature Sensors:

1. Sensors shall be platinum RTD type, with the following minimum performance:
 - a. Temperature Coefficient of Resistivity (TCR): 0.00385 ohm/ohm/°C
 - b. Accuracy: $\pm 0.54^{\circ}\text{F} + (0.005 \times T)$ Class B
T = Temperature of interest
 - c. Conformance: DIN-IEC 751
 - d. Operating Range: 32 to 122°F, 0 to 99% rh
2. Thermistors will be acceptable in lieu of RTD provided thermistor carries 5 year guarantee that device will maintain its accuracy within tolerance of $\pm 0.36^{\circ}\text{F}$ between 32°F and 150°F, and 0.5°F between -20°F and 212°F.
3. Unless otherwise stated, space sensor cover shall be manufacturer's standard plastic cover.
4. Provide visible setpoint, set point adjustment, and space temperature indication.

B. Duct Mounted or Insertion Temperature Sensors:

1. Platinum RTD type, with the following minimum performance:
 - a. Temperature Coefficient: 0.00385 ohm/ohm/°C
 - b. Accuracy: $\pm 0.54^{\circ}\text{F} + (0.005 \times T)$ Class B
 - 1) T = Temperature of interest
 - c. Conformance: DIN-IEC 751
 - d. Operating Range: -50 to 170°F, 0 to 99% RH
2. Sensors mounted in pipes:

- a. Install insertions sensors in stainless steel (carbon or stainless steel pipe) or brass (copper pipe) thermowells. Process coupling to be 3/8" or 1/2" NPT. Extension shall exceed insulation thickness by 1". Thermowell shall project into middle third of the process fluid when installed.
 - b. Sheath diameter shall not exceed 5/16". Length shall be such that sheath, containing sensor, projects into middle third of the process fluid when installed.
 - c. Connection head to be NEMA 4, cast iron, with screw on cap. Provide internal screw terminations for RTD and wire connection. Conduit connection shall be 1/2" NPT.
 3. Outside air sensors shall be weatherproof of noncorrosive construction and protected with solar shield. Mount outside air sensors on north side of building or in area intake wells for air handling systems to avoid thermal effects from direct sunlight.
 4. Sensors mounted in air streams, such as air handling units, supply ducts, exhaust ducts or return ducts, shall be averaging type. Averaging type sensor to be installed in ducts larger than 24x24" or greater than 576"2 ⁵⁷⁶"2. Mount averaging sensor across duct area in a "Z" pattern using mounting clips specific for averaging temperature sensor probes.
 5. Thermistors will be acceptable in lieu of RTD provided thermistor carries 5 year guarantee that device will maintain its accuracy within tolerance of $\pm 0.36^{\circ}\text{F}$ between 32°F and 150°F , and 0.5°F between -20°F and 212°F .
- C. RTD Temperature Sensor/Transmitters:
1. Manufacturers: Rosemount, Burns, Minco Products, Weed or Pyromation
 2. Transmitters shall provide 2 wire, 4-20 mA current output signal proportional to specified temperature span of transmitter and compatible with DDC equipment.
 - a. These shall be 100 Ohm platinum RTD type temperature instruments for process immersion or air duct mounting
 - b. Operating Temperature: -20 to $+180^{\circ}\text{F}$
 - c. Power Supply Voltage: 13 to 35 VDC unregulated
 - d. Accuracy or Output Error: 0.1% of span of sensor and transmitter combination
 - e. Temperature Coefficient: 0.00385 ohm/ohm/ $^{\circ}\text{C}$
 - 1) Thermowells: By same manufacturer as Sensor/Transmitter or approved alternate.
 3. Provide local temperature indicator with 3 LCD digital readout.
- D. Space Humidity Sensors/Transmitters:
1. Manufacturers: General Eastern, Automation Components Inc., Veris Industries, Setra, Belimo, Honeywell Hycal, Rotronic or Vaisala
 2. Space humidity sensors shall be wall mount type with brushed aluminum or brushed nickel cover to match room thermostats and/or temperature sensors.
 3. Sensing element shall be resistive bulk polymer, or thin film capacitive type. Sensor/transmitter shall have the following minimum performance:
 - a. Accuracy: $\pm 2\%$ rh at 25°C over range of 20-95% rh including hysteresis, linearity and repeatability
 - b. Temperature Effect: Less than 0.06% per $^{\circ}\text{F}$ at baseline of 68°F
 - c. Sensitivity: 0.1% rh
 - d. Repeatability: 0.5% rh

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- e. Hysteresis: Less than 1%
 - f. Long Term Stability: Less than 1% rh drift per year
 - g. Adjustment: $\pm 20\%$ rh zero, non-interactive; $\pm 10\%$ rh span, non-interactive
 - h. Operating Range: 0-99% rh, non-condensing, sensor; 0-95% rh, non-condensing, electronics
 - i. Output: 4-20 mA, 0-100% linear, proportional
 - 1) Power: 12-36 VDC
- E. Duct Mounted Humidity Sensors/Transmitters:
- 1. Manufacturers: General Eastern, Automation Components Inc., Versis Industries, Setra, Minco, Rotronic or Vaisala
 - 2. Probe type, temperature compensated, resistive bulk polymer or thin film capacitive type. Sensor/transmitter shall have the following minimum performance.
 - a. Accuracy: $\pm 2\%$ rh at 25°C over 20-95% rh including hysteresis, linearity and repeatability
 - b. Temperature Effect: Less than 0.06% per °F at baseline of 68°F.
 - c. Sensitivity: 0.1% rh
 - d. Repeatability: 0.5% rh
 - e. Hysteresis: Less than 1%
 - f. Long Term Stability: Less than 1% drift per year
 - g. Adjustment: $\pm 20\%$ rh zero, non-interactive; $\pm 10\%$ rh span, non-interactive
 - h. Operating Range: 0-99% rh, non-condensing, sensor; 0-95% rh, non-condensing, electronics
 - i. Output: 4-20 mA, 0-100% linear, proportional
 - j. Power: 2-36 VDC
- F. Combination Temperature/Humidity Transmitter:
- 1. Manufacturers: Automation Components Inc., Veris Industries, Vaisala, Minco or General Eastern
 - 2. Combination Temperature and Humidity sensor/transmitter shall meet the following minimum requirements:
 - 3. Temperature:
 - a. Temperature Sensor: 100 or 1000 Ohm Pt RTD
 - b. Temperature Coefficient: .00385 ohm/ohm/°C
 - c. Accuracy: $\pm 0.54^\circ\text{F} + (0.005 \times T)$ Class B
T = Temperature of interest
 - d. Operating Range: -10 to 160°F
 - e. Supply Voltage: 18 to 36 VDC / VAC
 - f. Output Ranges: 2-wire, 4 to 20 mA or 3-wire, 0 to 5, 0 to 10 VDC or 4 to 20 mA (24 VAC)
 - 4. Humidity:
 - a. Temperature Compensated: Full range of rh signal

- b. Response Time: 30 seconds for 63% step
 - c. Accuracy Range: $\pm 2\%$ rh between 20 to 95% rh Span (including hysteresis, linearity repeatability).
 - d. Sensing Element: Resistance or Capacitance humidity sensor
 - e. Operating rh Range: 0 to 100% rh(non-condensing)
 - f. Supply Voltage: 24 VDC (current or voltage output) 24 VAC (contact factory)
 - g. Output Ranges: 4 to 20 mA, 0 to 5 V, 0 to 10 V
 - h. Long Term Stability: Less than 2% rh drift per year
5. Enclosure shall be made of ABS Plastic or equivalent and include an optional LCD display on face of enclosure.
6. Optional LCD readout shall be capable of $^{\circ}\text{C}$ or $^{\circ}\text{F}$ operation with an adjustable display toggle switch to change from temperature to humidity display. Unit shall include capability of temperature and humidity setpoint value display during adjustment.
- G. Ducted Air System Static Pressure and Differential Pressure (Velocity) Transmitters:
- 1. Manufacturers: Setra, Belimo, Ashcroft XLDP or approved equal
 - 2. Provide transducers/transmitters to convert velocity pressure differential or static duct pressure relative to sensor location into electronic signal.
 - 3. Unit shall be capable of transmitting linear 4 - 20 mA DC output signal proportional to differential (total minus static or static minus ambient) pressure input signals with the following minimum performance and application criteria:
 - a. Span: Not greater than twice duct static or velocity pressure at maximum flow rate, or more than 16 times velocity pressure at minimum flow rate.
 - b. Accuracy: $\pm 1.0\%$ of span or $\pm 1.0\%$ of full scale
 - c. Dead Band: Less than 0.5% of output
 - d. Hysteresis: Within 0.5% of span or within 0.5% of full scale
 - e. Linearity: Within 1.0% of span or within 0.5% of full scale
 - 1) Repeatability: Within 0.5% of output
 - f. Response: Less than 1 second for full span input
 - g. Stability: $\pm 0.5\%$ of span/year
 - 4. Transmitters that require "auto-zeroing" in frequencies less than every 6 months are not acceptable.
 - 5. Return and exhaust air system static pressure transducers/transmitters shall be furnished with protective integral air filters on pressure sensing lines from static pressure sensing stations and with static air probes to prevent migration of moisture and particulate matter into transducers. If inputs to pressure transducers/transmitters are dead-ended, integral air filters are not required. Supply air system sensors do not require integral air filters.
- H. Thermal Dispersion Air Flow Measurement Sensor/Transmitter:
- 1. Manufacturers: Ebtron or approved equal
 - 2. Duct Mounted Flow Sensor:

- a. Multi-probe type thermal dispersion flow sensing station consisting of aluminum probe assembly with flanged connection and multiple hermetically sealed sensors in glass-filled polypropylene housing. Arrangement of sensors along probe assembly factory set to perform equal area traverse of duct cross section.
 - b. Flow Sensor:
 - 1) Accuracy: $\pm 2\%$ of reading
 - 2) Repeatability: $\pm 0.25\%$ of reading
 - 3) Materials: Probe – Aluminum; Sensor Housing – Glass-Filled Polypropylene; Mounting Brackets – 304 SS
 - 4) Calibrated Range: 0 – 5,000 fpm
 - c. Temperature Sensor:
 - 1) Accuracy: $\pm 0.15\%$
 - 2) Sensor Temperature Range: 20 to 160°F 0-1500 fpm, 30 to 160°F 1500 fpm.
 - 3) Humidity Range: 0 – 99%, non-condensing
 - 4) Probe Size Range: 8" to 120"
 - d. Transmitter:
 - 1) Power Requirements: 24 VAC (22.5 to 29 VAC), 8 VA max.
 - 2) Enclosure: Aluminum Housing
 - 3) Outputs: 4 to 20 mADC
 - 4) Output Resolution: 0.025% of selected range
 - a) Output 1: Airflow (0 – 5000 fpm)
 - b) Output 2: Temperature (-20 to 160°F)
 - 5) Ambient Temperature: -20 to 120°F
- I. Current Transformers:
- 1. Manufacturers: General Electric, Schneider Electric, NK Technologies or Veris Industries
 - 2. Alternating current transformers shall conform to latest applicable Standards including AEIC, EEI-NEMA, Standards for Instrument Transformers (MSJ-11) and IEEE C57.13 for instrument transformers.
 - a. Rated Voltage: 480 V
 - b. Insulation Class: 600 V
 - c. Basic Impulse Level 60 Hz
 - d. Short Time Current Rating: 100% (1 second)
 - e. Accuracy Class: 0.3
 - f. Continuous Current Rating: 150%
- J. Space CO2 Sensors
- 1. Manufacturers: Vaisala, Automation Components Inc., Veris, BAPI or approved alternate.
 - 2. Sensors shall have the following minimum characteristics:
 - a. Power Requirements: 24 VAC, 50/60 Hz, 50 VA
 - b. Signal Input: Integral Sensor
 - c. Signal Output: 4-20 mA DC or 0-10 VDC

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- d. Range: 0-2000 ppm
 - e. Accuracy: ± 40 ppm at 600 ppm and 1000 ppm at sea level and 25°C
 - f. Drift: $\pm 5\%$ of range over 5 years
 - g. Sensor: Infrared CO2 Sensor
 - h. Mounting: Wall-mounted
- 3. CO2 transmitter may be combined with the space temperature sensor as a single unit.
 - 4. Provide local display for continuous reading of CO2 levels.
 - 5. Units shall be certified by manufacturer to require calibration no more frequently than once every 5 years.

K. Outdoor Weather Station

- 1. Manufacturers: Lufft USA, Vaisala, Met One Instruments or approved equal.
- 2. All-in-one pole or tripod mounted weather station/sensor shall provide measurement of temperature, relative humidity, air pressure, wind speed and wind direction.
- 3. Wind speed/direction measurement minimum requirements:
 - a. Sensor Type: Ultrasonic
 - b. Wind Speed Range: 0-60 m/s _
 - c. Wind Speed Accuracy: ± 0.3 m/s or $\pm 3\%$ @ 10 m/s
 - d. Wind Speed Resolution: 0.1 m/s
 - e. Wind Direction Range: 0° - 359.9°
 - f. Wind Direction Accuracy: $< 3^\circ$ RMSE
 - g. Wind Direction Resolution: $> 1^\circ$
- 4. Air temperature measurement minimum requirements:
 - a. Range: -60 to 140°F
 - b. Accuracy: $\pm 0.5^\circ\text{F}$
 - c. Output Resolution: 0.1°F
- 5. Relative humidity measurement minimum requirements:
 - a. Range: 0 - 100 %RH
 - b. Accuracy: ± 3 %RH at 0 - 90 %RH
 - c. Output Resolution: 0.1 %RH
- 6. Barometric pressure measurement minimum requirements:
 - a. Range: 600 -1100 hPa
 - 1) Accuracy: ± 0.5 hPa at 32 to 86°F, -60 to 140°F
 - b. Output Resolution: 0.1 hPa / 10 Pa / 0.001 bar / 0.1 mmHg / 0.01 inHg
- 7. Provide all cabling, software and interface devices (communication gateway, signal convertors, etc.) required to configure instruments and for proper connection to BAS.
- 8. Provide all hardware required to mount sensor, including roof-mounted pole/tower or tripod.

PART 3 - EXECUTION

3.1 GENERAL

- A. Install control equipment, wiring and air piping in neat and workmanlike manner and in accordance with manufacturer's recommendations. Maintain clearances, straight length distances, etc., required for proper operation of each device. Mark and detail on coordination drawings, exact locations of inline devices, wells, and taps to be installed by Mechanical Contractor.
- B. Coordinate timely delivery of materials and supervise activities of other trade Contractors to install inline devices such as immersion wells, pressure tappings, any associated shut-off valves, flow switches, level switches, flow meters, air flow stations, and other such items furnished by Control Contractor which are to be installed by Mechanical Contractor.
- C. Install control devices in accessible location.
- D. Mount motor control devices within 5 ft of disconnect switch, or starting device furnished by Electrical Contractor unless noted otherwise. Maintain required NEC clearances.
- E. Control Contractor and Mechanical Contractor shall review proposed static pressure sensor and flow meter locations with Owner and Engineer for approval prior to installation.
- F. Install control devices in adherence with manufacturers recommendations.
- G. Locations of pressure sensing taps in pipes or ducts above ceilings shall be clearly identified on ceiling. Coordinate preferred identification method with Owner/Architect.

3.2 GENERAL INSTRUMENTATION

- A. Thermometers (Temperature Indicators):
 - 1. Install thermometers at each point of temperature transmission and control, except for those that are indicated at local control panels. Install thermometers to permit easy reading from floor or operating platform (within 3 ft of line of sight). Provide remote bulb thermometers with readout indicators mounted within 3 ft of line of sight whenever sensing point is more than 3 ft from line of sight.
 - 2. Thermometer wells in piping will be installed by Mechanical Contractor.
- B. Local Control Panels:
 - 1. Install remote mounted devices, controllers, I/O terminal blocks, power supplies, etc., inside of local control panels.
 - 2. Locate panels as shown on drawings.
 - 3. Mount top of panels between 5 and 6 ft above floor so that gauges and indicators are at eye level.
- C. Pressure Differential Switches (Static Pressure Safety Switches)
 - 1. Install static pressure switches in an accessible location where the reset switch can be accessed from the floor without the use of a ladder.

3.3 DISCRETE AND ANALOG INSTRUMENTATION

- A. Wall Mounted Space Thermostats/Temperature Sensors:
1. Install space thermostats/sensors where indicated, as required to perform specified control sequences, and as directed to meet job site conditions.
 2. Provide space temperature sensors without remote setpoint adjustment in all public spaces, hallways, and mechanical rooms unless otherwise specified.
 - a. Mount space thermostats/sensors at 5 ft above floor unless otherwise indicated.
 3. Provide space temperature sensors with temperature displays and remote setpoint adjustment in all patient rooms, office, and conference rooms.
 - a. Mount space thermostats/sensors with accessible setpoint adjustment or temperature reading (thermometer or digital temperature readout) at 4 ft above floor meeting ADA requirements.
 4. Space thermostats/sensors located on exterior walls shall be mounted on thermally insulated sub-base.
 5. Relocate space thermostats/sensors if required due to draft, interferences with cabinets, chalkboards, etc., or improper sensing.
 6. Space thermostats/sensors in gymnasium, locker rooms, corridor, stairways, vestibules and toilets shall be aspirating type.
 7. Provide labels for all wall mounted sensors.
 - a. Sensor labels shall indicate which terminal device (VAV, fin-tube, fan-coil, etc.) sensor is wired to, and shall match the Record Document device tag. Tags shall not be provided until Record Documents have been provided.
 - b. Labels shall be 1/2" x 1-3/4" self-adhesive type, by Avery. Lettering shall be printed through inkjet or laser printer. Manually written labels are not acceptable.
 - c. Label colors shall be selected by Architect/Owner.
- B. RTD Temperature Transmitters:
1. Provide RTD temperature transmitters whenever DDCPs cannot receive RTD type inputs.
- C. Low Limit Temperature Switches (Freeze Stats):
1. Install low limit controls where indicated on drawings or as specified. Unless otherwise indicated, install sensing element on upstream face of cooling coil where cooling coil is provided, or at downstream side of heating coils where no cooling coil is provided.
 2. Distribute sensing element across entire area of medium being sensed. Install controls at accessible location with suitable mounting brackets and element duct collars where required.
 3. For low limit temperature sensors installed on roof top units and other outdoor equipment, install heaters in enclosures housing freeze stats to prevent freeze stat tripping.
- D. Duct Mounted Humidity Sensors:
1. Duct mounted humidity sensors used for discharge humidity or high limit control shall be mounted at minimum 6' downstream from the humidifier or no less than the steam absorption distance indicated by the humidifier manufacturer.

E. Static Pressure and Air Flow Stations:

1. Furnish static pressure and air flow measuring stations to Mechanical Contractor for installation.
2. Stations shall be installed in strict accordance with manufacturer's published requirements. These stations serve as primary signals for airflow control systems; therefore it shall be responsibility of Control Contractor to verify location and installation to assure that accurate primary signals are obtained.
3. Pressure differential switches shall be piped across device creating differential between fan discharge and fan suction.

F. Outdoor Static Pressure Sensor:

1. Furnish outdoor static pressure sensor as specified in control sequence. Mechanical Contractor will install sensor and associated pipe to below roof as shown on detail.

G. Direct Insertion Temperature Sensors:

1. Install sensor so that sensor is pointed down stream.

H. Outside Air Temperature Sensors:

1. Mount on north side of building or in intake area wells for air handling systems. Provide solar shields for installations where sensors may be exposed to sunlight conditions.

I. Building or Space Static Pressure Control System:

1. Extend 2" pipe between spaces for room pressure control or between space and outside for building static pressure control. Mount velocity sensor in tee fitting with 1 ft of straight pipe on either side of sensor. Terminal space and points inside of sheet metal plenum attached to return/exhaust grille. Terminate outside sensors on prevailing windward side of building with flapper type damper and full weather cover shroud constructed of aluminum painted to match building exterior.

J. Sensor Wells:

1. Wells mounted in pipe 3" and larger may be installed in horizontal or vertical lines provided that element is always in flow, (for condensate and other gravity return lines, install in bottom of pipe). Wells mounted in pipe 2-1/2" and smaller shall be installed at elbow tee fittings with well pointed upstream. Minimum of 2" pipe size for elbow tee installation.

K. Transmitters, Indicators, and Transducers:

1. Locate transmitters at sensing devices or within 100 ft of remote mounted transmitters. For hot systems (150°F and higher) mount electronics on side of pipe or remotely mount.
2. For indicating type instruments, locate indicating element within 6 ft of floor with readout easily visible from floor level. Provide remote readouts if necessary.
3. Locate transmitters and transducers within 5 ft of floor to allow for calibration and maintenance.
4. Provide P-E transducers to convert analog pressure signals to analog electronic signals for input to DDC panels.

L. Static Pressure Transmitters/Temperature Sensors

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1. Transmitters/Sensors shall be hardwired back to controller where logic and control outputs to VFD, valves, dampers, etc. will reside. Sharing the transmitter signal via the network shall not be allowed for direct control.
2. Transmitters/sensors located remotely or in a building separate from the controlled device can be shared via the network but will reset the setpoint of a local transmitter/sensor hardwired as indicated previously.

END OF SECTION 230903

SECTION 230923 - DIRECT DIGITAL CONTROLLERS AND NETWORKS

PART 1 - GENERAL

1.1 DEFINITIONS

- A. The following abbreviations, acronyms, and definitions may be used in addition to those found elsewhere in Contract Documents.

ASC:	Application Specific Controller. A networked device or node that contains a complete, configurable application that is specific to a particular task.
Alarms & Events:	The exchange of data between devices related to the occurrence of a predefined condition that meets specific criteria (event).
BC:	Building Controller. Provide supervisory control, scheduling, trend logging & alarm handling.
B OWS:	BACnet Operator Workstation
B BC	BACnet Building Controller. Same as SLC.
B AAC:	BACnet Advanced Application Controller. Same as PPC.
B ASC:	BACnet Application Specific Controller
B SA:	BACnet Smart Actuator
B SS:	BACnet Smart Sensor
BBMD:	BACnet Broadcast Management Device
BIBBS:	BACnet Interoperability Building Blocks. Specific individual function blocks for data exchange between interoperable devices.
Broadcasting:	The propagation of data from a device to the control network. Software objects that broadcast data to the network may include the following parameters:
Send on Delta:	An adjustable parameter that defines a requirement to broadcast when the data generated by the software object changes by an amount that exceeds this parameter's value. For binary data, this parameter defaults to a change of state. The broadcast of data is initiated when this criteria and the minimum send time requirement have been met. Also referred to as a "Change of Value".

Minimum Send Time:	An adjustable parameter that defines a mandatory time period during which no broadcasting of data will occur. Once this time period has been exceeded without a broadcast, the send on delta parameter or the maximum send time parameter shall determine when a broadcast is initiated.
Maximum Send Time:	An adjustable parameter that defines the maximum time period between broadcasts of a software object's data to the network. Should the value of a software object remain constant over an extended period of time, the value will be rebroadcast once every maximum time period.
BTL:	BACnet Testing Laboratory.
Channel:	One or more segments not containing a router.
Domain	A logical collection of devices on one or more channels.
FLN:	Floor Level Network. BACnet MS/TP.
HMI:	Human-Machine Interface. Graphical operator BAS interface. Same as Graphical User Interface (GUI).
LAN:	Local Area Network. Same as Floor Level Network.
Maximum Send Time:	Event driven communication parameter specifying the time period for which data must not be sent more than once.
Minimum Send Time:	Event driven communication parameter specifying the time period for which data must be sent at least once.
PICS:	Protocol Implementation Conformance Statement. Detailed description for a given BACnet device stating its inherent BACnet capabilities.
Point:	Group of data, which corresponds to a hardware input, output, or calculated value.
PPC:	Programmable Process Controller. Same as Advanced Application Controller (AAC)
Repetitious Controls:	Controls for critical systems where the control is spread across multiple controllers with separate power sources so there is no single point of failure for the entire system.

Scheduling:	The exchange of data between devices related to the establishment and maintenance of dates and times at which specified output actions are to be taken.
Send on Delta:	Event driven communication parameter specifying the amount of variable change before data is to be sent between the Minimum and Maximum send times.
SLC:	Supervisory Level Controller. Same as Building Controller.
Segment:	A section of uninterrupted cable where multiple devices may be installed.
Subnet:	Logical division of a domain.
Trending:	The accumulation of (time, value) pairs at specified rates for a specified period duration.

1.2 SUBMITTALS

A. Shop Drawings:

1. Submit shop drawings for each hardware device used and submit complete description of software applications used. Submit manufacturer's printed product data sheets for each device or software program used. Datasheets shall be submitted electronically in pdf format with bookmarks provided for each individual device and table of contents listing each device manufacturer and full model number with links to device pages. Organize sheets in order of model number, alphabetically, then numerically. When a manufacturer's data sheet refers to a series of devices rather than a specific model, the data specifically applicable to the project shall be highlighted or clearly indicated by other means.
2. Submittals shall include points list of each control input and output, controlled devices, locations of devices, and symbol or label of each control point in software.
3. Device data sheets shall be submitted with electronic bookmarks as specified in Section 230901 - Control Systems Integration. Refer to PART 1 – GENERAL, subsection SUBMITTALS.
4. Device data sheets shall be submitted simultaneously with Control Systems Integration submittal. Refer to submittals section in 230901 - Control Systems Integration.

B. Operating and Maintenance Manuals: Refer to Section 230901 - Control Systems Integration.

C. Software Manual:

1. As part of operating and maintenance manuals, submit one software manual per workstation plus one extra copy for archive use. Software manuals shall be divided into separate parts with tabs for each part.
2. Software manual parts shall include:

- a. Complete description of operating system including all commands, configuration programs, printouts, logs, database functions and passwords. Describe general operating procedures, starting with system overview and proceeding to detailed description of each software command feature with sample printed displays and system function description for each option. Include instructions on verifying errors, status, changing passwords and initiating or disabling control programs.
- b. Complete description of programming language including all commands, configuration programs, control loop functions and testing. Describe general programming procedures, starting with system overview and proceeding to detailed description of each software command feature. Include instructions on creating or modifying any control algorithm or parameter, debugging, etc. This shall include all control functions, algorithms, mathematic equations, variables, setpoints, time periods, messages, and other information necessary to load, alter, test and execute custom or pre-written programs.
- c. Software Backup: Upon successful completion of acceptance testing, submit to Owner 2 archive copies of all accepted versions of source code and compiled code for all application programs and data files on CD ROM backup disks or USB flash drives. All control software must be readily accessible by Owner using BAS workstation hardware and software.
- d. Web server/data historian SQL database schema (table format) for trend data and event/alarm data.
- e. Control Loop Documentation: Submit indexed summary of each control loop program. Summary shall list in tabular form, name of system, name of control loop, all I/O points used, and reference to sheet number in shop drawings to describe control sequence programmed. For each control loop submit complete printed listing of source code used, all setpoints, high/low alarm points, time event schedules, proportional gains, integrals, derivative values, and other database values.
- f. BAS Points List Summary: Provide detailed summary for each point in the system. Summary shall be cross-index listing of all points in alpha/numerical order with list of control loops which use each point. For each point, include an abbreviated point name, expanded point description, detailed description of each input instrument or output device, and detailed description of exact location of all field hardware. Location descriptions shall include room names, column numbers, elevation (above ceiling, bottom of duct, etc.).

1.3 WARRANTY

- A. Provide 1 year warranty on all materials and labor.
- B. Warranty requirements shall include furnishing and installing software upgrades issued by the manufacturer during the warranty period.

1.4 FCC COMPLIANCE

- A. Digital equipment furnished under this contract shall be tested and made to comply with limits for Class A computing devices pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against interference when operated in commercial environments. Literature shall so note and equipment shall be so labeled to show this compliance.

PART 2 - PRODUCTS

2.1 DIRECT DIGITAL CONTROL (DDC) CONTROLLERS

A. General:

1. DDC controllers shall be microprocessor based, field programmable controllers, capable of performing control and energy management functions, and shall be UL listed as Signaling Systems. Each controller shall include its own microprocessor, power supply, input/output modules, and termination modules as required to perform intended function.
2. DDC controller shall receive discrete electrical and/or analog electronic field input signals, convert signals for use by controller, perform control sequences, convert controller information into output signals, and provide control output signals to actuators and field control devices. Inputs and outputs, including communication connections, shall be electrically or optically isolated from controllers.
3. All DDC controllers shall be provided by the same manufacturer.
4. DDC controller with analog input modules shall be capable of accepting any form of linear or non-linear voltage (0-5 VDC or 0-10 VDC), current (4-20 mA) or resistive input (0-1000 ohm).
5. DDC controller with discrete input modules shall be capable of accepting discrete inputs from any device with isolated, dry-type contacts (no grounds or no voltage) of either normally open (NO) or normally closed (NC) configuration. Provide visible status lights (LEDs) to indicate input point status.
6. Provide input modules capable of interfacing with pulsed output type sensors as required.
7. DDC controller with discrete output modules shall have isolated, dry-type contacts (no grounds or no voltage) of either normally open (NO) or normally closed (NC) configuration. Provide visible status lights (LEDs) to indicate output point status.
8. DDC controller shall have capability to scale, offset, and display proper analog value without field hardware modification. DDC controller shall convert analog input signals to digital values (A/D conversion) and convert digital values to analog outputs (D/A conversion) for modulating control purposes. Some application specific controllers may utilize tri-state or Triac outputs for floating point control of control devices. Floating point control should be limited to non-critical room temperature control and mechanical space heating and cooling.
9. Failsafe hardware shall be provided such that BAS failures result in immediate return to local control. If DDC controller uses database values from other DDC controllers and communication network fails or malfunctions, control loop outputs shall continue to function using last value received from BAS.

10. Failure of network or control devices (i.e. building level controllers, floor level controllers, application specific controllers, routers, repeaters, etc.) shall be alarmed at the Operator Workstation as a Level 3 Critical Alarm.
11. All DDC Hardware shall meet the following requirements:
 - a. All DDC controllers shall be connected to an ASHRAE Std 135 MS/TP, BACnet over ARCNET or BACnet/IP control network and communicate via ASHRAE Std 135 exclusively.
 - b. MS/TP controllers shall operate at a minimum baud rate of 38.4 kbps.
 - c. All DDC controllers shall implement all required functionality of the application network interface via BACnet objects, properties, and services.
 - d. All DDC controllers shall conform to the BACnet Testing Lab's Device Implementation Guidelines and be BTL Listed.
 - e. Application programs and configuration settings shall be stored in a manner such that a loss of power does not result in a loss of the application program or configuration settings.
 - f. All settings and parameters used by the application shall be fully configurable to the greatest extent possible, via properties of BACnet objects that can be written to via BACnet services or via properties of BACnet objects that can be written to via BACnet services for the following:
 - 1) Setpoint
 - 2) Alarm limit
 - 3) Schedule modification
 - 4) Trend modification
 - g. All other settings and parameters that cannot be written to via BACnet services shall be fully configurable via either properties of BACnet objects that can be written to with a configuration tool, or via hardware settings on the controller itself to support the application.
12. Each DDC panel shall have sufficient I/O capacity to perform specified control sequences and/or include points listed in point schedules. If DDC controller does not have sufficient capacity, provide additional slave I/O panels to achieve required point count.
13. Analog and critical safety discrete control loops shall have inputs and outputs into/from same DDC panel. Analog control loops for major equipment (chilled water, hot water, convertors, air handling units, etc.) shall have PID control.

B. BACnet Building Controller (B-BC):

1. BACnet Building Controllers (B-BCs) shall provide direct connection to high speed, BACnet/IP Local Area Network (LAN) and Campus Ethernet network and serve as communications router for other controllers on slower speed BACnet MS/TP or BACnet over ARCNET Floor Level Network (FLN).
2. Communication between B-BC's shall be through BACnet/IP communication.
3. B-BC's shall have sufficient processor capabilities, hard-drive storage and RAM to implement all types of custom software applications and shall provide supervisory control, scheduling, trend logging & alarm handling functions as follows:
 - a. Scheduling:

- 1) Each B-BC shall support a minimum of 250 BACnet Schedule Objects and 250 BACnet Calendar Objects.
- b. Trending:
 - 1) Any object in the system (real or calculated) may be logged. Sample time interval or Change of Value (COV) definition shall be adjustable at the operator's workstation.
 - 2) B-BC shall periodically upload trended data to networked BAS Web Application Server for long term archiving.
 - 3) Archived data shall be stored in standard database format and shall be made available for use in third-party spreadsheet or database programs.
- c. Alarm Generation:
 - 1) Alarms may be generated within the system for any object change of value or state either real or calculated. This includes analog object value changes, binary object state changes, and various controller communication failures.
 - 2) B-BC shall periodically upload alarm logs to networked BAS Web Application Server for long term archiving.
4. B-BC's shall have uninterrupted real time clocks capable of time of day, week, and year information to the system as needed to perform software functions. Clock shall be programmed to reset twice per year to allow for Daylight Savings Time. Clocks in all DDC Controllers and devices which support time synchronization shall be synchronized to automatically match designated "time master" B-BC or Web server. Accuracy shall be within 1 second per day.
5. Batteries shall maintain volatile memory and real time clocks for a period of at least 72 hours during power failure. Batteries shall be maintenance free and have minimum life of 2 years. When power has been restored, the following shall occur automatically:
 - a. Orderly startup of controlled equipment (user defined)
 - b. Continuation of control algorithms
 - c. Database revision
 - d. Logging of power interruption and restoration times
 - e. Battery recharging
6. Provide local visual indication and system annunciation of low battery power for each battery.
7. Each B-BC shall include its own micro-processor, power supply, input/output modules, and termination modules as required to perform intended function.
8. BACnet UDP port number to always be set to 47808 (BAC0).
- C. BACnet Application Specific Controllers (B-ASC):
 1. B-ASCs are defined as having standard software burned into EPROM, set points in EEPROM or RAM maintained by battery, and are designed to handle specific types of control sequences.
 2. Application specific DDC Controller shall be capable of communicating to BAS network via BACnet MS/TP connected to Building Controller or via BACnet/IP directly.

3. Control outputs may be in the form of floating point control or true analog output control of end devices. Floating point control shall be limited to non-critical room temperature control or mechanical space heating and cooling.
4. Controllers with integral damper actuators using floating point control shall be provided with position feedback/potentiometers. Calculation of floating point damper position is not allowed in applications where damper position is required for duct static pressure reset control.
5. B-ASCs shall be provided with sufficient inputs and outputs to implement control sequences for each specific application. Add-on, 3rd-party summing/averaging modules will not be accepted for summing zone supply/exhaust/return air flows due to a lack of room controller I/O.
6. Provide communication ports integral room temperature sensors/thermostats for interface with local terminal equipment controllers or a low range wireless (Bluetooth®) Commissioning tool that provides a temporary wireless connection between the MS/TP network and the laptop computer used to commission.

D. BACnet Router

1. BACnet MS/TP to BACnet/IP and BACnet/ARCNET to BACnet/IP Routers shall perform layer 3 routing of BACnet MS/TP or BACnet/ARCNET packets over an IP network in accordance with ASHRAE Std 135 Annex J. The router shall provide the appropriate connection to the IP network and connections to the BACnet MS/TP or BACnet/ARCNET network. BACnet Routers shall be capable of configuration via DHCP and Write-Broadcast-Distribution-Table messages but shall not rely on these services for configuration.
2. One router in the IP subnetwork shall be designated as the BBMD (BACnet Broadcast Management Device) and shall be indicated as so on the Network Architecture.
3. BACnet router functionality can also be incorporated into BACnet Building Controllers.

E. BACnet Gateways:

1. Provide gateways to connect BACnet to non-BACnet devices, and non-BACnet DDC controlled equipment.
2. Provide with each gateway an interoperability schedule, showing each point or event on the non-BACnet side that the BACnet "client" will read, and each parameter that the BACnet network will write to. Describe this interoperability in terms of BACnet services, or Interoperability Building Blocks (BIBBS), defined in ASHRAE Std 135 Annex K. Provide two-year minimum warranty for each gateway, including parts and labor.
3. The following minimum capabilities are required:
 - a. Gateways shall be able to read and view all readable object properties listed in the interoperability schedule on the non-BACnet network to the BACnet network and vice versa where applicable.
 - b. Gateways shall be able to write to all writeable object properties listed in the interoperability schedule on the non-BACnet network from the BACnet network and vice versa where applicable.
 - c. Gateways shall provide single-pass (only one protocol to BACnet without intermediary protocols) translation from the non-BACnet protocol to BACnet and vice versa.

- d. Gateways shall meet the requirements of Data Sharing Read Property (DS-RP-B), Data Sharing Write Property (DS-WP-B), Device Management Dynamic Device Binding-B (DM-DDB-B), and Device Management Communication Control (DM-DCC-B) BIBBs, in accordance with ASHRAE Std 135.
- e. Gateways shall include all hardware, software, software licenses, and configuration tools for operator-to-gateway communications. Provide backup programming and parameters on CD media and the ability to modify, download, backup, and restore gateway configuration.

F. Power Supplies / Control Transformers:

- 1. Power supplies and control transformers shall operate on nominal 120 VAC, 60 Hz, single-phase power. DDC Controllers shall be provided with surge and noise protection. Power fluctuation shall not affect control system.
 - a. Isolation transformers shall be included when connections are being made between 2 separate buildings.
 - b. Each power supply or transformer shall be fuse protected on both sides of device.
 - c. Power supplies and transformers shall be sized for a minimum of 20% spare capacity for each circuit.

2.2 DIRECT DIGITAL CONTROL SOFTWARE

A. General:

- 1. DDC Controller control strategies shall be Owner definable from engineering workstations.
- 2. Software functions and algorithms shall be sufficient to enable implementation of control sequences as specified and shall be able to maintain continuous control as intended.
- 3. Control functions shall include both mathematical and logical operators. Control algorithms shall include proportional, integral and derivative control (PID). Adaptive (self-tuning) PID loop parameters, if offered by DDC Controller manufacturer, shall not be used unless adaptive limits are used to adjust limit values based on system status; or written request is submitted and approved by Engineer.
- 4. Allow operators with appropriate control access to assign unique identifiers of their choice to each connected point. Identifiers shall have at least 8 alpha/numeric characters. References to these points in programs, reports and command messages shall be by these identifiers.
- 5. Provide access control (user defined passwords) for system operation. There shall be minimum of 3 access levels. First level shall allow system monitoring only. Second level shall allow monitoring, set point adjustment, and scheduling revision. Third level shall allow modification of control algorithms. System shall return to secured (monitoring only) mode after 5 minutes of inactive operation.
- 6. Each DDC Controller shall contain self-diagnostics that continuously monitor proper operation of panel.
- 7. If microprocessor malfunctions, control loop outputs shall continue to function using last value received from microprocessor.

B. Building Controller Software:

1. Provide DDC Controller software application program modules for performing energy management control functions such as time of day change of database values (programmed start/stop, temperature setbacks, etc.), supply air temperature reset based on space load demand, economizer control, optimum start/stop based on current indoor and outdoor psychometrics, duty cycling and client tailored programs required for special applications such as VAV fan matching and supply fan control, enthalpy control, intermediate season or "dead band" control, totalizing, and holiday programming.
2. Provide manufacturer's standard operating system for real time control of system interactions, including database information requests/transfers by system hardware or by operators. Operating system shall also have the following additional capabilities (given that operator has appropriate security access level):
 - a. User interface and online system configuration software embedded in Building Controller.
 - b. Support for Web services at the automation network level.
 - c. Displaying database (point) value including measured values, controlled variables, setpoints, gain factors, and any other adjustable parameters.
 - d. Changing or overriding any database value.
 - e. Error detection, correction, re-transmission of database values, arithmetic or logical faults.
 - f. Alarm reporting including sending alarms to remote workstations, User Interface Web Server or Data Historian on network.
 - g. Alarm buffer to retain alarms in order of importance without losing any alarms.
 - h. Creating and displaying historical trend logging of any value, limited only by available memory.
 - i. Creating new variable database values (soft points) based on arithmetic calculation (including summation or totalizing) on other database values.
 - j. Adding new hardware points without overall BAS shutdown.

C. B-ASC Controller Software:

1. Manufacturer's standard software for B-ASC's may be used only if control sequences can be implemented without modification. If control sequence cannot be accomplished with standard software, provide battery backed RAM or EEPROM DDC Controller (B-AAC) capable of being programmed for specified control sequence.
2. Provide software for portable PC units to communicate with terminal controllers at the room level network. Software shall allow access to modify, delete or create control strategies at the room sensor location.

2.3 WEB APPLICATION SERVER

- A. Refer to 230924 - Graphical User Interface Integration.

2.4 DDC ENGINEERING (PROGRAMMING) - SOFTWARE

- A. Provide engineering software for existing Engineering Workstations and existing laptops.
- B. Software shall have the same characteristic and capabilities as DDC Controllers. In addition, operator's workstations shall have the following features.

C. User Programmability:

1. Engineering workstation software shall include field-engineering tools (software & hardware) for programming all controllers supplied.
2. All application software shall be interactive, fully prompted, and menu driven and shall provide the following functionality as a minimum:
 - a. Determine control strategies, which have been defined for specific piece of equipment.
 - b. Add control loops to system using English language type program language equal to BASIC or other easily learned language or function block programming. (PASCAL, C, or other assembly type languages are not acceptable.)
 - c. Add points to system.
 - d. Create, modify or delete control strategies.
 - e. Create, modify or delete system graphics.
 - f. Assign sensors and/or actuators to control strategy.
 - g. Tune control loops through adjustment of control loop parameters.
 - h. Enable or disable control strategies.
 - i. Generate hard copy records of control strategies on printer or soft copies to files compatible with Microsoft Office applications.
 - j. Select points to be alarmable and define alarm state(s).
 - k. Select points to be trended over a period of time and initiate recording of values.
 - l. Override Input/Output points for each individual controller.

2.5 NETWORK HARDWARE

- A. Provide network interface hardware for each device connected to network. Each device shall have sufficient performance as not to degrade specified processing speed.
- B. Provide network cabling with sufficient performance as not to degrade specified communication speed. Cabling shall be compatible with proposed system and shall comply with requirements specified in Section 230901 - Control Systems Integration.
- C. Provide other network support devices that are required for proper operation of network, such as file servers, signal repeaters, network hubs, etc.
- D. Provide network diagnostic tool for measuring/confirming bandwidth usage on IP layer.

PART 3 - EXECUTION

3.1 GENERAL

- A. Install control equipment in neat, professional manner to satisfaction of Architect and Engineer.
- B. Coordinate timely delivery of materials and supervise installation of DDC Controllers and network cabling and devices.
- C. Install DDC Controllers and network control devices in accessible locations.

- D. All communications wiring/cable routing shall be documented on the mechanical or electrical plans. Device addressing and the location of bus end-of-lines, repeaters, routers, coordinators, power supplies and similar equipment shall be documented on the mechanical or electrical plans. These plans shall be kept current and made available, on as progress basis, upon request by the GC or mechanical contractor and it shall be turned over as part of the as-built documentation.
- E. BAS performance issues such as timeouts, network speed issues or other are the responsibility of the Contractor to resolve.

3.2 OVERALL BAS ARCHITECTURE

- A. Provide hardware/software to update database in less than 1 second for fast-acting control loops such as pressure control, air or water flow rate control, and air handling unit temperature control, or 10 seconds or less for other control loops.
- B. Control software algorithm and inputs and outputs for a single system or piece of equipment shall reside on a single controller and shall not be distributed amongst multiple controllers. If multiple pieces of equipment are to be interlocked, a single "Master" controller shall provide control for all interlocked pieces of equipment, i.e. an AHU and interlocked return fan and exhaust fans.
- C. Control loop software algorithm for each analog control loop shall reside on same controller as inputs and outputs required for that specific control loop.
- D. Networks that operate via polled response or other types of protocols that rely on central processors, file servers, or other such devices to maintain or manage peer-to-peer communications, shall have redundant components to maintain network in event of failure at central device. Provide automatic changeover (without operator intervention) to redundant device upon failure of any central type processor.
- E. Floor Level Network (FLN) network shall be multi-drop digital transmission network utilizing BACnet MS/TP (76.8kbs) communication.
- F. Each multi-drop trunk shall be within manufacturer's allowable line lengths without signal degradation. Multi-drop trunks shall be interfaced to system via standard EIA or other industry recognized interfaces so that single failure does not disrupt or halt network.
- G. Communications between Building Level DDC Controllers and operator's workstations shall be peer-to-peer, allowing multiple users to access and use system simultaneously with no loss of system performance.
- H. Provide levels of connected networks to connect all DDC Controllers, including terminal DDC Controller. Communications to terminal devices shall be similar to capabilities and functions of other DDC Controllers and shall be transparent to operator.
- I. Quantity of nodes (devices connected) on any one FLN (MS/TP) shall not exceed 50% of maximum node capacity published by equipment manufacture Provide additional hardware to meet this requirement.

- J. Alarm reports from DDC Controllers shall not be impeded by use of either remote or local monitor, or control stations on network either in access mode or programming mode.
- K. Provide transient voltage surge suppression devices for controllers and other electronic devices requiring separate line voltage power source.

3.3 DIRECT DIGITAL CONTROLLERS

A. DDC Controller Usage:

- 1. Select DDC Controller to provide speed of response required for each control loop type. Pressure, flow rate, and air handling unit temperature control must be via Building Level DDC Controller. Application specific DDC Controller may be used for other control loop types.
- 2. Each DDC Controller shall have sufficient I/O capacity to perform specified control sequences and/or include points listed in any point schedules. If DDC Controller does not have sufficient capacity, provide additional remote I/O panels to achieve required point count.
- 3. Analog and critical safety discrete control loops shall have inputs and outputs into/from same DDC Controller. Analog control loops for major equipment (chilled water, hot water, convertors, air handling units, etc.) shall have PID control. Air terminal control loops may utilize floating point control from tri-state or Triac outputs from the controller, but require some type of feedback device to prove position.
- 4. Provide at least one Building Level DDC Controller per mechanical equipment room .
- 5. For valves and dampers within 100 ft of associated DDC Controller, mount current to pneumatic (I/P) converter within DDC Controller panel or in adjacent panel. Otherwise mount I/P converters at valve or damper. Provide pressure gauges on main air, and all control output signals.

B. Point Capacity:

- 1. Provide point capacity required plus spare I/O point capacity in each B-AAC or B-BC being utilized for system control. Spare I/O point capacity is defined as terminal connections, which are ready to accept digital or analog inputs, dry contacts for digital outputs, and variable voltage or current terminals for analog outputs. Universal type points are acceptable for both discrete and analog type points. Spare points do not include any input or output conversion devices.
- 2. Spare points in each B-AAC shall be as follows (does not apply to terminal unit or room controllers):
 - a. 4 Digital Inputs
 - b. 4 Digital Outputs
 - c. 8 Analog Inputs
 - d. 4 Analog Outputs

C. Building Controllers/Routers:

- 1. Provide one BBMD in each IP subnet.
- 2. BACnet UDP port number to always be set to 47808 (BAC0).

3. Provide quantity of Building Controllers/Routers as required to meet the following requirements for each at time of commissioning. If a Building Controller/Router cannot meet these requirements additional Building Controllers/Routers shall be provided at no cost to the Owner or the network shall be reconfigured to meet these requirements:
 - a. Maximum nominal processor usage: 50% for 5 minutes
 - b. Maximum nominal memory (RAM) used: 50%
- D. Application Specific Controllers (ASC):
 1. ASCs serving critical spaces that require maintained space pressurization shall have an acceptable solution to the Auto-Zero/Auto-Calibration sequence if the submitted controller sensors require periodic automatic calibration. Control contractor shall provide one of the following solutions to eliminate loss of room pressurization:
 - a. Auto-zero module
 - b. Pressure transmitters/flow measuring sensors that require annual calibration in place of standard transmitters that require daily/weekly calibration.
 - c. Control contractor shall provide a solution to the mechanical/controls engineer for approval.
 2. Air terminal ASCs serving spaces with air flow offset control shall be provided with enough physical on-board I/O points to allow for hardwired flow and offset setpoint sharing. Sharing of flow and offset setpoints via network is not acceptable.
 3. Distributing control for a single space between multiple controllers is not acceptable.
- E. Gateways:
 1. Gateways may be used for communication with non-BACnet control hardware subject to all of the following limitations:
 - a. Non-BACnet control hardware shall not be used for controlling built-up units.
 - b. Non-BACnet control hardware shall not perform system scheduling functions.
- F. Cabinets:
 1. Provide local control cabinets for DDC Controllers. DDC Controller cabinets provided with air terminals may be used directly if enclosures are rated for NEMA 1.
 2. All cabinets, with exception to air terminals and fan coil units, shall utilize a single master key. Provide 2 spare key sets to Owner.
 3. All control cabinets shall be labeled. Labels shall be keyed to the unique identifiers shown on the As-Built drawings
 4. Refer to specification 230901 - Control Systems Integration for additional requirements.
- G. Controller Firmware
 1. Provide latest version of controller firmware. Include firmware updates for period of one year after system acceptance, coinciding with warranty period. If the upgrade of firmware causes the need to upgrade or reconfigure/reprogram related systems, controllers or software, Contractor shall notify Owner prior to upgrade and provide additional work scope in coordination with other Contractors, as required, at no cost to Owner.

3.4 OPERATOR/ENGINEERING WORKSTATIONS

- A. Security access levels for the engineering workstation software shall be setup as follows:
 - 1. Guest (View-only) access level shall have the ability to perform the following tasks:
 - a. View Data
 - b. View Trends
 - 2. Operator access level shall have the ability to perform the following tasks:
 - a. View Data
 - b. Acknowledge Alarms
 - c. View Reports
 - d. Override Points
 - e. Change Setpoints
 - f. View Trends
 - g. Edit Schedules
 - 3. Engineer access level shall have the same access as Operator level with the ability to perform the following additional tasks:
 - a. Add Devices
 - b. Address Changes
 - c. Create Applications
 - d. Download Applications
 - e. Configure ASCs
 - f. Setup Trends
 - g. Setup Reports
 - h. Modify Alarm Settings
 - 4. System shall provide an Auto Logout Feature that shall automatically logout user when there has been no keyboard or mouse activity for 5 minutes. Time period shall be adjustable by system administrator. Auto Logout may be enabled and disabled by system administrator. Operator terminal shall display message on screen that user is logged out after Auto Logout occurs.

3.5 DDC SOFTWARE INSTALLATION

- A. Operating system (OS): Contractor shall install the OS on workstations and laptops and configure user names and passwords.
- B. Virus Protection software: Contractor shall install the virus protection software on each server, laptop and workstation and shall configure weekly virus scans.
- C. Contractor shall install and configure all software packages required to maintain and configure all types of controllers provided as part of this project on each engineering workstation.

- D. Software from panels shall be permanently stored on CD ROM and on at least one hard disk at operator's workstation or Web Application Server. Provide auto re-boot feature on power up from system failure. System failures shall not necessitate manual reprogramming to restore normal system function.
- E. Provide the latest version of all standard software, including operating system and control software. Include any software updates for period of one year, coinciding with warranty period. Beta released software shall not be used.

3.6 INITIAL PROGRAMMING

- A. Control Contractor shall provide initial programming of controllers to accomplish sequences specified.
- B. Provide back-up documentation per software manual submittals for all programs, in both written and electronic media formats.
- C. Include automatic restart logic for all controllers due to loss of power, safeties, fire alarm shutdown, etc.
- D. Outputs, whether sequenced or not, shall have separate programmable hardware outputs. For air handling units, minimum outside air, maximum (economizer) outside air, return air, relief air, smoke dampers, heating valves, cooling valves, humidifier valves, etc., shall each have separate output.
- E. Provide programming of menus to assist new users in accessing screen displays of each point group. Point groups (user definable) shall be initially arranged by DDC Controller for major equipment and by floor and area for terminal devices. Terminal devices shall also be grouped by air handling system where applicable.
- F. When adding to an existing system, groupings, tag names, descriptions, engineering units, etc. shall match the existing system. Transitions from the existing system to the new system shall be seamless in look, functionality, and operation. Controls Contractor shall verify with Owner if any standard naming conventions are being used and continue with those naming conventions when applicable.
- G. BACnet Naming and Addressing
 - 1. Every BACnet device shall have an assigned and documented MAC Address unique to its network. For Ethernet networks, document the MAC Address assigned at its creation. For MS/TP, assign from range as indicated by vendor documentation.
 - 2. Assign unique numbers to each new network installed on the BACnet internetwork. Provide ability for changing the network number; either by device switches, network computer, or field operator interface. The BACnet internetwork (all possible connected networks) can contain up to 65,534 possible unique networks.
 - 3. Every BACnet Building Controller (B-BC) and BACnet Router UDP port number shall be set to 47808 (BAC0).

4. Assign unique Device "Object_Identifier" property numbers or device instances for each device on the BACnet internetwork. Provide for future modification of the device instance number; either by device switches, network computer, or field interface. BACnet allows up to 4,194,302 possible unique devices per internetwork.
5. The Object Name property field shall support 32 minimum printable characters. Assign Object Name properties with plain-English names descriptive of the application..
 - a. Object names shall be unique and include respective equipment tag, system identification or Room/Zone identifier. Examples include "AHU-1-SAT", "CH-1-ENA", "FCU-1212-SS", "ZONE-1-T_SPACE".
 - b. Object Descriptions shall be an expanded plain-English descriptor of the Object Name including respective equipment tag, system identification or Room/Zone identifier. Examples include "AIR HANDLING UNIT, AHU-1, SUPPLY AIR TEMPERATURE", "CHILLER, CH-1, ENABLE COMMAND", "FCU-1212 START STOP COMMAND", "ZONE 1 SPACE TEMPERATURE".

H. Minimum BACnet Object Requirements

1. For the following points and parameters, use standard BACnet objects, where all relevant object properties can be read using BACnet's Read Property Service, and all relevant object properties can be modified using BACnet's Write Property Service: all device physical inputs and outputs, all set points, all PID tuning parameters, all calculated pressures, flow rates, and consumption values, all alarms, all trends, all schedules, and all equipment and lighting circuit operating status.
2. The Object Description property shall support 32 minimum printable characters. For each object, complete the description property field using a brief, narrative, plain English description specific to the object and project application. For example: "HW Pump 1 Proof." Document compliance, length restrictions, and whether the description is writeable in the device PICS.
3. Support and provide Description and/or Device Type text strings matching signal type and engineering units shown on the points list.
4. Support and provide Inactive Text and Active Text property descriptions matching conditions shown on the points list.
5. For devices with scheduling capability, provide at least one Calendar Object with ten-entry capacity. Enable the writeable Date List property and support all calendar entry data types.
6. Use Schedule Objects for all building system scheduling.
7. Use Loop Objects or equivalent BACnet objects in each applicable field device for PID control. Regardless of program method or object used, allow authorized operators to adjust the Update Interval, Setpoint and all constraints associated with Object, such as Proportional Constant, Integral Constant, and Derivative Constant for Loop Object, using BACnet read/write services.

I. Minimum BACnet Service Requirements

1. Use commandable BACnet objects to control machinery and systems, providing the priority levels listed below.

Priority Level	Application
1	Manual-Life Safety
2	Automatic-Life Safety

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3	(User Defined)
4	(User Defined)
5	Critical Equipment Control
6	Minimum On/Off
7	(User Defined)
8	Manual Operator
9	(User Defined)
10	(User Defined)
11	Load Shedding
12	(User Defined)
13	(User Defined)
14	(User Defined)
15	(User Defined)
16	(User Defined)

J. Point Object Naming Convention

1. The implemented point naming convention shall comply with Owner Standards. Request tagging standards from Owner prior to start of programming.
2. Point objects describe a point, such as analog or binary inputs and outputs. Point objects may be derived from the standard BACnet catalog or customized via vendor. BACnet defines the following object types as standard objects and defines their required minimum behavior:
 - a. Binary Input, Output, and Value
 - b. Analog Input, Output, and Value
 - c. Averaging
 - d. LifeSafetyZone and LifeSafetyPoint
 - e. Multi-state Input, Output, and Value
 - f. Loop
 - g. Calendar
 - h. Notification Class
 - i. Command
 - j. File
 - k. Program
 - l. Schedule
 - m. Trend Log
 - n. Group
 - o. Event Enrollment
 - p. Device
3. Point Object Naming Configuration
 - a. Level 1 – Site / Building
 - b. Level 2 – Room Number, System or Equipment Type
 - c. Level 3 –Point Type

K. Data Sharing:

1. Data communication from Controllers to Engineering Workstation and BAS web server shall be programmed to use Change of Value (COV) data sending and not continuous data polling to limit net work traffic.
2. Data communication parameters for analog inputs and analog values shall be operator configurable and setup as follows:
 - a. Minimum Send Time: (where property is available): 1 minute
 - b. Maximum Send Time: (where property is available): 15 minutes
 - c. Send on Delta (COV) :
 - 1) Space Temperature: $\pm 1.0^{\circ}\text{F}$
 - 2) Process Temperature: $\pm 0.5^{\circ}\text{F}$
 - 3) Duct Static Pressure: $\pm 0.10'' \text{ W.C.}$
 - 4) Relative Humidity: $\pm 1.0\%$
 - 5) Air Flow: $\pm 5\%$ of calibrated span
 - 6) Water Flow: $\pm 2\%$ of calibrated span
 - 7) Water Pressure: $\pm 0.5 \text{ psi}$
 - 8) Space Pressure (Pharmacy & ORs): $\pm 0.005'' \text{ W.C.}$
 - 9) Space / Building Pressure (General): $\pm 0.01'' \text{ W.C.}$
 - 10) Space CO2 sensors: $\pm 100 \text{ ppm}$
 - 11) Gas Monitoring (O2 Depletion): $\pm 0.1\% \text{ O}_2$
 - 12) Not Mentioned Above: $\pm 5\%$ of range of sensor
 - 13) Analog Values (calculated values): Same as COV for calculation input values (e.g. calculated space air flow offset would have a COV of $\pm 5\%$ of the value range, same as individual air terminal air flows)
3. Digital data points shall be sent whenever a state change occurs.

L. Historical Trending:

1. All inputs, outputs, analog values, setpoints and calculated values shall be trended and shall be fully configured and operational.
 - a. Analog point and calculated value sample time shall be one minute, unless indicated otherwise.
 - b. Space temperature, humidity, dewpoint and CO2 analog point sample time shall be 15 minutes, unless indicated otherwise
 - c. Digital points shall be trended based on change of state/value.
 - d. Chiller plant real-time electrical energy use and efficiency (COP) shall be trended every 15 minutes. Hourly, daily, monthly and annual electrical energy use and efficiency (COP) shall be trended and data shall be maintained for a minimum of 36 months.
2. Program historical file for run-times and quantity of start/stops of motor driven equipment
3. Trend logs are to be stored at the building controllers and xported to the BAS web server or data historian when the building controller trend buffer size reaches 90% full or every 24 hours (FA).

4. History exports from building controllers to the BAS web server/data historian shall be scheduled to mitigate network or BAS web server/data historian outage due to excessive network traffic.
5. Provide additional building controllers as necessary to meet requirements above.

M. Alarm/Event Management:

1. All alarm handling shall be fully configured with consistent alarm messages and priorities or category numbers to identify the system from which the alarm originates.
2. Each alarm entry shall include a clear, non-cryptic plain English description of the event-initiating object generating the alarm. Description shall be an alarm message of at least 256 characters in length. Entry shall include time and date of alarm occurrence, time and date of object state return to normal time and date of alarm acknowledgment and identification of operator acknowledging alarm.
3. BAS shall utilize first-in, first-out alarm scheme. When a unit/system/space is shutdown, either by manual override or failure, the BAS shall alarm the first event which caused the shutdown. All other respective alarms, with exception to safety alarms, shall be repressed until 5 minutes after unit/system/space has been restarted.
4. BAS shall employ alarm suppression/inhibition to minimize nuisance alarms resulting from higher level/system alarms:
 - a. Heating water system and chilled water system alarms suppress AHU supply air temperature alarms.
 - b. Chilled beam water system alarms suppress chilled beam space temperature alarms.
 - c. AHU alarms suppress associated air terminal and space temperature alarms.
 - d. Fire alarms suppress associated HVAC equipment.
 - e. Refer to BAS Point Lists for system specific additional requirements.

N. Program alarms using the following levels:

1. Level 1 - Maintenance Alarm, requiring attention within 1 to 2 days. (Examples: 2-3°F temperature variance from set point; 15-25% relative humidity variance; etc.)
2. Level 2 - Low Level Alarm, requiring attention within 8 h, preferably during the same shift. (Examples: More than 3°F variance from set point, 30 percent relative humidity or more variance from set points; excess start/stops per day; etc.)
3. Level 3 - Critical Alarm, requiring immediate attention. (Examples: Non-operation of primary equipment; H-O-A overrides; failure of controllers, routers and repeaters.)
4. Level 1 and 2 alarms shall not interrupt current user operation, but shall be logged into alarm summary file, indicating status, acknowledgment, and by whom. Level 3 alarms shall interrupt user via audible and/or flashing warning until acknowledged, without losing any work in progress. When alarms are acknowledged, program shall display point group or appropriate graphic display. Level 3 alarms shall also be logged into alarm summary file in similar manner as Level 1 and 2 alarms.

O. Time Schedules:

1. Provide time schedules for HVAC components/systems as indicated in Control Sequences.
2. Coordinate additional time schedule requirements with Owner.

3. All time schedules shall be fully configured with weekly schedules and all holidays identified by the Owner.
4. Time schedules shall reside in the Building Controllers.
5. Lighting control schedules shall provide the following minimum building schedules: Occupied/Unoccupied, holiday, special events, Building Sweep All On & All Off (multiple sweep times).

3.7 POINT LIST

- A. Provide points required to implement control sequences specified, whether or not they are listed in schedules. In addition to control points, provide additional points listed in point schedules or defined in Control Sequences.
- B. All points shall be programmed with a point name and detailed description. Control contractor shall submit point naming convention to Laboratory/Engineer for approval prior to system programming.
- C. Refer to Owner BAS Point Naming Convention document for naming requirements. When additional controls points are necessary which are not covered under the point naming convention document, the controls contractor shall follow the guiding principles of the Owner BAS Naming Convention to complete the point naming and any new names generated during the project shall be shared with Owner prior to programming for review.

END OF SECTION 230923

SECTION 230924 - GRAPHICAL USER INTERFACE INTEGRATION

PART 1 - GENERAL

1.1 SYSTEMS DESCRIPTION

- A. Building Automation System (BAS) Graphical User Interface (GUI) shall be accomplished via a web-server environment.
- B. BAS web server shall communicate with individual Building Systems via BACnet/IP protocol on the Owner provided Enterprise Ethernet network.
- C. Provide remote alarm paging via text message, alphanumeric message and email integral to web server software.
- D. Operator workstations connected to building Ethernet network shall be able to access information as determined by Graphical User Interface (GUI) software through standard web browsing software (Microsoft Edge, Mozilla Firefox, Safari or Google Chrome). GUI software shall allow transparent access to each connected building and building component/system for control and/or monitoring.
- E. Building Campus currently has an existing JCI BAS Web server which provides system monitoring, alarming, scheduling, reporting and historical trend functions via graphical user interface.
- F. Contractor shall integrate the new BAS provided under Section 230923 - Direct Digital Controllers and Networks to the existing BAS Web Application Server.

1.2 REFERENCE

- A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.
- B. This section specifies a system or a component of a system being commissioned as defined in Section 01 9100 Commissioning. Testing of these systems is required, in cooperation with Owner and Commissioning Authority. Refer to Section 01 9100 Commissioning for detailed commissioning requirements.

1.3 SUBMITTALS

- A. Refer to Section 230901 - Control Systems Integration.

1.4 OPERATION AND MAINTENANCE MANUALS

- A. Refer to Section 230901 - Control Systems Integration.

1.5 RECORD DRAWINGS

- A. Refer to Section 230901 - Control Systems Integration.

1.6 OWNERSHIP OF PROPRIETARY MATERIAL

- A. Refer to Section 230901 - Control Systems Integration.

1.7 WARRANTY

- A. Refer to Section 230901 - Control Systems Integration.

PART 2 - PRODUCTS

2.1 USER INTERFACE WEB SERVER - SOFTWARE

- A. Web server shall provide dynamic, real-time graphical control/monitoring interface for all HVAC, plumbing, lighting control and electrical systems shown on System Diagrams or included in Control Sequences. Refer Section 230901 - Control Systems Integration.
- B. Graphics shall be HTML based. The use of JAVA is not allowed.
- C. Graphics shall auto-size based on accessing device (Workstation, Laptop, Cell Phone, Tablet) providing similar user experience across device platforms.
- D. Graphical displays shall also include alarm displays, scheduling displays and trending displays. Data associated with an active display shall be no more than 5 seconds out-of-date.
- E. BAS web server shall be provided with all software applications and licenses required to provide web access to minimum of 3 simultaneous clients.
- F. Operator web access Graphical User Interface (GUI) shall be interactive, fully prompted, menu driven and shall provide the following functionality as a minimum:
 - 1. HVAC, Plumbing and Electrical Systems:
 - a. GUI shall allow for hierarchical graphical navigation between individual buildings and building control systems within individual buildings, graphical representations of systems, access to real-time data for each system, ability to override points in a system, and access to all supervisory monitoring and control functions including building/equipment schedules.
 - b. Each system display shall clearly distinguish between the following point data types and information: Real-time data, User-entered data, Overridden or operator-disabled points, Devices in alarm (unacknowledged), and Out-of-range, bad or missing data.
 - c. Graphical displays shall be provided with software "links" to equipment/instrumentation manufacturer cutsheets and system control sequences.
 - d. Software shall allow the user to create, modify, and delete displays and graphic symbols.
 - e. Operator shall be able to monitor/control all data points, setpoints and calculated values as listed in DDC/BAS Point Schedules, Control Sequences and shown on flow diagrams via graphic displays.
 - f. Operator shall be able to view and modify all Occupied/Unoccupied schedules.
 - 2. Alarm and Event Management:

- a. Web interface shall provide audible, visual, and printed means of alarm indication. The alarm dialog box shall always become the top dialog box regardless of the application(s) currently running.
 - b. Web interface shall provide log of alarm messages. Alarm log shall be archived to the hard disk of the web server. Each entry shall include the follow as a minimum:
 - 1) Point Tag
 - 2) Point Description
 - 3) Description of the event-initiating object generating the alarm. Description shall be an alarm message of at least 256 characters in length.
 - 4) Time and date of alarm occurrence. time and date of object state return to normal time and date of alarm acknowledgment and identification of operator acknowledging alarm.
 - 5) Time and date of object state return to normal time.
 - 6) Time and date of alarm acknowledgment and identification of operator acknowledging alarm.
 - c. Alarm Notification and Routing: Software shall perform alarm notification and routing functions. Upon receipt or generation of an alarm, software shall immediately perform alarm notification and routing according to an assigned routing for that alarm. Software shall support at least 100 alarm routes; an alarm route shall be a unique combination of any of the following activities:
 - 1) Generate a pop-up up display on designated workstation monitors. The pop-up display shall include identification of the alarm, date and time of the alarm, alarm message, and current value/status of the alarm point. Alarms shall be capable of being acknowledged from the pop-up display by operators with sufficient permissions. Pop-up displays shall be displayed until acknowledged.
 - 2) Send a text message to user cell phone. The text message shall contain a scripted message and all alarm data. The text message recipient and scripted message shall be user configurable for each alarm route.
 - 3) Send an e-mail message via simple mail transfer protocol (SMTP; RFC 821). The e-mail shall contain a scripted message and all alarm data. The e-mail recipient and scripted message shall be user configurable for each alarm route.
 - 4) Print alarms to designated alarm printers. The printed message shall be the same as the pop-up message.
 - 5) Alarm Notification Escalation: Software shall notify sequential devices on a predetermined list, at a configurable time interval (15 minutes initially) if prior contacts do not acknowledge receipt of notification. Software shall begin resending alarms if not acknowledged within 30 minutes.
3. Scheduling:
- a. Web interface shall show all information in easy-to-read daily format including calendar of current month and next. All schedules shall show actual ON/OFF times for day based on scheduling priority.
 - b. All schedules shall reside on BACnet Building Controllers. BAS server shall house master schedules which are to be exported to respective building controllers.
 - c. Schedules shall be provided for individual HVAC system Occupied/Unoccupied operation.

- d. Lighting control schedule shall provide the following minimum building schedules: Occupied/Unoccupied, holiday, special events, Building Sweep All On & All Off (multiple sweep times).
 - e. Operator shall be able to change all information for a given schedule if logged on with the appropriate security access.
4. Trending & Data Archiving:
- a. Trend logs are not to be server based using polling. Trend logs are to be initially stored at the BAS controller and periodically uploaded to the Web Server data historian for long-term storage.
 - b. Users logged into the system shall not have direct access to any of the raw trend data located in the BAS controllers or Web Server data historian.
 - c. Trend log files shall be appended with new sample data, allowing samples to be accumulated. Systems that write over archived data shall not be allowed, unless limited file size is specified.
 - d. Web interface shall provide ability to graphically view trend data using two-axis (x,y) graphs that display up to ten object types at the same time in different colors. Graphs shall show object values relative to time.
 - e. Operator shall be able to change trend log setup information if logged on with the appropriate security access. This includes the information to be logged as well as the interval at which it is to be logged. All input, output, and value object types in the system may be logged.
5. Report Generating:
- a. Web Server Software shall be provided with commands to generate and format reports for displaying on current Workstation, printing, and storing on disk.
 - b. Reports shall be stored by type, date, and time. The destination of each report shall be selectable by the operator.
 - c. Dynamic operation of system shall not be interrupted to generate a report. The report generation mode, either automatic or requested, shall be operator assignable. The report shall contain the time and date when the samples were taken, and the time and date when the report was generated.
 - d. Software shall be capable of saving reports to a file. If the file format is not in a format compatible with standard Microsoft Office software, Control Contractor shall provide a means to export or convert the file to a compatible format.
 - e. Software shall allow for automatic or manual generation of reports. For automatic reports, the operator shall be able to specify the time the initial report is to be generated, the time interval between reports, end of period, and the output format for the report. The operator shall be able to modify, or inhibit a periodic report.
 - f. Manual report generation shall allow for operator to request at any time the output of any report.
6. Activity Logging:
- a. System shall maintain a historical file logging all activity of the system.
 - b. This file shall maintain, as a minimum, a record of all operators logged onto the system, alarm acknowledgments, commands issued and all database modifications. Passwords shall not be logged.

- c. Activity log shall be maintained at the web application server hardware. System shall automatically provide a mechanism for archiving the log files for long term record storage.
- d. System shall maintain a minimum of 2 years of log files.

G. User Access Permissions:

1. Web Application Server Software shall manage user information and shall recognize at least 100 separate users and have at least 3 levels of user permissions. User permission levels (from most restrictive to most permissive) shall include:
 - a. Guest (View-only) access level shall have the ability to perform the following tasks:
 - 1) View Data
 - 2) View Trends
 - b. Operator access level shall have the ability to perform the following tasks:
 - 1) View Data
 - 2) Acknowledge Alarms
 - 3) View Reports
 - 4) Override Points
 - 5) Change Setpoints
 - 6) View Trends
 - 7) Edit Schedules
 - c. Engineer access level shall have the same access as Operator level with the ability to perform the following additional tasks:
 - 1) Add Devices
 - 2) Address Changes
 - 3) Create Applications
 - 4) Download Applications
 - 5) Configure ASCs
 - 6) Setup Trends
 - 7) Setup Reports
 - 8) Modify Alarm Settings
 - 9) Create and modify System Graphic Displays
2. Passwords shall not be displayed.
3. System shall provide an Auto Logout Feature that shall automatically logout user when there has been no keyboard or mouse activity for 5 minutes. Time period shall be adjustable by system administrator. Auto Logout may be enabled and disabled by system administrator. Operator terminal shall display message on screen that user is logged out after Auto Logout occurs.

H. Graphics and Controls:

1. Graphics shall be configured for “point-and-click” operation to allow user to navigate through the building systems with ease. The user shall be able to define the action of control buttons configured on the graphics.

2. Building systems and equipment drawings can be created from built-in image library or may be imported from a scanner, the Internet, CAD drawing, or other files such as bitmap (.BMP), JPEGs or Icon files.
3. All symbols used by the Contractor in the creation of graphic pages shall be saved to a library file for use by the Owner. Provide additional copy of library file on CD.
4. Graphic Editor: The graphic editor shall enable the user to create, modify, and delete displays and graphic symbols. The primary use shall be for adding and modifying graphic displays, status displays, system summaries, and system directories, as new controllers, points, data, and other necessary changes are made.

2.2 DATA HISTORIAN – DATA ARCHIVING

- A. Data historian software may reside on the same physical server as the BAS software or on a separate server. The data historian shall seamlessly integrate to the BAS software without the need for a 3rd party application.
- B. System shall provide a means to gather, archive and retrieve trend, alarm, and operatorsystem activity records. Archived information shall be available for the life of the system.
- C. Historian shall have minimum of five (5) simultaneous user licenses.
- D. Historian database shall be Microsoft SQL Server. Microsoft Access databases are not allowed.
- E. System shall allow archival to/from a mass storage device.
- F. System shall provide means to export historical data to Excel compatible file. Operator shall have the ability to define points to export, start time of export and duration of export via graphical interface.
- G. Historian shall homogeneously combine historical data from multiple collection intervals for a given point (e.g., 15 minute and change of value trends shall be blended into a common view).
- H. System shall be able to perform exception reporting (e.g., show all values below or above a certain value).
- I. System shall be able to perform advanced analysis of BAS alarms to include the following information:
 1. Number of alarms for a given period
 2. Detailed alarm information; initial alarm, alarm cleared, duration, and highest level achieved during alarm.
 3. Statistical information: longest alarm duration, average duration, and total duration.
- J. Archived data shall be maintained for a minimum of 5 years.

2.3 FAULT DETECTION AND DIAGNOSTICS (FDD) SOFTWARE:

- A. Provide an FDD rule execution engine either integral to BAS Web Server software or 3rd software application, which can monitor all available monitored data and alarms, and execute user defined logic to determine or predict equipment operational or efficiency faults.

- B. FDD software shall monitor equipment parameters in real-time and read historical data and data derivations, via any or all open data connectivity methods.
- C. FDD software shall provide for the organization of all equipment as a hierarchical structure of assets, representing all structure and equipment. Multiple rules, or fault detection logic will be supported for each asset.
- D. FDD software shall provide default conditional logic for fault detection. The user shall be able to modify the logic and inputs of any fault rule. The user shall be able to add any number of new faults rules, including all fault analysis logic, to any asset.
- E. FDD software shall continuously monitor all referenced input values, input states, historical derivations, and determine if a fault condition has occurred. On occurrence of a Fault condition, the system shall display, and issue alert notifications. On occurrence of a fault the system shall analyze all referenced inputs continuously and calculate all possible causes and calculate the probability of all possible causes.
- F. FDD software shall use tagging to model and describe data and shall support the use of the open source tagging standard developed by Project-Haystack: <http://project-haystack.org/>. The Haystack naming convention is the current standard for tagging locations and equipment.

2.4 BAS WEB APPLICATION SERVER – HARDWARE INTEGRATION INTO EXISTING SERVER

- A. Provide all hardware required to integrate the BAS into the existing Campus BAS Web Application Server for operator control/monitoring of building control systems.

2.5 BAS WEB SERVER – SOFTWARE INTEGRATION INTO EXISTING SERVER

- A. Provide all necessary software upgrades or additional licenses to accommodate the additional point capacity required to integrate all BAS monitoring and controls points. Refer to specifications 230905 - Instrument Point List and 230993 - Control Sequences.

PART 3 - EXECUTION

3.1 GENERAL

- A. Install all control equipment in neat and workmanlike manner to satisfaction of Architect and Engineer.
- B. Coordinate timely delivery of materials and supervise installation of control devices.

3.2 SOFTWARE

- A. Software shall be permanently stored on compact disk and on Web Application Server. Provide auto re-boot feature on power up from system failure. System failures shall not necessitate manual reprogramming to restore normal system function.

- B. Provide the latest version of all software, including, operating system and application software. Provide all software updates, and hardware updates associated with such software updates, for period of one year coinciding with warranty period. No beta released software shall be used.

3.3 BAS WEB SERVER – SOFTWARE PROGRAMMING

A. User Access Permissions:

- 1. Coordinate Users and access levels with Owner and setup in software.

B. Alarm and Event Management:

- 1. Web Server Software shall be programmed to receive BACnet alarm event notifications from individual controllers and manage system alarm/event notification and routing.
- 2. Web Server Software shall be programmed to monitor status of each controller and provide alarms on loss of communication/status.
- 3. Operator shall be able to adjust alarm limits if logged on with the appropriate security access.
- 4. Configure routing for all alarms. Coordinate alarm routing with Owner.
- 5. Alarm logs shall be maintained for a minimum of 1 year.

C. Scheduling:

- 1. Web Server Software shall be programmed to provide scheduling interface for individual HVAC system, space and lighting Occupied/Unoccupied operation as indicated in Control Sequences.

D. Trending & Data Archiving:

- 1. Web Server shall provide data archiving for all inputs, outputs, setpoints, integration points and calculated values.
- 2. Archived data shall be maintained for a minimum of 2 years.
- 3. All trend log information shall be displayed in standard engineering units.
- 4. Data points indicated to as “LEED” in the DDC Point Schedules shall be have a sampling time of 1 minute and averaged over 15 minutes.

E. Report Generating: Software shall have a report generation utility programmed for generating the following standard reports:

- 1. Energy usage Report: An energy usage summary, operator selectable, for a unit and building. Report shall be divided by utility, and shall be capable of reporting on at least four separate utilities. Report shall include the following information:
 - a. Beginning and ending dates and times
 - b. Total energy usage for each utility for the current and previous day
 - c. Total energy usage for each utility for the current and previous month
 - d. Maximum 15-minute interval average rate of consumption for each utility for the current and previous day and current and previous month
 - e. Average Outside air (OA) temperature and OA relative humidity (rh) for current and previous month and current and previous day
 - f. Calculated degree days

2. Chiller plant energy and efficiency: Daily, monthly and annual reports.
3. Current Alarm Summary Report: Current alarms by building or unit, including time of occurrence.
4. Daily Alarm Summary Report: Current alarms by building or unit, including time of occurrence for a user specified day.
5. Daily Room Summary Report: Average, high & low values for temperature, humidity and air change rate for a user specified day.
6. Device Failure Report: Failed devices including instruments, points, controllers and network hardware, including time of failure, and identification of operator acknowledging failure alarm.
7. Override Report: Points overridden, including time overridden, and identification of operator overriding the point.
8. Lockout Report: Points locked-out, including time locked-out, and identification of operator locking-out the point.
9. Run Time Reports: A report totalizing the accumulated run time of individual pieces of equipment. The operator shall be able define equipment groupings and shall be able to generate reports based on these groupings.
10. Provide allowance for ten (10) additional Owner defined custom reports.

3.4 GRAPHICS PROGRAMMING

- A. Graphics shall be designed to match graphic displays on the existing system following existing campus graphics standards and utilizing owner furnished templates. Transition from existing graphics to new graphics shall be seamless transition for operator in look, functionality, and operation.
- B. Navigation Scheme: System graphic displays of HVAC, plumbing and electrical systems and points shall be hierarchical displays using a building-to-equipment point-and-click navigation scheme. Each display shall show the building/Area name and number.
- C. Program color graphic displays for each system as described herein. Graphic displays shall consist of pictorial presentations with text description, system schematic, or picture; alarm fields; and database fields for associated points, including dynamic input values, output values, set points, gains, time schedules, etc.
- D. Make use of color to highlight system components.
 1. Color and texture meanings shall be consistent across all displays. Components of similar type shall be of same color for graphics (example: dampers shall be purple, valves yellow, etc.). Alarm fields shall be flashing black letters on red background. Affected component shall also turn red whenever alarm status is indicated. Database fields shall be dynamically updated and re-displayed on screen by periodically polling database points not less than once every 5 seconds. Each display shall clearly distinguish between the following point data types and information:
 - a. Real-time data
 - b. User-entered data (setpoints)
 - c. Overridden or operator-disabled points
 - d. Devices in alarm (unacknowledged)

- e. Out-of-range, bad, or missing data
- 2. 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.
- E. Graphics shall be configured to automatically update values without any action by the operator.
- F. All standard graphic features, 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.
- G. 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.
- H. Graphical displays shall be provided with software "links" to As-Built Control System submittal documents.
- I. Display all control loop and alarm setpoints on respective system graphic. Provide ability to change control loop setpoints, alarm setpoints and start/stop equipment from system graphic, provided user has appropriate access. If system graphic seems too cluttered, provide separate, text-based, System Overview page.
- J. Display time, date, outside temperature and humidity on each display in same location on each graphic. Provide command to direct specific displays without accessing main menu. Provide means of displaying directory of screens. Arrange displays by group and type.
- K. Graphic displays shall be designed to be easily understood. When display screen is too cluttered due to size, limit information to important monitoring data. Provide sub-graphic(s) to display data not displayed on main display.
- L. Each graphic shall have a shortcut to the main menu graphic and to previous graphic.
- M. Main menu graphic shall be automatically displayed when user logs on to system.
- N. Graphics shall include, but not be limited to:
 - 1. Site Plans, including each building, building name, and status of exterior points such as lighting, etc.
 - 2. Overall building plan. Indicate location of mechanical rooms and areas served by each air handling unit.
 - a. Provide link from building plan to individual building floors and mechanical rooms.
 - 3. Overall HVAC floor plan of each Area/Floor with indication of individual space temperatures, humidity, occupancy status, equipment status, equipment locations and alarm status for displayed values. Include room names and numbers for all spaces on floor plan graphics.
 - a. Provide link from displayed values and equipment to associated equipment graphic.

- b. Provide link to overall building plan.
 - c. Label equipment and displayed values according to mechanical floor plans and BAS program.
 - d. Provide links to individual room/zone control graphics.
 - e. Identify HVAC zones served by specific air handling units.
- 4. Overall Lighting Control System floor plan of each floor with indication of individual light status and outline of lighting zones.
 - a. Provide link from floor graphic to manual control graphic for each space/zone. Operator shall be able to select individual offices, conference rooms and open office zones from floor graphic and initiate manual control graphic.
 - b. Manual control graphic shall provide lighting status indication and one-touch ON/OFF override control for respective room/zone.
- 5. Overall Fire Alarm System floor plan of each floor with status of individual Fire Alarm/Control Zone. Zone status shall be indicated as follows:
 - a. Red: Alarm
 - b. Yellow: Warning
 - c. Magenta: Supervisor
- 6. Schematic type graphics for:
 - a. Site Main Menu, with background digital picture of site, showing each building, shall have direct links to each individual building Main Menu.
 - b. Individual Building Main Menu, with background digital picture of building, shall have direct links to each of the following, as applicable:
 - 1) Overall Building Plan
 - 2) Heating Hot Water System
 - 3) Each Air Handling Unit (AH)
 - 4) Each Exhaust Air System
 - 5) Air Handling Unit Summary
 - 6) Power Monitoring System
 - 7) Each HVAC Floor Plan
 - 8) BAS Network Architecture
 - c. Each Air Handling Unit (AH)
 - 1) Supply fan control loops
 - 2) Return fan control loops
 - 3) Cooling coil control loops
 - 4) Heating coil control loops
 - 5) Heat recovery coil control loops
 - 6) Humidifier control loops
 - 7) Damper control loops
 - d. Fan Coil Units
 - e. Exhaust Air Systems
 - 1) Exhaust fan control loops

- f. Space Temperature Control (Air Terminals)
 - 1) Each air terminal serving space
 - 2) Space environmental information
 - 3) Provide link to associated air handling unit graphic
- g. Space Specific Control & Monitoring
- h. Heating hot water system showing all components
 - 1) Individual Boilers
 - 2) Temperature control loops
 - 3) Pump control loops
 - 4) Individual Pump VFDs
- i. Each Plumbing System
- j. Each Packaged System/Equipment
- k. BAS Network Architecture indicating status of all devices/controllers
- l. HVAC Schedules
- m. Fire Alarm System
 - 1) Each Floor Plan
- n. HVAC Trends
- 7. Submit sample graphics (one per type) for review and approval by Owner prior to starting graphics programming.
- 8. Provide allowance for five (5) additional Owner defined custom graphics.

3.5 FAULT DETECTION AND DIAGNOSTICS (FDD) SOFTWARE:

- A. The software shall be programmed to generate the following values and faults:
 - 1. Air Handling Units:
 - a. Damper failure
 - b. Simultaneous Heating and Cooling
 - c. Heating Coil Valve Leaking
 - d. Determine the stability of control devices (valves/actuators/VFDs).
 - e. Compare sensor readings to setpoint and flag out-of-range, drift and offset errors from faulty sensors.
 - f. Compare outputs (controllers) setpoints to actual conditions to find failed devices.
 - g. Diagnose flow measurement systems to ensure readings are in range of expectations.
 - h. Ensure ventilation rates are adequate (testing minimum outdoor air volume settings).
 - 2. Air Terminal Unit:
 - a. Damper Failure
 - b. VAV Unstable Air Flow
 - c. VAV Heating Water Valve Failure
 - d. Simultaneous Heating and Cooling
 - e. Overheating
 - f. Overcooling

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- g. Determine the stability of control devices (valves/actuators).
- h. Compare sensor readings to setpoint and flag out-of-range, drift or offset errors from faulty sensors.
- i. Compare outputs (controllers) setpoints to actual conditions to find failed devices.
- j. Diagnose flow measurement systems to ensure readings are in range of expectations.

3.6 STARTUP

- A. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 9100 Commissioning.

3.7 FUNCTIONAL PERFORMANCE TESTS

- A. System functional performance testing is part of the Commissioning Process as specified in Section 01 9100. Functional performance testing shall be performed by contractor and witnessed and documented by Commissioning Authority.

END OF SECTION 230924

SECTION 230993 - CONTROL SEQUENCES

PART 1 GENERAL

1.1 REFERENCE

- A. The Work under this section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.2 DEFINITIONS

- A. The following abbreviations, acronyms, and definitions may be used in addition to those found elsewhere in Contract Documents.
1. Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.
 2. ASC: Application Specific Controller
 3. BAS: Building Automation System
 4. COV: Changes of value
 5. Point Type:
 - a. AI Analog Input (4-20 mA, 0-5 volt DC, 0-10 volt DC, etc.)
 - b. DI Digital (Binary) input
 - c. AO Analog Output (4-20 mA, 0-5 volt DC, 0-10 volt DC, etc.)
 - d. DO Digital (Binary) output
 6. Process Variable (PV) / Process Measurement: The measured value (temperature, pressure, etc.) read by a sensor that the process is controlling. A sensor may be either an element/transmitter or a switch.
 7. Setpoint (SP): The value of the Process Variable that the control system is trying to maintain.
 8. FAS: Fire Alarm System
 9. Final Control Element: The instrument affecting control on a process (e.g. valve or variable speed drive)
 10. Loop: The combination of the process, process measurement, process controller, and a final control element.
 11. PID control: A Proportional-Integral-Derivative (PID) Controller shall adjust the final control element (e.g. valve) based on the process or measured variable (PV) input to the PID controller. The controller shall calculate the new valve position continuously based on the difference between (PV) and setpoint, and the PV rate of change. All modulated devices (e.g. modulated valves and VFD's) shall be controlled using PID control.
 12. Direct Acting Control: If the (PV) is above the setpoint, the final control element modulates toward 100%. If the (PV) is below the setpoint, the final control element modulates toward 0%.

13. Reverse Acting Control: If the (PV) is above the setpoint, the final control element modulates toward 0%. If the (PV) is below the setpoint, the final control element modulates toward 100%.
14. Interlock or Safety Circuit: The arrangement of device control so that their operation is interdependent in order to assure proper coordination and to prevent system to start or operate if hazard(s) exist. An interlock will put a system in a safe state whenever a device is not in the proper on/off state. An interlock is required to start a system and keep it operational.
15. Permissive: The arrangement of device control so that their operation is interdependent in order to assure proper startup of a system to prevent system from operating if a hazard(s) exist. A permissive is required to start a system but not required to keep it operational.
16. Field Adjustable (FA): Adjustable value that an operator, maintenance personnel, or engineer can adjust using an interface to the control system. (All setpoints shall be field adjustable unless otherwise noted.)
17. Deadband (DB): Is an interval of a signal domain or band where no action occurs (the system is dead)
18. Lead: The device that operates first in a Lead/Lag configuration.
19. Lag: The devices that operates after the Lead device to provide more capacity. Some systems may have more than one Lag device.
20. Primary: The device that operates in a Primary/Standby configuration.
21. Standby: The devices that operates if the primary, lead or lag device fails.
22. Occupied: A period of time that someone is using a space.
23. Unoccupied: A period of time a space has no one in it.
24. Scheduling: A method using time to start systems, determine Occupied/Unoccupied periods, and determine when to rotate Lead/Lag/Standby devices.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Refer to sections stated under related work.

PART 3 EXECUTION

3.1 GENERAL CONTROL SEQUENCES

- A. Transmitters/Sensors
 1. Shall be hardwired back to controller where logic will reside. Sharing the transmitter signal via the network shall not be allowed for control unless transmitter is located in a building separate from the controlled device (VFD, valve, damper, etc.).
- B. Safety Devices
 1. Shall be manual reset type unless otherwise noted.
- C. Control sequences coordination

1. Systems shall perform in accordance with control sequences. Refer to system diagrams, flow diagrams and related drawings for overall system arrangement. Provide all control devices and instrumentation required to perform the sequences whether or not specifically shown on the drawings.
2. Review and coordinate with shop drawings and submittals of controlled and monitored equipment and provide required control devices and wiring for proper interface and system integration. This shall include ARU and any other equipment provided with factory furnished control and monitoring devices.
3. Contractor shall review sequences prior to programming and suggest modifications where required to achieve the design intent. Contractor may also suggest modifications to improve performance and stability or to simplify or reorganize logic in a manner that provides equal or better performance. Sequence modifications shall not be implemented without Engineer and Owner approval.

D. Program requirements

1. Unless indicated otherwise, all setpoints, timers, deadbands, PID tuning parameters and alarm limits shall be field adjustable either at the local sensor or via workstation variables by users with appropriate access level whether indicated as adjustable in the sequences or not.
2. Controls contractor shall verify setpoints, time intervals, and limits based on actual field conditions. All setpoints, time intervals, and limits shall be optimized to achieve stable system operation, prevent damage to equipment, minimize maintenance requirements, and eliminate nuisance alarms (such as premature filter loading, false tripping of freezestats and other similar conditions).
3. Analog control loops for major equipment (chilled water, hot water, process cooling water, convertors, air handling units, VFDs, etc.) shall use PI control loops unless indicated otherwise.
4. Unless otherwise indicated, control loops shall be enabled and disabled based on the status of the system being controlled to prevent wind-up.
5. The term “proven” (i.e. “proven on” / “proven off”) shall mean that the equipment’s discrete input status point matches the state set by the equipment’s discrete output command point.
6. Values for all points, including real (hardware) points used in control sequences shall be capable of being overridden by the user (e.g. for testing and commissioning). If hardware design prevents this for hardware points, they shall be equated to a software point and the software point shall be used in all sequences. Exception: Not required for ASC hardware points.
7. Where zone data (such as damper or valve position, control loop signal) is used for reset of the AHU/Pump system serving the zone, the zone tag (name) shall be recorded when it is the zone driving the reset (such as the zone requiring the most cooling). This data shall be available for reports so that the zones that are undersized or otherwise driving the system can be identified for remediation if required.
8. Controlling distribution (air or water) pressure transmitters are to be documented on BAS graphics.

9. All analog control values (control valves, control dampers, VFDs, ECMs, etc.), regardless of physical range, i.e. 0-10V, 4-20mA, etc., shall be configured to present a value between 0-100% where 0% is always closed/zero frequency/off and 100% is always open/full speed.

E. H-O-A Operation:

1. Fan (AHU)

- a. When any fan is commanded to start via H-O-A switch on VFD or motor starter, the following sequence shall occur:
 - 1) Upon indication of fan H-O-A switch in Hand position, respective outlet smoke/isolation damper(s) shall open and prove open before starting. For 100% outside air units, outside air damper(s) shall open and prove open before starting.
 - 2) In Hand mode, fan shall start and operate at speed selected on VFD (line speed for motor starter) while remaining operating fan(s) shall continue to operate to maintain system airflow at setpoint as indicated in its respective system air volume/pressure control sequence.
 - 3) When all fan H-O-A switches on respective VFDs or motor starters are returned to Auto mode, the fan shall resume normal supply air control operation as indicated in this section.
- b. When any fan is commanded to stop via H-O-A switch in Off mode on a VFD or motor starter, the following sequence shall occur:
 - 1) Fan shall stop and AHU sequence shall execute lead-lag-standby logic for remaining fans.
 - 2) When fan H-O-A switch is placed back in Auto mode, fan shall be allowed to be put back in the lead-lag-standby sequence as a lag or standby fan.
- c. When an H-O-A switch is in any position other than Auto, an alarm shall be annunciated at the BAS.
- d. All safety devices shall be functional in Auto and Hand modes of operation.

2. Exhaust Fan

- a. When any fan is commanded to start via H-O-A switch on VFD or motor starter, the following sequence shall occur:
 - 1) Upon indication of fan H-O-A switch in Hand position, respective inlet/outlet smoke/isolation damper(s) shall open and prove open before starting.
 - 2) In Hand mode, fan shall start and operate at speed selected on VFD (line speed for motor starter) while remaining operating fan(s) shall continue to operate to maintain system airflow at setpoint as indicated in its respective system air volume/pressure control sequence. When a VFD H-O-A switch is in any position other than Auto, an alarm shall be annunciated at the BAS.
 - 3) When fan H-O-A switch on respective VFD is returned to Auto mode, the fan shall resume normal supply air control operation as indicated in this section.
- b. When fan is commanded to stop via H-O-A switch in Off mode on a VFD or motor starter, the following sequence shall occur:
 - 1) Fan shall stop and exhaust fan sequence shall execute lead-lag-standby or primary-standby logic for remaining fans.
 - 2) When fan H-O-A switch is placed back in Auto mode, fan shall be allowed to be put back in the lead-lag-standby sequence as a lag or standby fan.

3. When an H-O-A switch is in any position other than Auto, an alarm shall be annunciated at the BAS.
4. All safety devices shall be functional in Auto and Hand modes of operation.

F. VFD powered equipment

1. Each variable frequency (speed) drive (VFD) shall be integrated to Building Automation System (BAS) via communication interface to allow all information available from VFD to be viewed and all settings and adjustments to be made through BAS. Coordinate communication interface requirements with VFD manufacturer. Initially, BAS shall be programmed to poll VFD for the following information at minimum.
 - a. VFD fault
 - b. Motor speed feedback
 - c. Motor amps
 - d. Motor power (kW)
 - e. Hand-Off-Auto switch position
2. Motor run status, motor speed control signal and start/stop signal to/from the BAS controller shall be hardwired directly to the VFD and shall not be sent via the BAS network.
3. BAS shall be programmed so that speed setpoint of 0% corresponds to 0 Hz and speed setpoint of 100% corresponds to maximum speed programmed in VFD.
4. BAS shall start variable frequency drives (VFD) and hold at minimum speed setting prior to releasing to control. BAS shall ramp VFD down to minimum speed before stopping. Unless otherwise noted, the VFD shall be programmed to accelerate/decelerate full scale over 60 seconds.
5. BAS contractor shall coordinate with the VFD start-up technician to determine the minimum speed required for each motor controlled by a VFD to provide cooling of the motor as installed to prevent heat related problems or prevent stall or cavitation conditions. The VFD shall not be allowed to operate at less than 15 Hz unless paired with an inverter-duty motor rated for low frequency operation.
6. If electrical disconnect is connected between VFD and driven equipment, auxiliary contacts provided by the Division 26 contractor shall be terminated to VFD safety circuit. The auxiliary switch contacts shall open the VFD safety circuit and shall stop the VFD prior to disconnecting the electrical feed to the motor to prevent power surges in the VFD if the disconnect is pulled while the motor is operating.
7. All safety devices such as, freezestats, high static pressure safety switches, low static suction safety switches, smoke detectors, etc. shall be hardwired in series with safety circuits on VFDs and shall stop when safety device is tripped. Safety circuit shall be functional on drives with or without bypass contactors and shall be functional in both VFD and Bypass modes.
8. Upon signal loss to the VFD, or when signaled to stop, the VFD shall ramp down to the minimum pre-programmed speed at the programmed ramp rate.
9. On a failure of the VFD as defined by an output from the VFD, an alarm shall be generated at the BAS.

G. Equipment failure modes:

1. Pump/fan
 - a. When a device is required to run, the control system shall command the device to start by energizing the discrete output to the motor starter/VFD. The device shall run until the control system commands the device to stop by de-energizing the discrete output to the motor starter/VFD or an equipment failure occurs.
 - b. Equipment failure shall be detected by opening of a low current switch, pressure differential switch, current/torque input in low-low alarm condition (VFD) or VFD fault input when the device is commanded on or is operating, or anytime equipment status does not equal commanded state within 60 seconds of command changed of state. If a failure occurs, the device shall be stopped and an alarm shall be annunciated at the BAS designating that device has failed (see each sequence for alarm type details). Pump or fan shall be locked out after failure until manually reset through the BAS.
 2. Control valve/damper with feedback
 - a. When a device is required to open/close/modulate, the control system shall command the device with a discrete or analog output. If the device does not match the commanded state within designated time period, the device shall be indicated as failed. For analog feedback devices, the commanded and actual position must differ by greater than 5% (FA) to be considered as a failure. If the device is part of a lead/lag/standby unit, the unit shall be disabled and rotated to a lag or standby unit. If the device is not part of a lead/lag/standby unit, it shall continue to operate with the alarm active.
- H. Switch / alarm point activation
1. Safety limit alarms shall be manually reset at sensor location. Other alarms may be automatically reset when measured value returns to its normal range or set point.
 2. Provide each switch/alarm trip point with an adjustable time delay to prevent nuisance tripping. These time delays apply to all switch points whether hardware or software and are for normal operation. Additional or longer delays may be necessary during start-up or shut down as noted herein.
 3. For all commanded outputs that have status feedback, provide an alarm that will indicate the commanded output is not in its commanded state.
 4. For analog feedback devices, the commanded and actual position must differ by greater than 5% FA to be considered as an alarm. Provide alarms on all points as indicated on point list.
 5. BAS shall utilize first-in, first-out alarm scheme. When a unit/system/space is shutdown, either by manual override or failure, the BAS shall alarm the first event which caused the shutdown. All other respective alarms, with exception to safety alarms, shall be repressed until 10 minutes after unit/system/space has been restarted.
- I. Trending
1. During building commissioning, coordinate with commissioning agent and provide more specific trending requirements to support system performance verification, demonstration of proper system operation and troubleshooting as required per commissioning specifications.

END OF SECTION 230993

SECTION 232116 - PIPE AND PIPE FITTINGS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Specification of an item in this or any other sections shall not relieve Contractor from providing all items, articles, materials, operations, methods, labor, equipment and incidentals necessary for a complete and functional system.
- B. Use only new material, free of defects, rust and scale, and guarantee for services intended.
- C. Use material meeting the latest revision of ASTM specifications as listed in this specification.
- D. Follow local codes if they require other types of pipe or joints.
- E. Use only long radius elbows having centerline radius of 1.5 pipe diameters unless otherwise indicated.
- F. Manufacturer, pressure class, size and heat code of each fitting and flange shall be permanently identified on its body in accordance with MSS SP-25.
- G. Where size for a pipe segment is not indicated, the pipe segment size shall be equal to the largest pipe segment to which it is connected. Transition to smaller size shall occur on the side of fitting where smaller size is indicated.
- H. Unless otherwise indicated, fittings and accessories connected to pipe shall be of the same material as the pipe.
- I. Unless otherwise indicated, construct piping for highest pressures and temperatures in respective system in accordance with the latest revision of the applicable Sections of ASME Code for pressure piping, ASME B31 including the following:
 - 1. ASME B31.9 : Building Services Piping
 - 2. ASME B31.9: Building Service Piping for building heating and distribution steam and condensate piping for 15 psig or less, or hot water heating system for 30 psig or less.
 - 3. ASME B31.1 : Power Piping
 - 4. ASME B31.3 : Process Piping
 - 5. ASME B31.8 : Gas Transmission and Distribution Piping Systems
 - 6. ASME B31.4: Liquid Petroleum Transportation Piping Systems
- J. Boiler external piping shall comply with the latest revision of Section 1 of ASME Boiler and Pressure Vessel Code. This Contractor shall be responsible for materials, installation, testing and certification in accordance with the Code.
- K. Non-metallic piping is acceptable only for services indicated. It is not acceptable in occupied spaces and ventilation plenum spaces.

1.2 SUBMITTALS

- A. Submittals shall be in PDF format and shall include bookmarks to each product to enhance navigation and facilitate review process.
- B. Shop Drawings for each piping system for all pipe sizes including the following:
 - 1. Name of system
 - 2. Pipe; ASTM number, grade if known, type, wall thickness, material
 - 3. Fittings; ASME number, grade if known, class, type, wall thickness, material
 - 4. Joint type
 - 5. Flanges; ASTM number, grade, class, type, material
 - 6. Bolts and nuts; material
 - 7. Thread joint sealants; material
 - 8. Flange gaskets; material, rating
 - 9. Unions; ASTM number, type, material, rating
 - 10. Piping Systems Welding Submittal Matrix (refer to Part 3) with supporting documents
 - a. Welding Processes utilized
 - b. Procedure Qualification Record (PQR)
 - c. Welding Procedure Specification (WPS)
 - d. Welding Operator Qualifications (WPQ)
 - 11. Welding Quality Control Program
 - 12. Test pressure and media
 - 13. Pipe flushing/cleaning plan
 - 14. Pipe cleaning method
 - 15. All other appropriate data
- C. Submit pipe certification as specified under Pipe Certification in this Section.
- D. Submit required documents as specified under Pipe Welding in this Section.
- E. Provide Flushing and Cleaning Plan:
 - 1. Submit pipe flushing/cleaning plan for water, fluid, steam and condensate systems for approval. Plan shall detail methods for compliance with requirements of this section, including:
 - a. Flushing and cleaning procedure narratives.
 - b. Size, power source, and connection points of contractor provided pumps that will be used for flushing and cleaning.
 - c. If Contractor proposes to utilize project system pumps, method of protecting pumps from damage and developing required velocity of section of piping to be flushed.
 - d. Method of sectionalizing piping to obtain required velocity.
 - e. Minimum velocities at each section of pipe, clearly indicating any sections where 2 yd/s(6 fps) cannot be achieved.

- f. Location and means of temporary bypasses for coils, control valves and other equipment.
 - g. Flushing schedule and drawings or diagrams that will be used for inspection and sign off prior to and after procedure, at Owner's option.
- 2. Submit documents showing verification of flushing/cleaning following specified requirements and results.

1.3 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Furnish pipe with plastic end-caps/plugs on each end of pipe. Maintain end-caps/plugs through shipping, storage and handling to prevent pipe-end damage and eliminate dirt and construction debris from accumulating inside of pipe.
- B. Where possible, store materials inside and protect from weather. Where necessary to store outside, elevate well above grade and enclose with durable, waterproof wrapping.
- C. Before shipping, all carbon steel piping shall be free of rust and scale, and furnished with plastic end caps/plugs on each end of pipe.

1.4 PIPE WELDING

- A. Procedure and Welding Qualification Records:
 - 1. Submit Welding Procedure Specifications (WPSs) and their supporting Procedure Qualification Records (PQRs) to be used on the work to Engineer for review and approval prior to performing any welding. These documents shall meet requirements of ASME B31.1 and ASME B31.9, as applicable.
 - 2. Unless otherwise indicated, welding shall be done using only the following processes:
 - a. Shielded Metal Arc Welding (SMAW), also known as "stick" welding
 - b. Gas Tungsten Arc Welding (GTAW), also known as TIG and Heliarc welding
 - c. Gas Metal Arc Welding (GMAW), also known as MIG welding
 - d. Flux-Cored Arc Welding (FCAW), a variation of GMAW
 - e. Submerged Arc Welding (SAW)
 - 3. Root pass must be applied by GTAW process with argon gas purge for high-pressure steam and condensate (400 psig and over) and high temperature hot water (450°F and over) services.
 - 4. Root pass must be applied by only GTAW process with argon gas purge for stainless steel pipe.
 - 5. Unless otherwise stated, fabrication, installation, inspection, examination and testing shall be in accordance with ASME B31.1 or BASME B31.9, as applicable.
 - 6. Backing rings (chill rings) or consumable inserts are not allowed, unless specifically requested by Owner or Engineer.
- B. Quality Control Program:
 - 1. Submit written quality control program for review and approval prior to implementing any welding on this project. Quality control program shall include the following as minimum:
 - a. Explanation of how Contractor will assure proper fit-up for each weld.

- b. Explanation of how Contractor will document welds performed by individual welding operators for systems under ASME B31.1.
- c. Explanation of how Contractor will assure that proper welding procedure is being followed.
- d. Credentials of personnel responsible for required weld examinations.

C. Weld Inspection and Examination:

- 1. Provide examination services for all welding for this Project. Examination shall be in accordance with requirements of ASME B31.1, Table 136.4 or ASME B31.9, as applicable.
- 2. Periodically, as welding progresses, submit report, signed by weld examiner, indicating status of project welding quality.
- 3. Arrange with Owner's Inspector for observation of fit-up and welding methods prior to implementing any welds, including shop welds, on this Project.
- 4. In addition, Owner's Inspector will perform any additional observations deemed necessary before, during, or after fabrication to assure, to Owner's satisfaction, that proper welding is provided. Owner reserves the right to perform independent examination of welds. If Owner has any concern as a result of such examination Owner reserves the right to stop in progress welding work, without any cost to Owner, until resolution satisfactory to Owner is reached.

D. Welder Qualifications:

- 1. Each welder and welding operator must qualify by passing required performance test before performing any project welds. Submit copy of Manufacturer's Record of Welder or Welding Operator Qualification Tests (WPQS) as required by Section IX of ASME Boiler and Pressure Vessel Code for all welding procedures to be performed by welding operator.
- 2. Welder qualifications must be current. If welder's performance qualification test is more than 6 months old, provide record of welding continuity for welder.
- 3. Record of welding continuity is intended to show that welder has performed welding at least every 6 months since the date that welder qualification test was passed for the submitted welding procedure specification.
- 4. Record of welding continuity shall include the following, at minimum:
 - a. Welder's employer name and address
 - b. Date Welder Qualification Test was passed
 - c. Dates indicating welding continuity without lapse of greater than 6 months
- 5. Welders shall be qualified as required by ASME B31.1 or ASME B31.9, as applicable. In addition, there shall be an independent witness of welder tests. That witness shall be representative of independent testing laboratory, Authorized (Code) Inspector, Owner's or Engineer's Inspector or consultant approved by National Certified Pipe Welding Bureau.
- 6. Welder qualifications must cover all pipe sizes wall thicknesses, and pipe orientations used on this project. Welders shall not perform welds for which they do not carry current qualifications under ASME BPVC Section IX
- 7. At all times field welding is taking place, at least one welder qualified in Test Position 6G, or in both Test Position 2G and 5G shall be present.

E. Weld Record:

1. For welding within the scope of ASME B31.1 Power Piping, submit to Engineer for approval an administrative procedure for recording, locating, monitoring and maintaining quality of welds to be performed on the project. This quality control document record shall include but not be limited to:
 - a. Drawings and schedules identifying location of each weld by individual number, identification of welder who performed each weld by individual welder's name, stamp number, date, and WPS used.

1.5 PIPE CERTIFICATION

- A. Certification is required for all pipe within scope of ASME B31.1. Submit certification papers, as outlined below, within 30 days of delivery of pipe to project site.
- B. Type E or S Pipe:
 1. Furnish manufacturer's mill certificates (material test report) including dimensions, heat numbers, chemical analysis and tensile test results for pipe shipped to project site.

1.6 FLANGES

- A. Use either flat faced or raised-face flanges for mating with flat-faced or raised-face flanges.
- B. Welding Neck Flanges:
 1. All flanges shall be welding neck type unless otherwise indicated.
- C. Slip-on Flanges:
 1. Slip-on flanges shall not be used without specific approval of Engineer. Contractor shall submit written request for use of slip-on flange for specific instance where use of welding neck flange is problematic. Slip-on flanges over 4" pipe size are prohibited for any application under ASME B31.1.
- D. Bore dimension of flange shall match inside diameter of connecting pipe.
- E. Bolts and Nuts:
 1. Threads shall be in accordance with ANSI/ASME B31.1, Class 2A tolerance for external threads and Class 2B tolerance for internal threads. Threads shall be coarse-thread series except that alloy steel bolting 1-1/8" and larger in diameter shall be 8 pitch thread series.
 2. Threaded rods are not allowed in lieu of bolts.
- F. Where allowed under specific piping systems specified in this section, use of low strength (ASTM A307) bolts shall be limited to service temperatures of 400°F and used only with non-metallic flat ring gaskets.

1.7 CATHODIC PROTECTION

- A. Cathodic protection shall be designed and provided by system pre-insulated pipe manufacturer for pipe systems as specified in Part 2. Cathodic protection shall conform to recognized practices and shall be designed by qualified personnel. Measurements of corrosivity of soil environment expressed in terms of soil's electrical resistivity (ohm/cm) shall be taken and checked out by pre-insulated pipe manufacturer. Resistivities shall be given along proposed routing of piping systems. Anodes and test stations shall be provided by this Contractor as recommended by pre-insulated pipe manufacturer.
- B. After installation, field survey shall be made by pre-fabricated pipe manufacturer and measurement of current and conduit-to-soil potentials at each test station shall be taken.

PART 2 - PRODUCTS

2.1 VENTS AND RELIEF VALVES

- A. Unless otherwise indicated, use pipe and pipe fittings as indicated for the system to which relief valve or vent is connected.
- B. ASTM A53/A53M, Grade B, Type E or S, carbon steel pipe with standard weight, carbon steel fittings may be used for steam vents smaller than 4".
- C. Use ASTM A53/A53M, Grade B, Type E or S carbon steel pipe with ASTM A234/A234M Grade WPB/ASME B16.9, standard weight, seamless carbon steel weld fittings for refrigerant vent piping.

2.2 PRESSURE GAUGES AND TAPPINGS

- A. Use pipe and pipe fittings as indicated for the system to which pressure gauge or tapping is connected. Use "Threadolets", "Sokolets" or tee fittings for tappings. Refer to Part 3 under General for use of "Threadolets" and "Sokolets".
- B. Gauge pipe shall be 1/4" unless otherwise indicated.
- C. Gauge pipe shall be 1/2" for high pressure steam (101 psig and over) systems.

2.3 COOLING COIL CONDENSATE DRAIN

- A. Piping shall be one of the following, unless otherwise indicated on drawings:
 - 1. Galvanized Steel
 - a. Pipe: ASTM A53/A53M Grade A or B, Type F, standard weight, galvanized steel
 - b. Fittings: ASTM A126/ASME B16.4, cast iron, threaded, ASTM A123/A123M galvanized
 - 2. Copper
 - a. Pipe: ASTM B88 Type M, hard temper copper tubing
 - b. Fittings: ASME B16.22 wrought copper fittings
 - c. Joint: ASTM B32, 95-5 tin-antimony solder, Bridgit or Silvabrite

3. PVC

- a. Pipe: ASTM D1785, Schedule 40, polyvinyl chloride (PVC)
- b. Fittings: ASTM D2665, solvent weld PVC fittings

2.4 DIELECTRIC UNIONS, FLANGES AND FITTINGS (STEEL PIPE TO COPPER PIPE)

A. 2" and Smaller:

- 1. Use bronze ball valves specified in Section 232118 - Valves for dielectric purpose.
- 2. Dielectric fittings similar to Victaulic Style 647 or Clearflow Dielectric Waterway fittings may be used in lieu of dielectric unions for pipe sizes 2" and smaller.
 - a. Clearflow fittings shall be ASTM A53/A53M electro zinc-plated steel pipe with high temperature polyolefin polymer liner, suitable for continuous use at temperatures up to 230°F and pressures up to 300 psig.
- 3. ASTM A197/A197M/ASME B16, equal to Stockham Figure 693-1/2, Watts Series 3000 or Wilkins (Zurn) Model DU series dielectric unions with EPDM dielectric gasket, 250 psi at 180°F.

B. 2-1/2" through 4":

- 1. Watts dielectric flange fittings Series LF 3100/LF 3110 with dielectric gasket, 175 psi) at 180°F.
- 2. Dielectric fittings similar to Victaulic Style 647 or Clearflow Dielectric Waterway fittings may be used in lieu of dielectric unions for pipe sizes 2-1/2" and larger.
 - a. Clearflow fittings shall be ASTM A53/A53M electro zinc-plated steel pipe with high temperature polyolefin polymer liner, suitable for continuous use at temperatures up to 230°F and pressures up to 300 psig.

2.5 THREADED JOINT SEALANTS

- A. Paste type for brush application or cord type. Products shall be non-toxic, chemically inert, non-hardening, rated for -50 to 400°F and up to 10,000 psi (liquids) and 2000 psi (gases), certified by UL, CSA, and NSF.
- B. Use sealant similar to Loctite Model 54531 for piping handling oil or petroleum products.

2.6 WELD BRANCH OUTLET FITTINGS (WELDOLETS, THREADOLETS AND SOCKOLETS)

- A. Weld branch outlet fittings shall conform to MSS-SP-97, ASME B16.9 for weldolets, ASME B1.20.1 for threadolets and ASME B16.11 for sockolets.
- B. Materials shall match material of header piping and wall thickness of outlet or branch end shall match wall thickness of branch pipe.

2.7 REFRIGERANT PIPING

- A. ASTM B88 Type L hard drawn copper tube, cleaned and capped in accordance with ASTM B280, and marked "ACR" with ANSI B16.22 wrought copper or forged brass solder-type fittings.

PART 3 - EXECUTION

3.1 GENERAL

- A. Remove foreign materials before erection. Ream ends of piping to remove burrs.
- B. Install piping parallel to building walls and ceilings and at such heights so as not to obstruct any portion of window, doorway, stairway, or passageway. Install piping to allow adequate service space for equipment. Refer to drawings and/or manufacturer's recommendations. Install vertical piping plumb. Where interferences develop in field, offset or reroute piping as required to clear such interferences. In all cases, consult drawings for exact location of pipe spaces, ceiling heights, door and window openings or other architectural details before installing piping.
- C. Provide anchors, expansion joints, swing joints and expansion loops so that piping may expand and contract without damage to itself, equipment or building.
- D. Mitered elbows, welded branch connections, notched tees and "orange peel" reducers are not allowed. Unless specifically indicated, reducing flanges and reducing bushings are not allowed. Reducing bushings may be used for air vents and instrumentation connections.
- E. Unless otherwise indicated, use fittings as specified in Part 2 of this Section for elbows, tees, reducers, etc.
- F. Diverging tees (one inlet, two outlets) shall have inlet on "run" of tee. Converging tees (two inlets, one outlet) shall have outlet on "run" of tee. Bullhead tees will not be allowed unless specifically indicated or with approval of engineer.
- G. "Weldolets" with outlet size 2-1/2" and larger and "Threadolets" or "Sockolets" with outlet size 2" and smaller may be used for branch connections up to one pipe size smaller than main. Use "Threadolets" where threaded fittings are specified and use "Sockolets" where socket weld fittings are specified. Install in accordance with PFI (Pipe Fabrication Institute) Standard ES49.
- H. Install drains throughout systems to permit complete drainage of entire system.
- I. Do not install piping over electrical panelboards, switchgear, switchboards or motor control centers.
- J. Install valves, control valves and piping specialties, including items furnished by others, as specified and/or detailed.
- K. Make connections to equipment installed by others where that equipment requires piping services indicated in this Section.
- L. For piping within the scope of ASME B31.1 Power Piping, transfer piping material specification and "Heat Number" to each segment of pipe prior to cutting.

3.2 THREADED PIPE JOINTS

- A. Threads of pipe and fittings shall conform to ASME B1.20.1.

- B. Ream pipe ends after cutting and clean before erection. Apply thread sealants to cleaned male threads. Assemble joint to appropriate depth and remove any excess pipe joint compound from tightened joint.

3.3 FLANGED JOINTS

- A. Clean flange surfaces and align them parallel. Bolt holes of gaskets shall be cut slightly larger than bolt diameter. Gasket ID shall be slightly larger than flange ID.
- B. Position gasket concentrically so compression is equally distributed over entire gasket surface.
- C. Lubricate bolts and run nuts down by hand.
- D. By using torque wrench, tighten nuts in the proper sequence so gasket is compressed evenly, and to the appropriate torque specified by bolt manufacturer.
- E. Re-torque bolts 12 to 24 h after start up.

3.4 WELDED PIPE JOINTS

- A. Inspect pipe and pipe fittings for roundness before they are fit-up or set in place.
- B. Properly clean and prepare pipe base material before fit-up. Verify joint land and bevel.
- C. Preheat pipe base material as required by welding procedure specification. Temperature of pipe material must be minimum of 50°F before welding.
- D. Properly align and adjust joint as required by welding procedure and thickness of material. Verify tolerances after tacking sequence.
- E. Use weld material diameter as procedurally required for type and thickness of work being done.
- F. Use sufficient argon pre-purge and argon post-purge for GTAW processes. Post purge should be until weld is no longer glowing plus 5 seconds. Maintain purge for at least 2 layers of weld material.
- G. Properly store welding materials.
- H. Clean tacks before welding out. Remove slag after each pass by grinding to avoid slag inclusion.
- I. Weld reinforcement shall not exceed limits established in Chapter V of ASME B31.1.
- J. Brush each weld free of rust and paint with rust resistant product that matches piping surface color.
- K. For piping within scope of ASME B31.1, each weld shall be permanently marked by welder performing weld. Each welder shall sign and date field welding log record for all welds performed by welder as indicated in Part 1.
- L. Conduct radiographic test for sections or joints that cannot be tested by hydrostatic test methods (such as joints cut into existing piping systems) by qualified radiographic testing firm.

3.5 COPPER PIPE JOINTS

- A. Cutting of tubing shall not make tubing out of round. Ream cut tube ends to full inside diameter.
- B. Remove slivers and burrs remaining from tube cut by reaming and filing both pipe surfaces. Clean fitting and tube with emery or sand cloth. Remove residue from cleaning operation, apply flux and assemble joint. Use solder or brazing to secure joint as specified for specific piping service.
- C. Press Joint Option:
 - 1. Cut pipe square and ream before assembly
 - 2. Insert pipe fully into fitting and mark on pipe at shoulder of fitting
 - 3. Check fitting alignment against mark on pipe to ensure pipe is fully engaged
 - 4. Press joint with press tool approved by fitting manufacturer

3.6 VENTS AND RELIEF VALVES

- A. Install vent and relief valve discharge lines as indicated on drawings, as detailed, and as specified for each specific valve or piping specialty item.
- B. Steam safety valve vent pipes:
 - 1. Horizontal steam safety valve vent pipes not exceeding 10 feet in horizontal run shall pitch back toward safety valve drip pan elbow or condensate drain as detailed.
 - 2. Horizontal steam safety valve vent pipes exceeding 10 feet in horizontal run shall pitch in direction of steam flow and shall be drained through drip trap with thermostatic trap at each rise where condensate may collect.

3.7 COOLING COIL CONDENSATE DRAIN

- A. Trap each cooling coil drain pan connection with trap seal of sufficient depth to prevent conditioned air from moving through piping. Extend drain piping to nearest code approved drain location. Construct trap with plugged tee for cleanout purposes.
- B. Pitch pipe down at not less than 1/8" per ft for proper drainage.
- C. Where copper piping is allowed, joints and fittings may be secured with 95-5 tin-antimony solder or brazing alloys.

3.8 DIELECTRIC UNIONS AND FITTINGS

- A. Install dielectric unions, flanges or fittings in main and branch piping of water systems at each point where copper to steel pipe connection occurs. Dielectric unions or fittings shall not be used at terminal device connections.
- B. Concealed dielectric unions and fittings are not allowed.
- C. Install steel to steel pipe dielectric unions or flanges in _____ piping at each point where interior steel piping is connected to exterior underground steel piping.

3.9 UNIONS AND FLANGES

- A. Install union or flange at each automatic control valve and at each piping specialty or piece of equipment that requires tube pull or removal for maintenance, repair or replacement. If required, provide additional unions or flanges in order to facilitate removal of piping sections that interfere with tube pulls or equipment removal. Where valve is located at piece of equipment, provide flange or union connection on equipment side of valve.
- B. Concealed unions or flanges are not allowed.

3.10 PIPING SYSTEM PRESSURE TESTS

- A. Owner and/or Owner's representative may elect to witness pressure test. Notify Owner and/or Owner's representative at least 3 days in advance.
- B. Conduct pressure test prior to flushing and cleaning of piping systems.
- C. Conduct hydrostatic (HYDRO) test in accordance with ASME B31.1 137.4. Test pressure shall be in accordance with ASME B31.1, but shall not be lower than the minimum test pressure listed below.
- D. Conduct Pneumatic (PNEU) test with test medium of dry, oil free air, carbon dioxide, or nitrogen for natural gas, compressed air and fuel oil piping and in accordance with ASME B31.1 137.4.
- E. If leaks are found, repair with new materials and repeat test until leaks are eliminated. Caulking will not be acceptable.
- F. Pressure tests may be made of isolated portions of piping systems to facilitate general progress of installation. Any revisions made in piping systems require retesting of affected portions of piping systems.
- G. No systems shall be insulated until it has been successfully tested. If required for additional pressure load under test, provide temporary restraints at expansion joints or isolate them during test. Unless otherwise noted, minimum test time shall be 4 h plus such additional time as may be necessary to conduct examination for leakage.
- H. No pressure drop shall occur during test period. Any pressure drop during test period indicates leakage.
- I. Provide pumps, gauges, instruments, test equipment, temporary piping and personnel required for tests and provide removal of test equipment and draining of pipes after tests have been made.
- J. For hydrostatic tests, remove air from piping being tested by means of air vents. Measure and record test pressure at high point in system. Where test pressure at high point in system causes excessive pressure at low point in system due to static head, portions of piping system may be isolated and tested separately to avoid undue pressure. However, every portion of piping system must be tested at the specified minimum test pressure.

- K. Contractor shall provide all pumps, gauges, instruments; test equipment, flow meters, temporary piping and personnel required for tests and provide removal of test equipment and draining of pipes after tests have been made.
- L. If piping system is drained after testing and left empty or untreated for more than 3 days, provide vapor phase corrosion inhibitor, such as Cortec VpCI, or engineer approved equivalent, at recommended dosages for dry system lay-up. Provide specific treatment compatible with type of pipe installed following manufacturer's recommendations. Provide isolation valves or other provisions to isolate lay-up portions from non-lay-up portions. Re-apply lay-up treatment at intervals according to manufacturer's recommendations. Prior to placing lay-up piping into service, remove lay-up treatment and prepare system in accordance with manufacturer's recommendations.
 - 1. Confirm all piping system materials and components receiving treatment are compatible with applied inhibitor and lay-up treatment.
 - a. Note: High heat may cause VpCI to "cake". If piping system will be exposed to heat alternative treatment shall be used.
 - 2. Provide cleaning and treatment plan for Owner's review and approval. Plan shall include duration of lay-up and maintenance of lay-up through anticipated lay-up period(s).

3.11 FLUSHING AND CLEANING PIPING SYSTEMS

- A. Notify Owner and/or Owner's representative at least 7 days in advance.
- B. Flush new water, fluid, steam and condensate systems thoroughly for 15 minutes or longer, as required to ensure removal of dirt and foreign matter from piping system. Bypass pumps and equipment and remove strainers from strainer bodies. Provide circulation by Contractor-supplied portable pumping apparatus.
- C. Provide temporary piping or hose to bypass coils, control valves, heat exchangers, other factory-cleaned equipment, and any component that may be damaged.
- D. Sectionalize system to obtain minimum velocity of 6 fps. Provide temporary piping to connect dead-end supply and return headers as necessary. Flush bottoms of risers.
- E. For pipes 18" and larger, maintain velocity as close as 6 fps possible, but not below 5 fps.
- F. After initial flushing of system, use portable pumping apparatus to circulate cold water detergent for water systems. Refer to Section 232514 - Chemical Treatment Systems for pipe cleaning.
- G. After initial flushing of system, use portable pumping apparatus for continuous 24 h minimum circulation of cold water detergent similar to Nalco 2567 cleaner. Flush detergent clear with continuous draining and raw water fill for additional 12 h or until all cleaner is removed from system. Dispose of all cleaning and rinse water per local jurisdiction requirements and Facility Owner's requirements. Replace strainers and reconnect permanent pumping apparatus and all apparatus bypassed.
- H. Refer to Section 232514 - Chemical Treatment Systems for water analysis.
- I. Use oil when flushing hydraulic piping.

- J. Flush gas piping with clean, dry compressed air for one (1) h minimum. Open and clean drip legs. Repeat flushing until no debris is found in drip legs.
- K. Flush compressed air piping with clean, dry compressed air for one (1) h minimum. Open and clean drip legs. Repeat flushing until no debris is found in drip legs.
- L. For clean steam system, flush as indicated above followed by passivation in accordance with ASTM A380/A380M. Flush with purified water followed by 4 h with clean steam and wasting all condensate. Clean steam generator shall be valved out of system except when clean steam is generated. Submit results of passivation to Engineer.

3.12 FLUSHING AND CLEANING PIPING SYSTEMS

- A. Flushing and cleaning piping systems is not required.

3.13 INITIAL SYSTEM FILL AND VENT

- A. Fill and vent systems with proper working fluids.
- B. Use fluids chemically treated as specified in Section 232514 - Chemical Treatment Systems.
- C. Glycol system shall be filled with treated glycol as specified in Section 232514 - Chemical Treatment Systems

3.14 PIPE PAINTING

- A. Exposed exterior carbon steel, black iron or other ferrous pipe and fittings shall be prepared and painted by qualified painters using corrosion inhibitive paints. Pipe shall be prepared in accordance with paint manufacturer's instructions and primed (2 coats) and finish painted (2 coats). Paint type shall be approved by Architect/Engineer.
- B. Protect piping from weather and paint promptly to prevent corrosion.

3.15 PIPE WELDING SUBMITTAL MATRIX

- A. Submit the following welding procedure and qualification matrix or similar.

PIPE WELDING PROCEDURE AND QUALIFICATION SUBMITTAL MATRIX - SAMPLE			
Welding Process	Welding Procedure Specification (WPS)	Welding Procedure Qualification Record (PQR)	Welding Operators Qualified (WPQ)
Shielded Metal Arc Welding (SMAW)			
Gas Tungsten Arc Welding (GTAW / TIG)			
Gas Metal Arc Welding (GMAW /			

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MIG)			
Flux Cored Arc Welding (FCAW)			

B. Submit WPQ for each welding operator

END OF SECTION 232116

SECTION 232118 - VALVES

PART 1 - GENERAL

1.1 SUBMITTALS

- A. Shop Drawings for each system for all sizes including, the following:
 - 1. Name of system
 - 2. Manufacturer's name
 - 3. Type
 - 4. Model number
 - 5. Materials of construction
 - 6. Temperature/pressure ratings
 - 7. Manufacturer's data sheets clearly cross-referenced
 - 8. All other appropriate data

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Gate valves, globe valves, check valves, and drain valves: Crane, Nibco, Stockham, Powell, Milwaukee, Hammond, or Grinnell equal to manufacturer's Figure number listed. Provide valves of same make for these services.
- B. Other valves: acceptable manufacturers and Figure Number listed under each item.
- C. Butterfly valves and check valves manufactured by grooved coupling manufacturer will be acceptable where grooved pipe connection system is allowed, provided valves meet requirements for non-grooved valves specified.

2.2 WATER SYSTEM VALVES

- A. General:
 - 1. Valves 2" and smaller in steel piping shall have threaded ends.
 - 2. Valves 2" and smaller in copper piping shall have solder ends.
 - 3. Press Ends:
 - a. Valves with press ends will be acceptable where press joints are allowed, provided valves meet requirements specified in this section. Temperature and pressure ratings shall be equal to or exceed ratings of press fittings used.
 - 4. Provide valve stem extensions with sufficient length to allow for insulation where insulation is specified.
- B. Ball Valves:

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1. 2" and Smaller: ASTM B584 bronze body, chrome plated brass/bronze or stainless steel ball, full port 3/4"1", PTFE seat rings, blowout-proof stem, 2-piece construction, 600 psi CWP conforming to MSS-SP-110, 150 psi, Nibco Fig. T(S)-585-70, Apollo No. 77, Watts FBV, Milwaukee BA-400, Hammond, or Kitz
- C. Spring Loaded Check Valves:
1. 2" and Smaller: ASTM B584 or ASTM B62 bronze body, stainless steel spring, PTFE or brass disc, Class 125 (200 psi WOG), Nibco Figure T(S)-480, Mueller Model 303-BP or Milwaukee UP548T
 2. 2-1/2" and Larger: cast iron or ductile iron body, flanged or wafer type, stainless steel spring, bronze, aluminum bronze, or stainless steel disc, Buna-N, EPDM, or bronze seat, Class 125 (200 psi CWP), Nibco Figure F-910 or W-910, Milwaukee 1800 or 1400, Metraflex Style. 700, Stockham Figure WG-961 or WG-970, Crispin WC Series, Mueller Sure Check Model. 71, or Crane Duo-check II
 3. Victaulic series 716 or 779 with grooved end will be acceptable where grooved pipe connection system is allowed. Valves shall be ductile iron body, stainless steel spring aluminum bronze or ductile iron fully encapsulated in EPDM disc maximum working pressure 300 psi and maximum operating temperature 230°F
- D. Shut-Off Valves:
1. 2" and Smaller: ball valves as specified in this Section
 2. 2-1/2" and Larger: butterfly valves as specified in this Section
- E. Lockshield Valves:
1. Ball valves as specified above with locking handles for padlocking in open or closed position.
- F. Drain Valves:
1. Ball valve as specified above with threaded hose adapter and cap. If 3-piece ball valves are specified, use 2-piece ball valves with same construction.

PART 3 - EXECUTION

3.1 GENERAL

- A. Install valves as shown on plans, details and according to manufacturer's installation recommendations.
- B. After piping systems have been pressure tested and put into service, but before final adjusting and balancing, inspect valves for leaks. Adjust, replace packing or replace valves to stop leaks.
- C. Install control valves furnished under Control Systems. Provide reducing fittings as required.
- D. Refer to Section 232116 - Pipe and Pipe Fittings, Part 3 for reducing fittings requirement for valves smaller than pipe size.
- E. Provide chain operators for manually operated valves furnished with gear operators, which are located more than 8 ft above equipment room floor.

3.2 SHUT-OFF VALVES

- A. Provide shut-off valves at all equipment, at riser take-offs at each floor, and at each automatic valve for servicing.
- B. Install steam system shut-off valves in horizontal piping. Shut-off valves are not allowed in vertical piping.

3.3 DRAIN VALVES

- A. Provide drain valves at all low points of piping systems for complete drainage of systems.
- B. Unless otherwise indicated, provide 1/2" drain valve for 1/2" piping and minimum 3/4" drain valve for 3/4" and larger piping, except strainer blowdown valves shall be blowdown connection size.

END OF SECTION 232118

SECTION 232120 - PIPING SPECIALTIES

PART 1 - GENERAL

1.1 REFERENCE STANDARDS

- A. Metal bellows expansion joints shall be constructed and applied in accordance with "Standards of the Expansion Joint Manufacturer's Association", 10th Edition.

1.2 SUBMITTALS

- A. Shop Drawings for all items in this Section including the following:
 - 1. Manufacturer's name and model number
 - 2. Identification as referenced in the Documents
 - 3. Materials of construction
 - 4. Dimensional data
 - 5. Capacities/ranges
 - 6. Temperature/pressure ratings
 - 7. Pressure drop
 - 8. Expansion joint schedule indicating joint tag no., system, proximity to rotating or reciprocating equipment, required movement in all planes, service pressure, test pressure, service temperature, fluid velocity and cycles to failure (both thermally and seismically, if applicable).
 - 9. Steam trap insulation assemblies
 - 10. All other appropriate data.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Unless otherwise specified, select devices for highest pressures and temperatures existing in respective systems in accordance with ANSI Specifications.
- B. Piping specialties in copper piping shall have bronze or brass body with solder ends.

2.2 THERMOMETERS

- A. Manufacturers: Trerice, Weksler, Miljoco, Winters, or Weiss
- B. Pipeline mounted thermometers: 9" scale cast aluminum case and frame, clear acrylic plastic window front, permanently stabilized glass tube with mercury free indicating fluid, adjustable angle stem, extended neck suitable for insulated piping as required, and compatible with sockets as specified herein.

- C. Panel or remote mounted thermometers: vapor actuated dial type with remote bulb, 4-1/2" minimum diameter cast metal casing with double front. Sensing bulbs shall be of length to suit pipe diameter with extended necks as required for insulated piping, suitable for insertion in separable brass sockets as specified herein.
- D. Duct type thermometers: dial type with minimum dial size of 4-1/2" and maximum graduations of 2°F, complete with swivel mounting arrangement to permit up to 45° rotation for easy reading.
- E. Range of thermometer for particular installation shall extend from point at least 40°F below lowest point of equipment's or system's operating range to point at least 40°F above highest point of that range.
- F. Range of thermometers shall be:

Service	Scale Range	Increment
Heating Hot Water	30 to 240°F	2°F
Air (indoor)	0 to 160°F	2°F
Air (outdoor)	-40 to 100°F	2°F

- G. Thermometers by temperature control manufacturer meeting above Specification will be acceptable.

2.3 THERMOWELLS AND TEST WELLS

- A. Brass construction with threaded connections suitable for thermometer stems or bulbs and temperature control sensing elements, well length suitable for pipe diameter with extended neck as required to suit pipe insulation. For test well, furnish with brass cap and short chain to secure cap to body.
- B. Stainless steel construction for stainless steel piping.

2.4 PRESSURE GAUGES

- A. Manufacturers: Ashcroft, U.S. Gauge, Marsh, Trerice, Miljoco, Marshalltown, Weksler, Winters or Weiss
- B. Minimum 4-1/2" diameter die cast aluminum case, glass or acrylic plastic window, phosphor bronze or stainless steel bourdon tube with bronze bushed or stainless steel movement, recalibration from front of gauge dial and 1/4" NPT forged brass socket.
- C. Gauge accuracy shall meet ANSI B40.100 Grade 1A ($\pm 1\%$ full scale).
- D. Select gauge range so that normal operating pressure is at midpoint of gauge.
- E. Pressure Snubbers:
 - 1. 1/4" or 1/2" size, matching gauge pipe size as specified in Section 232116 - Pipe and Pipe Fittings, 1000 psig WP. Brass for carbon steel pipe or copper pipe. Stainless steel for stainless steel pipe.
- F. Coil Syphons:

1. 1/4" or 1/2" size, matching gauge pipe size as specified in Section 232116 - Pipe and Pipe Fittings , 500 psig WP. Material shall match system pipe material.

2.5 PRESSURE/TEMPERATURE TEST STATIONS

- A. Pete's plugs made by Peterson Equipment Company, Sisco, Super Seal by Flow Design Inc. (FDI), or approved equal.
- B. Test plugs shall be 1/4" or 1/2" NPT, brass body and cap, 1-1/2" length for non-insulated pipe and 3" length for insulated pipe, with Nordel self-closing valve cores, rated at 500 psig at 275°F, and shall receive either temperature or pressure probe with 1/8" OD.
- C. Furnish portable test kit within durable case containing the following:
 1. A compound pressure gauge, 3-1/2" dial, 30" Hg – 100 psi, field calibration screw, surge protector and stainless steel gauge adapter with 1/8" diameter probe (2% accuracy of mid range).
 2. Two pocket testing thermometers, 1-3/4" dial, 5" long stainless steel stem, 0 - 220°F and 25 - 125°F ranges with external calibration (1% accuracy of entire scale).

2.6 PIPELINE STRAINERS

- A. Manufacturers: Metraflex, Mueller Steam Specialty, Nibco, Hoffman, Eaton (formally Hayward), Sarco, Keckley, Armstrong, Wheatley, Conbraco, Titan, Watts, or Streamflo
- B. Liquid System:
 1. 2" and Smaller: full pipeline size, Y-type, with removable screen caps, cast iron, Class 250 (400 psi/150°F WOG), threaded ends for carbon steel piping and cast bronze, Class 125 (200 psi/150°F WOG), solder ends for copper piping. Screen caps shall have threaded blowdown connection.
 2. 2-1/2" and Larger: full pipeline size, Y-type, Class 125 (200 psi/150°F WOG), cast iron, flanged ends. Furnish strainer with bolted screen retainer and off-center blowdown connection.
 3. Strainers manufactured by grooved coupling manufacturer will be acceptable where grooved pipe connection system is allowed.
 4. Liquid Service Screens: stainless steel with screen perforation as indicated below. For strainers serving equipment where manufacturer requires specific screen perforation, provide per manufacturer requirements. Maximum pressure drop shall be 4 feet WG through clean strainer.

Pipe Size	Closed System	Open System
2" and smaller	1/32"(20 mesh)	1/8"
2-1/2" to 4"		1/8"
5" and over	1/8"	1/8"

- C. Steam Service Screens: stainless steel for low pressure and monel for high pressure with screen perforation size as indicated below. For strainers serving equipment where manufacturer requires specific screen perforation, provide per manufacturer requirements. Net area of screen shall be at least 4 times that of connected pipe.

Pipe Size	Perforation Size
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2" and smaller	1/50" (30 mesh)
2-1/2" to 10"	3/64" (.045")
12" and over	1/16" (.062")

2.7 STRAIGHTENING VANES

- A. Manufacturers: Daniel Industries, Inc., Houston, Texas or approved equal
- B. Straightening vane assembly shall consist of series of carbon steel pipes firmly welded together and to line size pipe. Furnish vanes with class 150 psi flanges for insertion into piping system.

PART 3 - EXECUTION

3.1 GENERAL

- A. Install piping specialties as indicated on plans, details and according to manufacturer's recommendations.

3.2 THERMOMETERS

- A. Install thermometers in thermowells in locations indicated.

3.3 THERMOMETER TEST WELLS

- A. Install test wells in locations as shown and at each point where temperature-sensing device is required under Control Systems.

3.4 PRESSURE GAUGES

- A. Install gauges for services other than steam with pressure snubbers and gauge valves.
- B. Install gauges for steam service with coil syphons and gauge valves.

3.5 PRESSURE GAUGE TAPPING

- A. Install tapplings with gauge valves at each point where sensing device is required under Control Systems and at gauge locations as shown.
- B. Use threadolets or tee fittings to mount gauge tapplings or test stations. Install fittings for side mounting to avoid collection of air or dirt.

3.6 PRESSURE/TEMPERATURE TEST STATIONS

- A. Pete's plug may be used in lieu of thermometer test well and pressure gauge tapplings.
- B. Use threadolets or tee fittings to mount gauge tapplings or test stations. Install fittings for side mounting to avoid collection of air or dirt.

3.7 PIPELINE STRAINERS

- A. Provide drain valve at each strainer blowdown connection with hose threaded adapter and cap. Valve size shall be same as blowdown connection size.
- B. Install strainers in steam system on entering side of all automatic control valves and as indicated elsewhere. Install Y-type strainers in horizontal lines so that basket is in horizontal plane to prevent condensate build-up in basket.
- C. Install clamped cover basket strainers in condenser water system as indicated.

END OF SECTION 232120

SECTION 233114 - DUCTWORK

PART 1 - GENERAL

1.1 SUBMITTALS

- A. For each duct system, submit schedule utilizing reinforcement tables from SMACNA HVAC Duct Construction Standards Metal and Flexible where applicable. Each duct system schedule shall include, but not be limited to, the following:
 - 1. Name of Contractor/manufacturer fabricating each duct system
 - 2. Material and gauge
 - 3. Pressure class
 - 4. Transverse joint type and length and reinforcement rigidity class with designated joint T number or proprietary duct connection if utilized for each system
 - 5. Certified test results of proprietary joint products, if used, tested in accordance with SMACNA procedures
 - 6. Intermediate reinforcement spacing and rigidity class with metal angle dimensions and gauge
 - 7. Type of longitudinal seam
 - 8. Fitting construction details
 - 9. Support methods including spacing, upper attachments, and lower attachments
 - 10. Sealant and gasket
 - 11. Sealing class
 - 12. Grease exhaust duct Testing Agency credentials and test procedures
- B. Duct leakage testing methods, apparatus and apparatus certification signifying meter is in conformance with ASME Requirements for testing meters.
- C. Duct liner including data on thermal conductivity, air friction correction factor, and temperature and velocity limitation.
- D. Submit shop drawings for manufactured duct system products
- E. Submit the following information for welded sheet metal ductwork:
 - 1. Welding Procedure Specification (WPS) for welded joints. Form to be similar to AWS D9.1/D9.1M Sheet Metal Welding Code, Annex "D".
 - 2. Procedure Qualification Record (PQR) for each WPS. Form to be similar to ANSI/AWS D9.1/D9.1M Sheet Metal Welding Code, Annex "E".
 - 3. Welder and Welding Operator Qualification Test Record (satisfactory performance) for each field or shop welder. Form to be similar to ANSI/ AWS D9.1/D9.1M Sheet Metal Welding Code, Annex "F".

1.2 DELIVERY, STORAGE, AND HANDLING

- A. Protect duct and fittings from damage due to normal handling during shipment and storage. Protection shall be applied to ends of duct to prevent dirt and moisture from entering ducts and fittings.

1.3 DESCRIPTION

- A. Furnish and erect ductwork free of objectionable vibration, chatter, and pulsations. Verify dimensions at site, making field measurements and drawings necessary for fabrication and erection.
- B. Duct sizes indicated are net inside dimensions.
- C. Where size for a duct segment is not indicated, the duct segment size shall be equal to the largest duct segment to which it is connected. Transition to smaller size shall occur on side of fitting where smaller size is indicated.

1.4 DESIGN CRITERIA

- A. All products shall conform to NFPA 90A, and shall possess flame spread rating of not over 25 and smoke developed rating no higher than 50.
- B. Unless otherwise indicated, construct all ductwork of galvanized sheet metal for pressure class not less than 2" WG for positive pressure ductwork and not greater than -2" WG for negative pressure ductwork.
- C. Ductwork shall comply with Local, State and Federal requirements.
- D. Use material, weight, thickness, gauge, construction, and installation methods as outlined in the following SMACNA publications, unless noted otherwise:
 - 1. HVAC Duct Construction Standards Metal and Flexible, 3rd Edition, 2005
 - 2. HVAC Air Duct Leakage Test Manual, 2nd Edition, 2012
 - 3. Round Industrial Duct Construction Standards, 2nd Edition, 1999
 - 4. Rectangular Industrial Duct Construction Standards, 2nd Printing 2004
 - 5. Accepted Industry Practice for Industrial Duct Construction, 2nd Edition, 2008
 - 6. Phenolic Duct Construction Standards ANSI/SMACNA 022 (2015)
 - 7. SMACNA Sheet Metal Welding Guide – 3rd Edition, 2007
- E. Unless otherwise indicated, pressure class for VAV system supply ductwork between supply fan discharge and air terminal device inlet shall be equal to static pressure at fan discharge but not less than 4" WG; pressure class for ductwork on suction side of air handling unit and suction side of return fan shall be equal to static pressure at inlet of return fan but not less than -2" WG.
- F. Unless otherwise indicated, pressure class for fume hood exhaust ductwork between exhaust fan inlet and exhaust air terminal device outlet shall be equal to static pressure at exhaust fan inlet but not less than -4" WG.

- G. Unless otherwise indicated, pressure class for constant air volume system ductwork shall be equal to external static pressure (fan entrance or discharge pressure minus associated unit internal component pressure drop), but not less than ± 2 " WG.
- H. Duct transverse joints and reinforcement material, including angle ring flanges and stiffeners, shall be of same material as duct.
- I. Tie Rods
 - 1. Tie rods shall be 1/2" or 3/4", galvanized steel EMT/conduits with bolt assembly consisting of rubber washer and friction anchored threaded insert similar to Ductmate Easyrod or PPI Condu-Lock.
 - 2. Internal tie rods are not allowed for welded ductwork and special exhaust systems, such as fume hood exhaust, BSC exhaust, animal room exhaust, BSL-3 exhaust, cagewash exhaust, shower room exhaust, kitchen hood exhaust, dishwasher exhaust, etc.
- J. Adhesives and sealants used on installation of ducts shall comply with South Coast Air Quality Management District (SCAQMD) Rule #1168; Indoor Environmental Quality Section, Credit EQ-4.

1.5 WELDING REQUIREMENTS

- A. The following requirements cover arc and braze welding of nonstructural sheet metal ductwork for HVAC, architectural metal and other FDA process applications where pressures do not exceed 120" WG (positive or negative). These requirements also apply to welding of structural members whose sole purpose is stiffening, supporting, or reinforcing of sheet metal material, as well as attachment of brackets or other accessories/components required to provide complete systems.
- B. Procedure and Qualification:
 - 1. Welding Procedure Specification (WPS) and Procedure Qualification Record (PQR) shall be prepared by installing contractor and/or fabricator prior to execution of related work. Qualification of welding procedure shall meet or exceed requirements of the latest revision of American Welding Society, Sheet Metal Welding Code ANSI/AWS D9.1/D9.1M .
 - 2. Provide certification of satisfactory performance testing for all welders and welding operators, which provide welding services on Project.
 - 3. Establish and provide written quality assurance/quality control (QA/QC) procedures to ensure compliance with specification requirements. Clearly identify appropriate steps for safe welding procedures (review Appendix J of D9.1) including additional safety material, screens, eye, personnel and clothing protection, fire suppression equipment, and fume extraction equipment needed adjacent to welding work area.

PART 2 - PRODUCTS

2.1 GALVANIZED STEEL SHEET

- A. Lock Former Quality (LFQ), cold rolled, open hearth soft steel sheet capable of double seaming without fracture, ASTM A924/A924M or ASTM A653/A653M . Galvanized coating shall be G90.

- B. Use G90 Galvaneal or Zinc grip where painting is specified.

2.2 FLEXIBLE DUCT

- A. Manufacturers: Thermaflex, Casco, or Flexmaster
- B. Factory fabricated, UL listed under UL 181 as Class 1 duct, meeting requirements of NFPA 90A with flame spread of 25 or less and smoke developed rating of 50 or under.
- C. Flexible duct shall have minimum ratings as follows:
1. Operating Temperature: -20 to 250°F
 2. Internal Working Pressure:
Positive: 6" WG
Negative: 1" WG
 3. Burst Pressure: 2-1/2 times working pressure
 4. Velocity: 5000 fpm
- D. Unless otherwise indicated, duct shall be nonmetallic insulated type composed of polyester film, polyethylene film, nylon film, CPE film, or coated woven fiberglass liner bonded permanently to corrosion resistant coated steel wire helix without adhesive.
- E. Insulation shall be flexible fiberglass insulation with minimum R-value of 6 at mean temperature of 75°F. Vapor barrier jacket shall be aluminum foil reinforced, polyethylene, or metalized polyester film with maximum perm rating of 2.87 ng/(s·m²·Pa)(0.05 perm) per ASTM.
- F. Insulation material shall not be exposed to air stream.
- G. Lined flexible duct shall have the following minimum acoustical performance in accordance with ARI Standard 885. Dynamic Insertion Loss in each octave band of 5 ft or 10 ft straight duct shall not be less than the following:

Duct Diameter (in)	Dynamic Insertion Loss (dB)					
	Octave Band Center Frequency (Hz)					
	(Based on 5 ft length)					
	125	250	500	1000	2000	4000
6"	6	9	18	22	24	15
8"	6	10	18	20	21	12
10"	5	11	18	18	18	9
Duct Diameter (in)	(Based on 10 ft 3 m(10 foot) length)					
	125	250	500	1000	2000	4000
6"	10	15	28	33	35	22
8"	10	18	29	32	32	20
10"	9	19	28	31	29	18

2.3 DUCT FLEXIBLE CONNECTORS

- A. Refer to Specification Section 233314 - Ductwork Specialties

2.4 MANUFACTURED ROUND DUCTWORK (POSITIVE PRESSURE)

A. Single Wall:

1. Manufacturers: Lindab, Semco or McGill AirFlow, or approved equal, equal to McGill AirFlow Uni-Seal duct and fittings suitable to positive 10" WG.
2. Ducts shall be machine formed round and/or flat oval as shown on drawings, constructed of G90 galvanized steel per ASTM A653, CS Type B. Use spiral lockseam construction. Longitudinal seam construction may be used for ductwork over 80" diameter with minimum 16 ga. Use fittings as indicated on drawings, as specified, and as required in accordance with manufacturer's published data.
3. Unless otherwise indicated, connection shall be slip type with minimum 2" insertion length or flanged joint in accordance with manufacturer's recommendations. When flange joints are required, use Van Stone flange with neoprene gasket. Face flange may be integral (machine formed on duct end) or welded to duct. Backing flange shall be free-floating for bolt-hole alignment. Seal shall be at face-to-face flanges.
4. Internal bracing is not allowed.
5. Pre-sealed snaplock pipe system "Greenseam +" as manufactured by Ductmate Industries may be used for low pressure supply air duct.

2.5 MANUFACTURED ROUND DUCTWORK (NEGATIVE PRESSURE)

- A. Ducts shall be machine formed round duct constructed of G90 galvanized steel. Use spiral lockseam construction unless otherwise indicated. Use fittings as indicated on drawings, as specified, and as required in accordance with manufacturer's published data.
- B. Connection shall use slip coupling, angle ring or Van Stone connectors in accordance with manufacturer's recommendations.
- C. Round spiral duct gauge/reinforcement shall be as follows:

Duct Diameter (")	-10" to -20" WG Gauge/Reinforcement
3 - 7	26 ga
7-1/2 - 8	26 ga
8-1/2 - 12	24 ga
12-1/2 - 15	22 ga
16 - 18	20 ga
19 - 22	18 ga
23 - 26	18 ga
27 - 34	18 ga w/AR 12 ft c/c
	or
	16 ga

35 to 42	18 ga w/FL + AR 6 ft c/c or 16 ga w/FL
44 - 50	18 ga w/FL + AR 4 ft c/c or 16 ga w/FL
52 - 60	18 ga w/FL + AR 4 ft c/c or 16 ga w/FL
62 - 70	16 ga w/FL + AR 6 ft c/c or 14 ga w/FL

1. single angle ring reinforcement at maximum indicated ft on center spacing.
2. fully welded flange angle rings at joint connections at maximum 12 ft spacing.

D. Fitting gauge shall be one even gauge heavier than the lightest allowable gauge of connecting downstream section of duct.

2.6 MANUFACTURED SELF-SEALING ROUND DUCTWORK SYSTEM

A. Single-wall:

1. Manufacturers: Lindab Spirosafe, Eastern Sheet Metal (ESM) Eastern Tight, or Tambe Metal Products Zip Seal
2. Ductwork system shall consist of fittings with factory-fitted sealing gasket and spiral duct which will seal duct joints without use of duct sealer.
3. Ducts shall be machine formed round as shown on drawings, constructed of G90 galvanized steel. Use spiral lockseam construction. Use fittings as indicated on drawings, as specified, and as required in accordance with manufacturer's published data.
4. Unless otherwise noted, duct and fittings shall be constructed per SMACNA's Duct Construction Standards (+10" WG shown in the following table:

Diameter (")	Galvanized Spiral Duct	Galvanized Fittings
3 - 14"	26 ga	24 ga
16 - 26"	24 ga	22 ga
28 - 36"	22 ga	20 ga
38 - 50"	20 ga	20 ga

5. All fitting ends shall have factory equipped with double-lipped, U-profile or tubular EPDM rubber gasket. Gasket shall be classified by Internationally Recognized Laboratory Authority to conform to ASTM E84-91a and NFPA 90A NFPA 90A flame spread and smoke developed ratings of 25/50.
6. Ductwork system performance shall meet SMACNA's Leakage Class 3 Requirements from -20" WG to +12" WG.

2.7 DUCT SEALANTS AND GASKETS

A. Sealant:

1. Flexible, water based, adhesive sealant compounded specifically for sealing joints and seams in ductwork. Hardcast, McGill AirSeal, Ductmate PROseal, Mon-Eco Industries, Childers, Foster, or Design Polymerics DP1010 or D1030.
2. Sealants shall be UL 723 (ASTM E84) classified, and meet NFPA 90A and 90B.
3. Sealants shall comply with requirements for LEED v4.
4. Select sealants as recommended by manufacturer for specific application.
5. Submit sealant manufacturer's data sheets including performance data, pressure ratings, surface burning characteristics data, VOC compliance with LEED v4, detailed installation instructions.
 - a. Sealants for exterior ductwork shall include explicit statement by manufacturer indicating suitability for application.
 - b. Sealants for exposed (uninsulated) exterior ductwork shall be UV resistant and include explicit statement by manufacturer indicating suitability for exposed exterior application.
6. Duct tapes are not allowed.

B. Gaskets:

1. Butyl, copolymer or neoprene based tape similar to Ductmate 440 Gasket Tape or Neoprene Gasket Tape for flanged joints.

2.8 CABLE SUSPENSION SYSTEM

- A. Suspension system shall be similar to Gripple Hang-Fast as manufactured and supplied by Gripple Incorporated or Ductmate Industries "Clutcher" cable hanging system.
- B. Suspension system shall be load rated and verified by SMACNA Testing and Research Institute to be in compliance with SMACNA HVAC Duct Construction Standards, 2005, Chapter 5.

2.9 ACOUSTIC DUCT ENCLOSURE

- A. Enclosure shall consist of inner layer 2" thick, minimum 48 kg/m³(3 psf) glass or mineral fiber similar to Type R insulation specified in Section 230700 - Mechanical Systems Insulation and outer layer of 2 layers of 5/8" sheet rock with staggered seams, attached to sheet metal studs. Sheet rock shall be attached to structure not ductwork.

2.10 ACOUSTIC DUCT COVERING

- A. Sound barrier material shall be similar to Kinetics Model KNM-100B or EAR Lag-10. Barrier material to have acoustic ratings of STC-27, 1.0 lb/ft² 4.89 kg/m²(1.0 lb/ft²) weight, and minimum continuous operating range from -10 to 180°F.
- B. Minimum sound transmission loss at each octave band shall be as follows:

Sound Transmission Loss (dB)					
Octave Band Center Frequency (Hz)					
<u>125</u>	<u>250</u>	<u>500</u>	<u>1000</u>	<u>2000</u>	<u>4000</u>
15	18	21	27	32	37

PART 3 - EXECUTION

3.1 GENERAL

- A. Unless otherwise indicated, install ductwork level, parallel , and/or perpendicular to building structure, walls, and ceilings and at such heights not to obstruct any portion of ceiling, window, doorway, stairway, or passageway. Install ductwork to allow adequate access and service space for equipment. Refer to drawings and/or manufacturer's recommendations. Install vertical ductwork plumb. Where interferences develop in field, offset or reroute ductwork as required to clear such interferences. In all cases, consult drawings for exact location of duct spaces, ceiling heights, door and window openings or other architectural details before installing ductwork.
- B. Make allowances for beams, pipes or other obstructions in building construction and for work of other contractors. Check plans showing work of other trades and consult with Engineer in event of interference. Transform, divide, or offset ducts as required, in such a manner as to maintain same cross sectional area of duct as indicated on drawings. Where it is necessary to install pipes or similar obstructions through ducts, consult with Engineer and obtain written approval from Engineer and Owner. If approved, provide streamlined encasement or collar designed in accordance with SMACNA Standards and seal to prevent air leakage.
- C. Ductwork shall be free of kinks and dents.
- D. Fabricate and install duct, fittings, joints, seams, reinforcement, supports, sealing, liner, etc., in sizes indicated on drawings and in accordance with manufacturer's published data and SMACNA Standards except as modified in this section of specifications or on drawings.
- E. Provide transitions where different size or different shape ductwork segments are connected. Use concentric transitions unless otherwise shown. Unless otherwise indicated, make diverging transitions with maximum angle of 15° per side (30° total diverging) and converging transitions with maximum angle of 25° per side (50° total converging).
- F. Provide transitions at ductwork system components and connections to equipment. Refer to Specification Section 233713 - Diffusers, Registers and Grilles, for additional information regarding diffuser/register/grille connections.
- G. Refer to ductwork symbols list on drawings for additional and dimensional requirements for fittings.

- H. Seal duct seams and joints to meet SMACNA Seal Class A as minimum for all ductwork including low-pressure ductwork.
- I. Construct ductwork so that interior surfaces are smooth. Internal duct hangers and internal bracing are not allowed. Refer to Part 1, Design Criteria for internal tie rods.
- J. Support coils, filters, air terminals, dampers, sound attenuator devices or other devices installed in duct systems with angles or channels and make all connections to such equipment including equipment furnished by others. Secure frames with gaskets, nuts, bolts and washers.
- K. Air terminal devices may be supported by strap hangers if air terminal manufacturer approves. Strap hangers are not allowed for fan powered devices, double wall type and Titus Steri-Loc type devices.
- L. Install outside air intake duct to pitch down at minimum 1" per 20 ft toward intake louver or plenum and to drain to outside of building. Solder or seal seams to form watertight joints.
- M. Install exhaust air duct to pitch down at minimum 1" per 20 ft toward exhaust louver.
- N. Blank off unused portion of outside air intake or exhaust louvers.
- O. Where 2 different metal ducts meet, install joint in such a manner that metal ducts do not contact each other by using proper gasket seal or compound.
- P. Install motor operated dampers and connect to or install equipment furnished by others. Provide necessary blank-off plates or transitions to mount control dampers as specified in Section 230901 - Control Systems Integration.
- Q. Do not install ductwork over electrical panelboards, switchgear, switchboards or motor control centers.
- R. When original galvanized finish is altered or damaged, apply field galvanizing paint as follows:
 - 1. Prepare surface with use of power sanders or wire brushes to remove rust, paint, etc.
 - 2. Apply cold galvanizing material equal to ZRC Products, Inc.

3.2 ELBOWS

- A. Rectangular Duct:
 - 1. Use radius elbows with centerline radius to width ratio of 1.5 (SMACNA Type RE 1).
 - 2. Where 1.5 centerline radius elbows do not fit due to limited space, use radius elbows with centerline radius to width ratio of 1.0 (SMACNA Type RE1 or RE-3).
 - 3. Where 1.0 centerline radius elbows do not fit, use radius elbows with centerline radius to width ratio of 0.75 (SMACNA Type RE-1 or RE-3) or 45° throat with radius heel elbows (SMACNA Type RE 8).
 - 4. Use single splitter vanes for 1.0 radius elbows, 0.75 radius elbows and 45° throat with radius heel elbows for elbows width 18" and over.
 - 5. Fabricate splitter vanes in accordance with SMACNA HVAC Duct Construction Standards, Chart 4-1, (page. 4.11) and Figure 4-9 (page. 4.13).

6. Square throat elbows with or without turning vanes are not allowed unless specifically indicated. Square throat elbows without turning vanes may be used for transfer air ducts.

B. Round and Oval Duct:

1. Unless specific type is indicated, use radius elbows with centerline radius to diameter ratio of 1.5 regardless of duct velocity. Where 1.5 radius elbows do not fit due to limited space, use 1.0 radius elbows.

3.3 LONGITUDINAL SEAM

A. Rectangular Duct:

1. Unless otherwise indicated, use Pittsburgh lock seam.
2. Seal longitudinal seams with approved sealant or pre-sealed with encapsulated mastic.
3. Button punch snap lock construction (SMACNA L-2) may be used for ductwork that is both 2" WG (+ or -) and lower, and 36" and smaller in width or height. For ductwork over 24" in width or height, add screw 4" from each end.
4. Button punch snap lock construction is not allowed for ductwork in chases and areas above inaccessible ceiling.
5. Button punch snap lock construction is not allowed on aluminum ductwork.

B. Round and Oval Duct:

1. Unless otherwise indicated, longitudinal seams shall be in accordance with SMACNA HVAC Duct Construction Standards with the following exceptions.
 - a. SMACNA Snaplock Seam Types 6A, 6B, 7 and 8 shown in Figure 3-2 are not allowed.

3.4 TRANSVERSE JOINT

A. Rectangular Duct:

1. Transverse joints shall be in accordance with SMACNA HVAC Duct Construction Standards.
2. Ductmate 25/35/45 connection systems with corner clips or optional nuts and bolts may be used. Incorporate use of all Ductmate accessories to ensure integrity of transverse connection. Install joints in strict accordance with the latest edition of Ductmate 25/35/45 Assembly and Installation Instruction Manual and Duct Construction Standards. Nexus or WDCI will be acceptable.
3. Lockformers TDC or Engles TDF may be used in accordance with T-25 flanges of SMACNA HVAC Duct Construction Standards Metal and Flexible, 2005, provided that corner pieces with bolts are used. If TDF/TDC flanges are damaged, replace the damaged joint(s) by straightening and reinforcing with minimum 1-1/2" x 1-1/2" x 1/4" angle at each side of transverse joint.

B. Round Duct:

1. Unless otherwise indicated, use beaded sleeve joints (SMACNA RT-1) with minimum 2" insertion length or flange joints (SMACNA RT-2 or RT-2A).
2. Connection systems manufactured by Ductmate Industries (Spiralmate and Ovalmate) or McGill AirFlow (Uni-flange) may be used for supply air ductwork.

3. AccuFlange connected systems may be used with gaskets specified in Part 2 of this Section.

3.5 DUCT SUPPORTS

- A. Unless otherwise indicated, use straps or Z bar hangers with 3/8" rods to support rectangular ducts 60" wide and smaller and trapeze hangers with rods or angles to support rectangular ducts over 60" wide.
 1. Use trapeze hangers to support externally insulated ductwork with weight bearing inserts. Refer to Section 230700 - Mechanical Systems Insulation and details.

- B. For round ducts 24" diameter or smaller, use single hanger.
 1. Cable Suspension System may be used up to 24" diameter at spaces higher than 8 ft above floor or platform.
 2. Round Duct Strap Bracket by Ductmate Industries may be used up to 24" diameter.

- C. For round ducts 25" diameter or larger, use 2 minimum 3/8" rods, with trapeze in accordance with the following schedule:

Duct Size	Trapeze (Half Round)
25" to 36"	1-1/2" x 1-1/2" x 1/8"
37" to 48"	or 2" x 2" x 1/8"
49" to 60"	2" x 2" x 1/4"
61" to 84"	2-1/2" x 2-1/2" x 1/4"

- D. Refer to Section 230700 - Mechanical Systems Insulation for ductwork insulation, weight bearing inserts and insulation protection shield requirements.
- E. Support ducts located on roof as detailed.
- F. Riser Supports:
 1. Unless otherwise noted, support risers at every floor in accordance with SMACNA Standard Chapter 5, 5.2.10, Figure 5-8 and Figure 5-10.
 2. If floor to floor exceeds 16 ft, support riser by its reinforcing as shown on FIG. B on Figure 5-8.
- G. The following upper attachments, upper attachment devices, lower hanger attachments, hanger devices, and/or hanger attachments are not allowed except where specifically indicated:
 1. Hook or loop
 2. Nailed pin fasteners
 3. Expansion nails without washers
 4. Powder actuated fasteners (forced entry anchors). Forced entry anchors may be used for upper attachments of flexible ductwork supports.
 5. Beam or "C" clamps without retaining clips or friction clamps (provide retaining clips for "C" clamps)
 6. Non-factory manufactured upper attachments for metal pan deck including rods, straps, or welded studs directly attached to metal deck (Items 16 through 21 shown in Fig 5-4 of SMACNA HVAC Duct Construction Standards)

7. Wire hanger shown in Fig. 5-5 of SMACNA HVAC Duct Construction Standards
 8. Trapeze hangers supported by wires or straps
 9. Drilled hole with attachment to structural steel
 10. Lag screw expansion anchor
 11. Rivets
 12. Non-metallic hangers or straps
- H. Supporting devices shall be standard products of manufacturers having published load ratings.
- I. Refer to Section 230529 - Mechanical Piping and Equipment Supporting Devices for additional support requirements including attachments to structural members, concrete inserts, and concrete anchors.
- J. For welded ducts, soldered ducts or ducts with watertight joints, do not use supports utilizing screws or other penetrations into ductwork.
- K. Unless Architectural Documents indicate the required framing, provide angle iron framing around roof opening where duct penetrates through roof decking, to maintain roof decking structural integrity in accordance with roof decking manufacturer's recommendations. This is not required for concrete decking. For concrete decking, consult with the project structural engineer for location and size of opening prior to execution of Work.

3.6 SHEET METAL WELDING

- A. Unless otherwise noted, sheet metal welding shall be performed in accordance with requirements of SMACNA Sheet Metal Welding Guide and AWS D9.1 Sheet Metal Welding Code.
- B. Unless otherwise indicated, welding shall be done using only the following processes:
1. Shielded Metal Arc Welding (SMAW), also known as "stick" welding
 2. Gas Tungsten Arc Welding (GTAW), also known as TIG welding.
 3. Gas Metal Arc Welding (GMAW), also known as MIG welding
- C. For welded stainless steel duct, use GTAW (TIG) process.
- D. Weld joints and adjacent base metal surface shall be cleaned. Use stainless steel wire brush for stainless steel welds.
- E. Unless otherwise noted, backing material and slip joints are not allowed.
- F. For horizontal ducts, locate longitudinal seam at top center position (12 o'clock) for round duct and top corner(s) or side(s) (3 o'clock and 9 o'clock) position for rectangular duct.
- G. Unless otherwise noted, use the following type of weld for longitudinal and traverse joints.
- H. Round Duct:
1. Longitudinal seam.
 - a. Use welded butt joint type seam.
 - b. Lap and seam welded (SMACNA RL-4) is acceptable.

2. Traverse joint.
 - a. Use welded butt joint.
- I. Rectangular Duct:
 1. Longitudinal seam.
 - a. Use welded butt joint.
 - b. Welded corner joint is acceptable.
 2. Traverse joint.
 - a. Use welded butt joint.
 - b. Edge flange weld (SMACNA T-21 or T-21a) is acceptable with continuous welding including at each corner for rectangular ducts.
- J. Attach welding cable leads directly to base metal to be welded. Do not jumper welding cable leads through building structure, to avoid emission of stray voltage/current through building structure.
- K. Welds on exposed ductwork in occupied spaces shall be brush polished with stainless steel brush.
- L. Welds at exterior of building shall be ground smooth and brush polished with stainless steel brush to prevent atmospheric contamination and rust formation.

3.7 PROTECTION OF DUCTWORK

- A. Protect ductwork during construction against entry of foreign matter and construction dirt.
- B. Keep ductwork capped when work is complete for the day or when duct is not being worked on or added to. Use of polyvinyl (VISQUEEN) with duct tape wrap is an adequate measure as long as it is secure with no openings or tears in product.
- C. If ductwork is not protected, remove dirt and foreign matter from the duct system and obtain inspection and approval from Engineer upon completion of cleaning before operating fans.
- D. Return fans are not allowed to operate during construction to avoid intake of construction dirt/dust into return air ductwork.

3.8 DUCT LEAKAGE TEST

- A. Refer to Test and Balancing portion of Section 230000 - General Mechanical Requirements .
- B. Owner and/or Owner's representative may elect to witness leakage tests. Notify Owner and/or Owner's representative at least 3 days in advance.
- C. Test supply, return, and exhaust ductwork as follows, unless otherwise indicated in this section or in schedules.
 1. Test 100% of total installed duct area for duct pressure positive or negative Class 3" wg and higher.
 2. Test 100% of total installed duct area for duct pressure positive or negative Class 2" wg.
 3. Test 100% of total installed duct area for ductwork located outdoors.

4. Test 100% of total installed duct area for ductwork located in inaccessible spaces including shafts.
 5. Engineer will select sections of ductwork to be tested.
 6. If test results are acceptable to Engineer, remainder of ductwork is permitted to proceed without further testing. If ductwork fails test, repair all ductwork including ductwork not tested. Then repeat leakage tests for new sections of ductwork as described above.
- D. Leakage test procedures shall be in accordance with test method described in Section 3 of SMACNA HVAC Air Duct Leakage Test Manual, except as modified in this Section. Test apparatus shall be in accordance with Section 5 of SMACNA HVAC Air Duct Leakage Test Manual.
- E. Test pressure shall be equal to duct pressure class. Negative pressure ductwork shall be tested with negative test pressure.
- F. Air leakage shall not exceed limits specified or scheduled. If leakage exceeds allowable limits, identify leaked areas, repair, seal and retest.
- G. Provide filter system on duct inlet to test blower. Filter system shall be equal to final filtering efficiency of AHU supply air duct system. Filters are not required for negative pressure testing.
- H. Do not insulate ductwork until it has been successfully tested.
- I. Maximum permitted leakage of ductwork systems are indicated on schedules on drawings.
- J. Maximum permitted leakage rate in cfm per 100 ft² of tested duct surface area shall be calculated by:

$$L = C_L \times P^{0.65}$$

Where:

L (maximum permitted leakage rate) = measured leakage of test section (cfm) / area of test section (ft²) / 100

F (leakage factor) = maximum permitted leakage rate (cfm/100 ft²) = $C_L \times P^{0.65}$

P = test pressure (inches w.g.); typically duct pressure class.

C_L (leakage class constant) = varies with test pressure according to the relationship $C_L = F/P^{0.65}$

$C_L = 2$ for round/oval ducts.

$C_L = 4$ for rectangular ducts and flexible ducts.

- K. Welded ductwork shall be air and watertight and shall have no air leakage with allowance stated below.
1. When using test apparatus and procedure described in SMACNA HVAC Air Duct Leakage Test Manual, 1st Edition, Chapter 5 (modified for negative pressure), the following losses can be expected during testing and are acceptable:
 - a. 1 cfm per 1" WG of static pressure is allowed for the test equipment and test connections (e.g. 3 cfm when testing at 3" WG).
 - b. 0.10 cfm per inch of diameter of temporary caps, regardless of pressure (e.g. 1 cfm for a cap on 10" diameter duct).

2. To the extent possible, walk and observe welded ductwork under test to check for cracked or hissing welds. All leaks in welded sections of ductwork shall be reported to the Client's Representative and repaired by welding. No caulking or sealing is allowed.

3.9 WATER LEAK TESTING OF KITCHEN GREASE EXHAUST DUCT SYSTEMS (SERVING TYPE 1 HOODS)

- A. Refer to Test and Balancing portion of Section 230000 - General Mechanical Requirements
- B. Owner and/or Owner's representative may elect to witness leakage tests. Notify Owner and/or Owner's representative at least 3 days in advance.
- C. Tests shall be performed by testing agency with verifiable experience in testing grease ducts utilizing water spray methods.
- D. Perform leak testing utilizing water spray method employing high pressure multi-nozzle "spinjet" in conjunction with 15 degree or wider single nozzle lance to be passed through grease exhaust duct with water spray contacting all interior portions of duct.
- E. Water used in tests shall be collected for discharge to sanitary drain.
- F. Water testing shall be scheduled after grease exhaust system installation is complete.
- G. Grease duct shall not be insulated until testing is successfully completed.
- H. Testing Contractor shall confirm status of system installation and availability of necessary utilities, access, and other provisions are in place prior to executing tests.
- I. Coordinate all work with other contractors.
- J. Leaks shall be repaired and tests shall be repeated until system passes tests.
- K. Upon completion of testing Testing Company shall dry the duct and return system to condition prior to tests.
- L. Test Report:
 1. Provide written test report in pdf format upon completion of testing.
 2. Test report shall include photographic document of system and procedures,
 3. Report shall document all tests performed, each leak discovered, leak remediation performed, and documentation of successful tests covering entirety of systems.
 4. Test report shall be signed by responsible party from testing agency.
- M. If any sealants are observed in duct system, testing shall immediately cease until all sealants are removed and seams and joints are repaired to full compliance with specification.

3.10 LOW PRESSURE DUCT CONSTRUCTION (PRESSURE CLASS 2" WG AND UNDER)

- A. Use welds, rivets or nuts, and bolts for fabricating ductwork. Fully threaded sheet metal screws may be used on duct hangers, transverse joints and other SMACNA approved locations if screw does not extend more than 1/2" into duct. Sheet metal "TEK" screws 3/4" in length may be used as fasteners in conjunction with factory made transverse joints.

- B. Unless otherwise indicated, construct branch take-off fittings as follows:
 - 1. For branch take-offs including branch ducts serving more than one diffuser or grille, use 45° entry fittings. For supply air ducts, conical taps may be used.
 - 2. For take-offs serving single diffuser, register or grille, use straight spin-in collars with manual balancing dampers.
- C. Splitter dampers and/or extractors are not allowed.

3.11 HIGH PRESSURE DUCT CONSTRUCTION (GREATER THAN PRESSURE CLASS 2" WG)

- A. Use manufactured ductwork or contractor fabricated ductwork meeting specified Construction Standards and fitting performance.
- B. Submit construction details including materials, type of service, reinforcing methods, and sealing procedures.
- C. Use elbows, tees, laterals, crosses and accessory fittings as shown on drawings and as required to fabricate duct system.
- D. Use conical tees for round ductwork and 45 degree entry fittings for branch take-offs from mains unless otherwise indicated.
- E. Provide manufactured bellmouth fittings at each fan supply air plenum to provide smooth entrance of air into duct system.
- F. Provide positive pressure relief doors as indicated on drawings.
- G. Provide negative pressure relief doors as indicated on drawings.
- H. Ductwork pressure class is indicated on drawings.

3.12 FLEXIBLE DUCT

- A. Install flexible ducts in accordance with manufacturer's installation instructions and SMACNA Standards, except as modified in this Section of Specifications.
- B. In supply air systems without air terminal devices, flexible ducts may be used for final connections to diffusers, grilles, and registers. Flexible ducts shall be of minimum length required to make connections, but shall not be greater than 6 ft in length, unless otherwise noted.
- C. In supply air systems with air terminal devices, flexible ducts shall be used for duct connections to diffusers, grilles, and registers for sound attenuation purposes, except above non-accessible ceilings. Flexible ducts shall be 6 ft long.
- D. In return and general exhaust air systems without air terminal devices, flexible ducts may be used for final connections to return grilles and registers and general exhaust grille and registers. Flexible ducts shall be of minimum length required to make connections, but no greater than 6 ft in length, unless otherwise noted.

- E. In return and general exhaust air systems with air terminal devices, flexible ducts shall be used for duct connections to grilles and registers for sound attenuation purposed, except above non-accessible ceilings. Flexible ducts shall be minimum 6 ft long and maximum 8 ft long.
- F. Centerline radius of bends shall not be less than one duct diameters. FlexFlow Elbow supports by Thermaflex or similar products shall be used at diffuser/grille connection to assure full radius elbow.
- G. Support flexible ductwork as recommended by manufacturer and with minimum 0.5" wide saddles with maximum sag of 0.5" per ft between supports. Spacing of supports shall be a maximum of 5 ft on center, with no portion lying on ceiling supporting system.
- H. Individual sections of flexible ductwork shall be of one-piece construction. Splicing of short sections is not allowed.
- I. Connect flexible duct liner to collars and rigid duct in accordance with manufacturer's installation instructions. If manufacturer's installation instructions do not include stainless steel draw-bands, provide stainless steel draw-bands in addition to manufacturer's installation instructions. One draw-band shall secure flexible duct to rigid duct and another shall secure flexible duct outer jacket to rigid duct. If collars have beads, position draw bands behind beads.
- J. Pull insulation and vapor barrier jacket over liner connection and secure with draw band. For terminations at externally insulated ductwork, fittings, grilles, diffusers, etc., secure flexible duct jacket to ductwork insulation jacket with compatible vapor barrier tape.
- K. Flexible ducts are not allowed in the following locations or applications:
 - 1. Above non-accessible ceilings
 - 2. In high pressure ductwork
 - 3. In exposed duct applications
 - 4. Through any partition, wall, floor or ceiling.

3.13 ACOUSTIC DUCT COVERING

- A. Wrap outside of duct with inner layer material. Apply outer layer material over inner layer material. Do not rigidly tie outer layer material to ductwork.
- B. If manufactured barrier materials are used, install in accordance with manufacturer's installation instruction.
- C. Apply covering to the following ductwork:
 - 1. Ductwork as indicated to be covered
 - 2. Supply and return ductwork for 20 ft from roof top air handling units

3.14 BATH OR SHOWER EXHAUST DUCT CONSTRUCTION

- A. Use aluminum sheet where indicated on drawings or as specified below, with joints and seams sealed with duct sealant or welded for watertightness.

INDOOR PRACTICE FACILITY
EAST CAROLINA UNIVERSITY, GREENVILLE, NC
SCO ID# 23-26345-01A
AIM # 1752

- B. Use aluminum duct for exhaust from bath or shower rooms if they contain more than one bath tub or more than one shower head. Aluminum duct shall extend from individual exhaust grilles to exhaust fan. Fabricate exhaust fan discharge ductwork of aluminum or galvanized steel.
- C. Seal or weld aluminum exhaust duct for watertightness.

END OF SECTION 233114

SECTION 233314 - DUCTWORK SPECIALTIES

PART 1 - GENERAL

1.1 SUBMITTALS

- A. Shop Drawings including the following:
 - 1. Manufacturer's name and model number
 - 2. Capacities
 - 3. Temperature/pressure ratings
 - 4. Materials of construction
 - 5. Dimensions
 - 6. Manufacturer's installation instructions and/or detailed drawings
 - 7. All other appropriate data

1.2 DESIGN CRITERIA

- A. Products and materials shall conform to NFPA 90A, possessing flame spread rating of not over 25 and smoke developed rating no higher than 50.
- B. Ductwork specialties exposed to air stream, such as dampers, turning vanes, and access doors, shall be of same material as duct or unit within which specialties are mounted. When complying with this material requirement performance requirements (pressure, temperature, velocity limits, etc.) shall be as specified for same product constructed of the standard specified materials found in Part 2 of this Section
- C. Unless otherwise noted, ductwork specialties shall be designed and constructed for pressure class of ductwork in which they are installed.

PART 2 - PRODUCTS

2.1 MANUAL BALANCING DAMPERS

- A. Manufacturers: Ruskin, Greenheck, Vent Products, Pottorff or Air Balance, constructed in accordance with SMACNA (HVAC DUCT CONST) Standards, except as modified below.
- B. Rectangular Dampers:
 - 1. For low pressure ductwork, for damper blade height up to 12", use single blade type with minimum 22 ga blade with minimum 3/8" rod for blade width up to 18", and with minimum 18 ga blade with minimum 1/2" continuous rod for blade width from 19-48 inch. For damper blade height more than 12", use multiple blade type with minimum 16 ga channel frames, opposed blade linkage operation, with blades minimum 16 ga and 6" to" maximum blade width, minimum 1/2" continuous rod and 1/2" x 1/2" angle blade stops. Bearings shall be nylon or molded synthetic. Construct dampers over 48" in width or height in multiple sections with mullions.

2. For high pressure ductwork, dampers shall be constructed to withstand maximum pressure of 5" WG (1250 Pa) at closed position and maximum velocity of 2000 fpm at open position. Frame and blades shall be constructed of minimum 16 ga with minimum 1/2" diameter or square rod.

C. Single Blade Round Dampers:

1. For low pressure ductwork, damper shall have blade 24 ga, but no less than two gauges more than duct gauge. Rod shall be minimum 3/8" diameter or square continuous. Bearings shall be nylon or molded synthetic.
2. For high pressure ductwork, damper blade shall be minimum 16 ga. Rod shall be minimum 1/2" square continuous and tack welded to blade. Provide sealed end bearing similar to Ventlok #609 and acorn nut type dial regulator similar to Ventlok #635 or 641.

- D. Provide damper operators with locking devices and damper position indicators. Sheet metal screws are not allowed in construction or installation of dampers. Use rivets or tack welds.

- E. Dampers shall be properly stiffened and fabricated to prevent vibration, flutter or other noise.

- F. Extend damper shafts through duct insulation or use elevated regulators for externally insulated ducts to accommodate specified insulation thickness.

2.2 SPLITTER VANES AND TURNING VANES

A. Radius Elbow Splitter Vanes (SMACNA Type RE-3):

1. Splitter vanes for radius elbows shall be constructed in accordance with SMACNA (HVAC DUCT CONST) Standards Chart 4-1, (p. 4.11) and Figure 4-9 (p. 4.13).

B. Turning Vanes (SMACNA Type RE-2):

1. Turning vanes are not allowed unless specifically indicated.

2.3 BACKDRAFT DAMPERS

- A. Manufacturers: Air Balance, Inc., American Warming and Ventilating, Pottorff, Louvers and Dampers, Inc., Advanced Air, Vent Products, Greenheck or Ruskin

- B. Dampers shall be multi-blade, weighted type with counter-balanced blades, equal to Ruskin Type CBD-4. Blade edges to have vinyl gasket or polyurethane foam seals with ball bearings. Dampers to be suitable for flange and gasket connection to ductwork.

2.4 BACKDRAFT DAMPERS

- A. Manufacturers: Ruskin or Greenheck

- B. Dampers shall be multi-blade, weighted type with counter-balanced blades and with 12 ga frame and extruded airfoil-shaped blades equal to Ruskin Type CBS 92. Blade edges shall have silicon rubber seals with ball bearings. Dampers shall be suitable for flange and gasket connection to ductwork or fan outlet.

- C. Dampers shall be rated to maximum velocity of 4000 fpm, maximum temperature of 250°F and maximum system pressure of 5" WG (1250 Pa) for damper width of 60" and 14" WG for damper width of 12".
- D. Maximum damper leakage shall be 13.5 cfm/sf based on pressure differential of 1" WG.

2.5 ACCESS DOORS

- A. Access doors shall be rectangular, minimum 22 ga frame and minimum 24 ga (0.709 mm) door, fit airtight with neoprene gasket and shall be suitable for duct pressure class. When access doors are installed in insulated ductwork or equipment provide insulated doors with insulation equivalent to what is provided for adjacent ductwork or equipment. Access doors constructed with sheet metal screw fasteners are not acceptable.
- B. Low Pressure Ducts (Pressure Class 2" and Under):
 - 1. Doors shall be hinged type with sash lock for exposed application and non-hinged type with cam latches for concealed application.
 - 2. Access doors constructed in accordance with SMACNA HVAC Duct Construction Standard (Figure 7-2) or similar to Ruskin Model ADC or ADH will be acceptable.
 - 3. Sandwich style access doors made by Ductmate, Ward Industries, Greenheck, or Flexmaster are acceptable, provided that they meet insulation requirements.
- C. High Pressure Ducts (Pressure Class 3" and Over):
 - 1. Use access doors factory fabricated and rated by manufacturer's published literature for installation in systems with pressures to positive or negative 10" WG.
 - 2. Sandwich access doors made by Ductmate, Ward Industries, Pottorf, Greenheck, or Flexmaster are acceptable, provided that they meet insulation requirements.

2.6 FLASHINGS

- A. Construct counterflashings of 16 ga galvanized Armco Zinc-Grip. Flashings are by General Contractor unless otherwise indicated.

2.7 DUCT FLEXIBLE CONNECTIONS

- A. Manufacturers: Unless specifically indicated, Ventfabrics, Inc., Ductmate or Duro Dyne. Material shall be glass fabric, fire retardant, waterproof, airtight and comply with NFPA 90A and 701 (formally UL 214).
- B. General Supply, Return and Exhaust Ductwork:
 - 1. Material for indoor use to be 30 oz per sq yd, double coated with neoprene, tensile strength (warp/fill) of 475/375 lbs, tear strength of 13x13 lbs, suitable for -40-200°F continuous operation.
 - 2. Material for outdoor use shall be combination of inner layer of Duro Dyne Neoprene or similar and outer layer of 24 oz per sq yd, coated with Hypalon, UV resistant, suitable for --40-200°F, similar to Duro Dyne Durolon.

2.8 SOUND ATTENUATING DEVICES

- A. Manufacturers: Semco, United McGill, Aeroacoustic, Vibro-Acoustics, VAW Systems, Price, or Ruskin subject to certification of teste standards indicated below.
- B. Units shall be tested in accordance with ASTM E477-20 silencer test standard in aero-acoustic test facility which is NVLAP accredited for ASTM E477-20 Standard. Submit copy of laboratory's NVLAP accreditation certificate on dynamic insertion loss, self-noise power levels, and aerodynamic performance. If tests are not conducted in accordance with SASTM E477-20, manufacturer must provide documentation of equivalency of test standard used with respect to dynamic insertion loss, self-noise power levels, and aerodynamic performance.
- C. Outer casing of units shall be not less than 22 ga steel in accordance with recommendations in the latest edition of ASHRAE Guide and Data Book for high pressure rectangular ductwork for 8 WG or pressure class indicated for duct system, if it is higher than 8 WG. Seams shall be lock formed or continuously welded and mastic filled.
- D. Acoustic Materials:
 - 1. Media shall be long fiber fiberglass protected with covering material and lined with not less than 26 ga perforated liner. Filler and facing material shall meet requirements of NFPA 90A with flame spread rating of 25 or less, and smoke development rating of 50 or less.
 - 2. Media shall be non-fiberglass containing 100% natural cotton fibers treated with EPA registered, non-toxic borate solution, "flash dried" to actively inhibit growth of mold, mildew, bacteria and fungi. Media shall not contain any formaldehydes, phenolic resins or Volatile Organic Compounds (VOC's) that can off-gas, and/or cause health concerns. Media shall be 100% recyclable. Media shall comply with UL 181 and NFPA 90A. Media shall not cause or accelerate corrosion of aluminum or steel.
- E. Covering Materials:
 - 1. Covering material shall be glass fiber cloth, high tensile strength, long strand glass fiber woven to thread count of 44 x 32 and have minimum weight of 6 oz per sq yd, minimum breaking strength 250x200 lbs/in, similar to Burlington Style 1675, BGF Industries Style 1528, or JP Stevens Style 7628.
 - 2. Covering material shall be Mylar film.
 - 3. Provide spacers between covering material and perforated metal.
- F. Ends of attenuators shall be covered at factory with plastic, heavy-duty paper, cardboard, or other appropriate material to prevent entrance of dirt, water, or any other foreign matter to inside of attenuators. Caps shall not be removed until attenuator is installed in duct system.
- G. Unless otherwise indicated, sound attenuating devices shall meet acoustical performance requirements as scheduled in each octave band frequency under the flow conditions.

2.9 INTAKE AND RELIEF HOODS

- A. Manufacturers: Carnes, Greenheck, Ammerman, Acme, Cook, Louvers and Dampers, Vent Products, Jenn-Air, or Penn
- B. Hoods shall be low silhouette type.

- C. Hoods shall be louvered penthouse type with stormproof louvers.
- D. Hoods shall be aluminum, all welded construction with mitered corner.
- E. Hoods shall be removable, cross broken, undercoated with insulating mastic and fabricated of aluminum alloy 3003-H14. Louver blades and extruded members shall be aluminum alloy 6063-T5.
- F. Finish shall be baked enamel; color selected by Architect. Submit color selection charts with shop drawings.
- G. Intake hoods shall be furnished with 1/2", 19 ga, galvanized steel bird screen and motor operated damper except those furnished by Control Contractor.
- H. Relief hoods shall be furnished with 1/2", 19 ga galvanized steel bird screen and motor operated damper except those furnished by Control Contractor.
- I. Hoods shall be furnished with factory fabricated curbs and extended bases, as required for mounting with inlet/outlet minimum of 24" above roof.
- J. Curbs shall be galvanized steel or extruded aluminum with continuous welded corner seams, treated wood nailer, minimum 1-1/2" thick 3 lb/ft³ density rigid mineral fiberboard insulation with metal liner.

2.10 LOUVERS

- A. Louvers will be provided by General Contractor.
- B. Blank-off panels on unused portion of louver shall be 2" thick insulated panels fabricated of minimum 22 ga galvanized steel on both surfaces. Insulation to be rigid type with minimum R value of $m^2 \cdot ^\circ C / W$ $(10[(h \cdot ft^2 \cdot ^\circ F) / (1.76[(Btu)])]$). Panels shall be reinforced with minimum 20 ga steel stiffeners.

2.11 BIRD AND INSECT SCREENS

- A. Bird screens shall be 1/2" square mesh formed with 0.063" diameter aluminum wire. Insect screen to be 18 x 16 with 0.017" diameter aluminum mesh.
- B. Frame shall be removable type of minimum 12 ga, extruded aluminum.

2.12 AIR FLOW MEASURING UNITS

- A. Furnished by Control Contractor.

2.13 INSTRUMENT TEST HOLES

- A. Manufacturers: Ventlok 699 (up to 1" insulation thickness) or Ventlok 699-2 (over 1" insulation thickness).
- B. Use concave gaskets for round ductwork.

2.14 CONTROL DAMPERS

- A. Furnished by Control Contractor.

PART 3 - EXECUTION

3.1 MANUAL BALANCING DAMPERS

- A. Install manual balancing dampers in supply, return and exhaust branch ducts, as shown on drawings and as required to regulate airflow to meet air balance requirements.
- B. Install manual balancing damper in branch duct to each diffuser and grille. Install dampers as close as possible to take-offs.
- C. Install balancing dampers so as not to flutter or vibrate and as far as possible upstream from the air outlet.
- D. Do not install balancing dampers in supply ductwork upstream of air terminal devices.
- E. Balancing damper is not required where terminal air device serves a single diffuser or grille.

3.2 SPLITTER VANES AND TURNING VANES

- A. Install splitter vanes (SMACNA Type RE-3) as shown on drawings and as specified in Section 233114 - Ductwork, for rectangular radius elbows. Install splitter vanes in accordance with SMACNA Standards and/or manufacturer's recommendations.
- B. Turning vanes (SMACNA Type RE-2) are not allowed unless specifically indicated.

3.3 BACKDRAFT DAMPERS

- A. Install backdraft dampers where indicated on drawings.
- B. Where motorized dampers are shown in exhaust fan discharge duct, or in duct connecting to relief or exhaust louver, backdraft dampers are not required unless specifically indicated. Where motorized dampers are not shown, provide backdraft dampers in these locations.

3.4 ACCESS DOORS

- A. Install access doors where specified, indicated on drawings, and in locations where maintenance, service, cleaning or inspection is required, including automatic dampers, fire dampers, smoke dampers, smoke detectors, fan bearings, heating and cooling coils, reheat coils, humidifiers, filters, bird/insect screens, valves and control devices within duct or casing, at outside air intake duct and at inlet side of turning vanes in return ductwork.
- B. Locate access doors for greatest ease of access.
- C. Size and quantity of duct access doors shall be sufficient to perform intended service, but not less than the following:

Rectangular Duct Size	Minimum Access Door Quantity and Size
-----------------------	---------------------------------------

10" and smaller	(1) 8"x 8"
12" to 15" and smaller	(1) 10" x 10"
16" to 21"	(1) 14" x 14"
22" x 27"	(1) 18" x 18"
28" to 51"	(1) 24" x 24"
52" to 96"	(2) 24" x 24"
Round Duct Size	Minimum Access Door Size
10" and smaller	8" x 4"
15" and smaller	12" x 8"
29" and smaller	16" x 12"
30" and over	24" x 18"

- D. Increase duct size to accommodate access door size indicated above where required.
- E. Access doors for life safety dampers shall be adequate size for inspection and maintenance, but not less than 12" x 12". If adjacent duct or damper is smaller than 12" x 12", provide larger size duct or damper to accommodate minimum access door size without transition.

3.5 FLASHINGS

- A. Install counterflashings where shown on drawings. Install in accordance with SMACNA recommendations.

3.6 DUCT FLEXIBLE CONNECTIONS

- A. Connect ductwork to fans or casings containing rotating equipment or mounted on vibration isolators with duct flexible connections. Installed width shall be suitable for specific application but shall not be less than 4". Install flexible connections in accordance with SMACNA Standards with double lock or "Grip Loc" connection.
- B. Duct flexible connections are not allowed for fan connection serving kitchen hood, or perchloric acid hood.

3.7 SOUND ATTENUATING DEVICES

- A. Install sound attenuating devices as indicated on drawings and/or as scheduled.
- B. For modular installation of sound attenuators, install holding frame of material matching associated duct, gaskets, seals, supports and fasteners in accordance with manufacturer's recommendations for multiple unit installation.

3.8 INTAKE AND RELIEF HOODS

- A. Install hoods as shown on the drawings and/or as scheduled.
- B. General Contractor will install curbs furnished with hoods unless otherwise indicated.

3.9 LOUVERS

- A. Provide insulated metal panel on unused portion of louver.
- B. Louvers will be provided by General Contractor.
- C. Install louvers as shown on the drawings and/or as scheduled.

3.10 BIRD AND INSECT SCREENS

- A. Provide bird screens or insect screens as indicated on drawings at louvers and at intake/exhaust openings.
- B. Unless otherwise indicated, provide bird screens where filters are specified and insect screens where filters are not specified.

3.11 AIR FLOW MEASURING UNITS

- A. Install where indicated on the drawings and/or as scheduled and in accordance with manufacturer's recommendations.

3.12 PRESSURE RELIEF DOORS

- A. Install doors vertically where shown on drawings and in accordance with manufacturer's recommendations.

3.13 CONTROL DAMPERS

- A. Install dampers in locations indicated on drawings, as detailed and according to manufacturer's instructions.
- B. Install blank-off plates or transitions as specified in Control Sections.
- C. Provide adequate operating clearance and access to operators.
- D. For dampers located outdoor, provide weather protection enclosure for parts of damper such as linkage and actuator located outside of duct. Enclosure shall be removable and made of material matching associated duct or housing.

3.14 INSTRUMENT TEST HOLES

- A. Provide instrument test holes at air entering and air leaving side of all internal air handling system components for static pressure differential (Delta P) or temperature differential (Delta T) measurements.
- B. Provide ductwork instrument test holes as shown on drawings, or as directed by TAB personnel, or Engineer.

END OF SECTION 233314

SECTION 233400 - FANS

PART 1 - GENERAL

1.1 SUBMITTALS

- A. Shop Drawings including the following:
 - 1. Manufacturer's name and model number
 - 2. Identification as referenced in the documents
 - 3. Capacities/ratings
 - 4. Fan curves
 - 5. Materials of construction
 - 6. Sound power levels
 - 7. Fan type, size, class, drive arrangement, discharge/rotation, bearings, drives
 - 8. Wheel type, diameter, rpm, tip speed
 - 9. Required fan hp including drive losses
 - 10. Motor data (refer to Section 230513 - Motors for Mechanical Equipment)
 - 11. Vibration isolators furnished with fans
 - 12. Dimensions and weights
 - 13. Special coatings where applicable
 - a. Product descriptive data
 - b. Complete chemical resistance charts
 - c. Coating manufacturer's base metal preparation requirements (cleaning/pretreatment)
 - d. Facility where special coatings will be applied
 - e. Recommended method of repairing damaged coating
 - 14. Color selection charts where applicable
 - 15. Manufacturer's installation instructions
 - 16. All other appropriate data
- B. Fan curves shall include series of curves indicating relationship of flow rate (cfm) to static or total pressure for various fan speeds, brake hp (kW) curves, and selection range (surge curves, maximum rpm, etc.).
- C. Indicate performance data, based on both design air quantity and 110% of design air quantity.
- D. For variable air volume application, indicate operating points at 100, 80, 60 and 40% of design capacity on fan curves including data to indicate effect of variable frequency drives on flow, pressure and hp.
- E. Complete equipment data sheet attached at end of this Section for each piece of equipment and submit with shop drawings. Shop Drawings will be returned without review if data sheets are not provided for each piece of equipment and if data sheet is not filled out completely.

1.2 DESIGN CRITERIA

- A. Fan ratings shall be tested and certified in accordance with AMCA Standards 211 and 311 and fans shall bear AMCA Seal.
- B. Fans shall be furnished complete with motors, wheels, drive assemblies, bearings and accessories as hereinafter specified. Motors for V-belt drives shall be furnished with adjustable rails or bases.
- C. Where backward Inclined or backward curved (BI) centrifugal fans are indicated, fans shall have solid (single-thickness) blades.
- D. Each fan wheel shall be statically and dynamically balanced to Balance Quality Grade G6.3 per ANSI S2.19 and AMCA 204-05. Complete fan assembly shall be factory balanced statically and dynamically in accordance with Standard AMCA 204-05 for Balance Quality and Vibration Levels for Fans and meet or exceed guidelines in Application Category BV-3.
- E. For fans furnished with 5 hp or larger hp (kW) motors, each fan assembly shall have factory run test including vibration signatures taken on each bearing in horizontal, vertical and axial direction. Filter-in reading as measured at fan's scheduled rpm shall not exceed the following values when fan is rigidly mounted.
 - 1. 0.15 in/sec peak velocity
 - 2. 0.08 in/sec peak velocity
 - 3. 0.08 in/sec peak velocity
 - 4. Written records of run test and vibration test shall be available upon request.
- F. Unless otherwise indicated, vibration level of installed fan assembly flexibly mounted shall not exceed 0.35 in/sec.
- G. Unless otherwise indicated, belt drives shall be V-belt drives selected for 150% of motor nameplate hp.
- H. Furnish fans specified with V-belt drives with either variable-pitch or fixed-pitch sheaves for drives 3 hp and smaller and fixed-pitch sheaves for drives 5 hp and larger. Select variable pitch sheaves to drive fan at such speed as to produce specified capacity at approximate midpoint of sheave adjustment.
- I. When fixed-pitch sheaves are furnished, system air balancing shall be accomplished by either trial of different fixed-pitch sheaves or use of temporary adjustable-pitch sheaves. This Contractor shall provide necessary trial and final sheaves and drive belts as required by TAB Contractor.
- J. Select each fan to operate at single stable operating point as predicted by fan curve. Fans having 2 potential operating points on fan curves are not acceptable.
- K. Provide OSHA Compliant belt and shaft guards for belt driven fans. Provide speed test openings at shaft locations. Paint guards bright yellow.
- L. Sound power levels shall be based on tests performed in accordance with AMCA Standards 300 and 301.

- M. Each fan and motor combination shall be capable of delivering 110% of air quantity scheduled at scheduled static pressure. Motor furnished with fan shall not operate into motor service factor in any of these cases.
- N. Consider drive efficiency in motor selection according to manufacturer's published recommendation, or according to AMCA Publication 203, Appendix L.
- O. Where inlet and outlet ductwork at any fan is changed from that shown on drawings, submit scaled layout of change and system effect factor calculations indicating increased static pressure requirements as described in AMCA 201. This Contractor shall be responsible for costs associated with any motor, drive, and/or wiring changes required as a result of duct configuration changes at fan.
- P. Exhaust fans serving fume hoods shall be marked with arrows to indicate proper direction of rotation.
- Q. Unless otherwise scheduled, AMCA Type C spark resistant construction shall be used for fans handling flammable or grease laden vapors. Fans having spark resistant construction shall be electrically grounded so as to prevent static electricity from building up.

PART 2 - PRODUCTS

2.1 PLENUM FANS

- A. Manufacturers: Twin City, Greenheck, Cook, Chicago Blower, or PennBarry
- B. General: Fans shall be airfoil centrifugal type designed for industrial duty and suitable for continuous operation. Fans shall be single width, single inlet, plenum fans with capacities and operating characteristics as indicated on schedules.
- C. Hubs: Hubs shall be cast or welded fabricated hubs with straight bores and keyways. Hubs shall be screwed to the shaft with a minimum of 2 set screws for positive attachment. Hubs using taper lock bushings are not acceptable.
- D. Wheels: 12-blade, airfoil type, double skinned and welded to center and wheel sideplates. Fan blades shall be designed to provide smooth airflow over all surfaces of blade.
- E. Shaft: Fan shafts shall be solid AISI 1040 or 1045 steel. Straight shafts shall be turned, ground and polished to a minimum 16 micro-inch finish. Shaft shall be sized for first critical speed of 200% over the maximum fan operating speed.
- F. Bearings: Air handling quality, heavy-duty, grease lubricated, pillow block, self-aligning ball or roller type. Bearings shall be selected for minimum life (ABMA L10) of not less than 80,000 h (equivalent to L-50 average life of 400,000 h) at maximum cataloged operating speed.

- G. Screen Enclosure: Entire plug fan and drive assembly shall be encased with protective screen enclosure. Enclosure shall be constructed of aluminum or galvanized steel mesh or expanded metal and sized to have no measurable system effect on fan performance. Screen shall be reinforced as required to maintain stable structure during fan operation. Access shall be provided for periodic service. Door shall be of suitable size to allow service personnel into enclosure. Enclosure shall be designed and constructed to allow for complete disassembly.
- H. Inlet Screens: Heavy gauge, corrosion resistant, zinc plated steel wire for fans without inlet ductwork.
- I. Inlet Cones: Inlet cones shall be precision spun. Inlet cones shall be aerodynamically matched to wheel side plate to ensure full loading of blades. Inlet cones shall be heavy gauge steel.
- J. Painting: All metal parts to be painted with prime coat after metal cleaning and surface preparation. In addition, apply second coat of paint to all exterior surfaces.
- K. Air Flow Meters:
 - 1. Provide factory mounted piezometer ring at inlet cone of each fan. Piezometer ring shall be completely outside of airstream and shall impose no airflow restriction.
 - 2. Terminate pressure tubing at exterior of fan housing.
 - 3. Display and Transmitter:
 - a. Provide electronics package, for remote mounting, for each fan flow meter consisting of digital display of volumetric flow and BACNet interface or analog outputs (4-20 mA, 0-10 VDC, etc.) for use by Controls Contractor. Refer to Instrumentation and Control Diagrams or System Flow Diagrams for requirements. Volumetric flow shall be calculated with empirically derived formulas based on testing by fan manufacturer. Provide necessary information to Controls Contractor for interpreting output signals or scaling output signal(s) to volumetric air flow.
 - b. Unit shall operate with 24 VAC power.

2.2 POWER ROOF EXHAUSTERS

- A. Manufacturers: Twin City, Greenheck, PennBarry, Jenn-Air, Cook, ACME, or Carnes
- B. Construct housings of spun aluminum.
- C. Construct housings of galvanized steel with baked enamel finish; color to be selected by Architect.
- D. Exhauster wheels shall be centrifugal, solid (single-thickness) backward inclined (BI), non-overloading type with full inlet cones to reduce air turbulence.
- E. Provide units with single phase motors with factory mounted and wired NEMA standard disconnect switches.
- F. Units shall be listed and bear UL 705 Label.
- G. Mount units on factory installed vibration isolators.
- H. Furnish units with bird screens.

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- I. Provide gravity backdraft dampers for fans when control dampers or motorized dampers are not scheduled or specified.
- J. Units shall be furnished with factory fabricated curb and extended base, as required for mounting minimum of 12" above roof.
- K. Curbs shall be constructed of galvanized steel or extruded aluminum with continuous welded corner seams, treated wood nailer, minimum 1-1/2" thick, 3 lb density, rigid mineral fiberboard insulation with metal liner.
- L. Units shall be furnished with factory fabricated sound curb as indicated.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install units as shown on drawings, and according to manufacturer's installation instructions. On units provided with drain connection, install drain valve and cap discharge of drain.
- B. Verify lubrication of motor and fan bearings and lubricate properly in accordance with manufacturer's recommendation and Section 230000 - General Mechanical Requirements, Part 3 under LUBRICATION.
- C. General Contractor will install curbs furnished with fans unless otherwise indicated.
- D. Perform field mechanical balancing, if necessary, to meet vibration tolerance specified in Part 1 of this Section.

END OF SECTION 233400

SECTION 233401 - FAN DATA SHEET

1.1 GENERAL

- A. Project: _____
- B. Identification: _____
- C. Service: _____
- D. Location: _____
- E. Type: _____
- F. Manufacturer: _____
- G. Model Number: _____

1.2 PERFORMANCE

- A. Capacity: _____
- B. Efficiency (%): _____
- C. Brake Horsepower at design flow rate (cfm): _____
- D. Brake Horsepower at 110% of design flow rate (cfm): _____
- E. Size: _____
- F. Class: _____
- G. Drive Arrangement: _____
- H. Discharge Rotation: _____
- I. Drive: _____
- J. Bearing: _____

1.3 MOTOR

- A. Manufacturer: _____
- B. Horsepower: _____
- C. Voltage: _____
- D. Phase: _____
- E. Hertz: _____

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F. RPM: _____

G. Type: _____

H. Enclosure Type: _____

I. Frame Type: _____

J. Insulation Class:

K. NEMA Design Designation: _____

L. Service Factor:

M. Nominal Efficiency: _____

N. Nominal Power Factor:

O. Full Load Amps: _____

P. Variable Frequency Drive Driven (Yes or No): _____

1.4 MISCELLANEOUS

A. Vibration Isolators: _____

B. Special Coating (Yes or No): _____

C. Special Coating Type: _____

END OF SECTION 233401

SECTION 233600 - AIR TERMINAL DEVICES

PART 1 - GENERAL

1.1 SUBMITTALS

- A. Shop Drawings including the following:
 - 1. Manufacturer's name and model number
 - 2. Identification as referenced in the documents
 - 3. Capacities/ratings
 - 4. Materials of construction
 - 5. Sound rating data
 - 6. Dimensions
 - 7. All other appropriate data

1.2 QUALITY ASSURANCE

- A. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70 by qualified testing agency and marked for intended location and application.
- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1 – 2010, Section 5 – “Systems and Equipment” and Section 7 – “Construction and System Start-Up.”

1.3 DESIGN CRITERIA

- A. Where any of air terminal devices are indicated on drawings to control space conditions in conjunction with reheat coil, that reheat coil may be furnished as integral part of or standard accessory to devices specified below. See related work above.
- B. When air terminal devices are furnished with reheat coils, either integrally or remotely mounted, control panels of terminal devices shall be mounted on the same side of air terminal device as reheat coil piping connection.
- C. Unless otherwise stated, units shall be system pressure independent and maintain air volume within $\pm 5\%$ of required airflow regardless of system air pressure. Inlet velocity pressure sensor shall be multi-point center averaging type and be capable of amplifying pressure signals.
- D. Unless otherwise stated, unit casings shall be constructed of galvanized steel or aluminum meeting SMACNA or ASHRAE Standards, but not lighter than 22 ga.
- E. Joints and seams of air terminal devices shall be sealed with appropriate sealant to minimize casing air leakage.
- F. Unit leakage test shall comply with ASHRAE 130 – Laboratory Methods of Testing Air Terminal Units.
- G. Unit performance shall be certified in accordance with AHRI 880 (I-P) including sound rating data certified for both casing discharge and radiated sound levels from 125 through 4000 Hz.

- H. Supply air units shall be capable of operating from minimum inlet static pressure scheduled to 3" WG.
- I. Provide supply air units with internal thermal insulation faced with minimum 0.001" thick aluminum foil. Insulation shall be compressed glass fiber with minimum 3/4" thick, 4 lb/ft³ density with R-value of (3.5(h·ft²·°F)/Btu). Insulation and facing shall meet requirements of UL 181 (Air Erosion, Mold growth and Humidity), and NFPA 90A (Flame 25/Smoke 50) and ASTM C665 (Fungi Resistance). Secure liner with full-seam-length, galvanized steel angles or Z-strips, which enclose and seal all edges. Tape or adhesive will not be acceptable. Liner assembly shall be similar to Titus Steri-Loc.
- J. Supply air units shall be lined with engineered polymer foam insulation, minimum 3/4" thick, 1.5 lb/ft³ density and thermal conductivity not more than (0.33(h·ft²·°F)/Btu at 75°F). Insulation shall meet requirements of UL 181 (Air Erosion, Mold Growth and Humidity), NFPA 90A (Flame 25/Smoke 50) and ASTM C665 (Fungi Resistance).
- K. Sound attenuators, where specified or required to meet sound performance specified for air terminal devices, shall be constructed of all metal or sound attenuating fiber material with erosion protection liner as required to meet sound requirement specified. Refer to Section 233314 - Ductwork Specialties for sound attenuators and erosion protection.
- L. Unit manufacturer or manufacturer's designated representative will be required to verify air terminal device performance and adjust or replace device within warranty period when it is determined that problem exists in area served by device.
- M. Air consumption of each pneumatic control assembly shall not exceed 35 scfm (1.2 scfh).
- N. Room sound levels due to discharge and/or casing radiation from units when operating from minimum pressure scheduled to 2" WG inlet static pressure shall not exceed noise criteria (NC) values in any spaces as indicated below. If units exceed sound level specified, provide terminal sound attenuators to comply with the noise criteria stated below. Refer to Section 233314 - Ductwork Specialties for sound attenuating devices.

Type of Room	Noise Criteria (NC)
All spaces unless otherwise indicated	35

1.4 CONTROLS COORDINATION

- A. Unit manufacturer shall provide unit inlet flow sensor, pneumatic tubing and control enclosure for Control Contractor's use.
- B. Control Contractor shall furnish all actuators, linkages if required, differential pressure transmitters, controllers and any other devices required for unit control that are not provided by unit manufacturer for unit manufacturer's factory mounting. Unit manufacturer and Control Contractor shall coordinate for proper factory installation.
- C. Unit manufacturer shall factory install devices furnished by Control Contractor to result in complete functioning unit. Unit manufacturer shall be responsible for reviewing compatibility of devices furnished by Control Contractor with units being provided.
- D. Unit manufacturer shall perform preliminary calibration based on scheduled airflow rates.

- E. Control Contractor shall be responsible for calibrating actuators and controllers through TAB work for scheduled airflow rates.
- F. Control Contractor's field mounting will be acceptable, provided Control Contractor coordinates proper installation with unit manufacturer. Control Contractor shall be responsible for complete functioning unit.

PART 2 - PRODUCTS

2.1 VARIABLE VOLUME AIR TERMINAL DEVICES

- A. Manufacturers: Titus, Price, Krueger, Enviro-Tec (ETI), Nailor, Carnes, Tuttle and Bailey, Metalaire, Trane, JCI or Carrier
- B. Units shall be suitable for 24 V electric control system. Control Contractor shall be responsible for wiring from control panels to each terminal unit.
- C. Units shall be suitable for 20 psi pneumatic control system and shall be normally open on loss of pneumatic pressure. Controller to be reset type with adjustable minimum and maximum setpoints, equal to Titus II Controller.
- D. Furnish units with reheat coils having capacities as indicated in schedules.
- E. Casing leakage rates shall not exceed the following maximum values:

Unit Size	Max. Casing Leakage (cfm)	
	0.5" WG	1.0" WG
4, 5, 6	2	3
7, 8	4	5
9, 10	4	6
12	5	7
14	6	9
16	7	10

- F. Provide access doors for all air terminal devices with reheat coils at inlet side of coils. Refer to Section 233314 - Ductwork Specialties for access doors. Unit manufacturer's standard access doors are acceptable, provided that access doors are appropriately sized and internally lined with same materials as unit casing. If access doors are provided in separate sections as extension of units, these sections shall be internally lined in same manner as units.
- G. Provide access doors for all boxes with reheat coils at inlet side of coils. Reheat coils shall be shipped loose and field mounted. Provide sheet metal connecting section between units and reheat coils for mounting access doors. Refer to Section 233314 - Ductwork Specialties for access doors.

2.2 CONSTANT VOLUME DOUBLE DUCT AIR TERMINAL DEVICES

- A. Manufacturers: Titus, Price, Krueger, Enviro-Tec, Nailor, Metalaire, or Tuttle and Bailey

- B. Units shall be suitable for 24 V electric control system. Control Contractor shall be responsible for wiring from control panels to each terminal unit.
- C. Units shall be suitable for 20 psi pneumatic control system. Hot deck shall be normally open and cold deck shall be normally closed on loss of pneumatic pressure.
- D. Furnish units with hinged or camlock fastener access doors on casing for service of all internal parts.

2.3 RETURN OR EXHAUST AIR TERMINAL DEVICES (VALVES)

- A. Manufacturers: Titus, Price, Krueger, Enviro-Tec (ETI), Nailor, Carnes, Tuttle and Bailey, Metalaire, Trane, JCI or Carrier
- B. Units shall be suitable for 24 V electric control system. Control Contractor shall be responsible for wiring from control panels to each terminal unit. Units shall be similar to Titus Model ECV.
- C. Unit casing shall be minimum 22 ga galvanized steel unless otherwise specified.
- D. Damper shall be heavy gauge steel. Shaft shall be steel with bronze oilite self-lubricating bearings. Damper shall incorporate mechanical stop to prevent overstroking and synthetic seal to limit close-off leakage to 2% of the nominal catalog rating at 3" water gauge inlet static pressure when tested in accordance with ASHRAE 130.
- E. Unit shall incorporate multi-point, center averaging velocity sensor. Sensor shall provide signal measurable by controller at inlet velocities of 500 fpm. Sensor shall provide control signal accuracy of $\pm 5\%$, with the same size inlet duct at any inlet condition. Multi-point flow sensor shall be able to be readily removable for servicing and replacing without removal of connected duct.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install units as shown on drawings and according to manufacturer's installation instructions.
- B. Install units with sufficient service space to unit control, actuators and access panels.
- C. Provide minimum length of 3 times box inlet diameter of straight rigid duct at box inlet.
- D. Provide access doors for terminal devices with reheat coils at inlet side of coils.
- E. Provide access panels compatible with ceiling for all units located above non-accessible ceilings.
- F. If air terminal devices that are not factory lined with thermal insulation are used for supply air application, provide external insulation in accordance with Section 230700 - Mechanical Systems Insulation.

END OF SECTION 233600

SECTION 233713 - DIFFUSERS, REGISTERS AND GRILLES

PART 1 - GENERAL

1.1 SUBMITTALS

- A. Shop Drawings including the following:
 - 1. Manufacturer's name and model number
 - 2. Identification as referenced in the Documents
 - 3. Capacities/ratings
 - 4. Materials of construction
 - 5. Sound ratings
 - 6. Dimensions
 - 7. Finish
 - 8. Color selection charts where applicable
 - 9. Manufacturer's installation instructions
 - 10. All other appropriate data

1.2 DESIGN CRITERIA

- A. Performance data shall be based on tests conducted in accordance with ASHRAE Std 70-2006.
- B. Screw holes on surface shall be counter sunk to accept recessed type screws.
- C. All diffusers, registers, and grilles shall be selected to of an NC value of 30 or less.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Titus, Price, Carnes, Nailor, Anemostat, Greenheck (formerly Metalaire), or Krueger
- B. Acceptable manufacturers for specialty products are listed under each item.

2.2 CEILING DIFFUSERS

- A. Diffusers shall be aluminum or steel as scheduled, unless otherwise indicated, and furnished with frame type appropriate to installation. Furnish diffusers with equalizing grids where it is not possible to maintain minimum 2 times duct diameter straight duct into diffuser. Equalizing grids shall consist of individually adjustable vanes designed for equalizing airflow into diffuser neck and providing directional control of airflow.
- B. Diffuser models, sizes and finishes shall be as shown on drawings and/or as scheduled. Unless otherwise noted, diffusers shall have baked enamel or powder coat finish with white color.

- C. Perforated face ceiling diffusers shall have minimum 51% free face area and pattern controllers accessible through removable or hinged faceplate. Unless otherwise indicated, pattern controllers shall be curved vane type mounted in neck of diffuser. Unless otherwise indicated, furnish diffusers with round neck inlets with minimum 1" depth.

2.3 ARCHITECTURAL SQUARE PANEL CEILING DIFFUSERS

- A. Architectural square panel ceiling diffusers shall be similar to Titus Model OMNI diffuser.
- B. Diffusers shall have one piece 18 ga face panels. Face panel shall be removable by means of four positive locking posts. Exposed surface of face panel shall be smooth, flat, and free of visible fasteners and have rounded off corners. Face panel shall project no more than 3/8" below outside border of diffuser back pan. Back of face panel shall have an aerodynamically shaped, roller edge to ensure tight horizontal discharge pattern.
- C. Ceiling diffusers with 24" x 24" full face shall have no less than 18" x 18" face panel size.
- D. Back pan shall be one piece die-stamped and shall include integrally drawn round inlet. Diffuser back pan shall be constructed of 22 ga steel. Diffuser neck shall have minimum of 1-1/4" depth available of duct connection. Back pan shape with face panel shall deliver 360° radial horizontal air pattern.
- E. Unless otherwise indicated, diffusers shall have baked enamel or powder coat finish with white color.

2.4 REGISTERS AND GRILLES

- A. Registers and grilles shall be aluminum or steel as scheduled unless otherwise indicated, and furnished with frame type appropriate to installation.
- B. Supply registers and grilles shall be double deflection type blades to provide for air deflection adjustment in all directions.
- C. Return and exhaust registers and grilles shall have fixed blade core.
- D. Registers shall be furnished complete with opposed blade volume control dampers, operable from face.
- E. Register and grille models, sizes and finishes shall be as shown on drawings and/or as scheduled. Unless otherwise noted, registers and grilles shall have baked enamel finish with color selected by Architect.

2.5 ADJUSTABLE LINEAR DIFFUSERS

- A. Linear diffusers shall be extruded aluminum and furnished with frame type appropriate to installation with diffuser elements being removable from frame. Diffuser vanes shall provide both air pattern and flow rate adjustment with air pattern having full 180° adjustment. Diffuser vanes of single slot shall be segmented on 2 ft or 3 ft centers.

- B. Diffuser models, lengths and slot sizes shall be as shown on drawings and/or as scheduled. Unless otherwise indicated, frame face shall have baked enamel or powder coat finish with color selected by Architect. Diffuser vanes and frame interior shall be finished in flat black.

2.6 FIXED BLADE LINEAR DIFFUSERS AND GRILLES

- A. Linear diffusers and grilles to be extruded aluminum with frame type appropriate to sidewall, sill or ceiling installation as indicated.
- B. Diffuser and grille models, lengths, blade spacing and blankoff strips to be as shown on drawings and/or as scheduled.
- C. Diffusers used for supply air to be furnished with straightening or equalizing vanes. Blades to be fixed at 0 or 15° deflection as scheduled.
- D. Unless otherwise indicated, diffusers and grilles shall have anodized aluminum finish with color selected by Architect.

2.7 WIRE MESH GRILLES OR SCREENS

- A. Grilles shall be 2 X 2 mesh (1/2") galvanized steel or aluminum hardware cloth in spot welded galvanized steel frame with 1-1/2" width.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install grilles, registers and diffusers as shown on drawings and according to manufacturer's instructions.
- B. Unless otherwise indicated, size ductwork drops to diffusers or grilles to match unit collar sizes.
- C. Seal connections between ductwork drops and diffusers/registers/grilles airtight.
- D. Support independently diffusers and grilles designed for T-bar mounting that exceed weight limit of ceiling suspension system in which they are to be installed.
- E. Unless otherwise shown, provide wire mesh screen at end of each open-ended duct (OED) that is exposed in occupied spaces.
- F. Blank off unused portion of linear diffusers and grilles.
- G. Where diffusers, registers and grilles cannot be installed to avoid seeing inside duct, paint inside of duct with flat black paint to reduce visibility.
- H. Protect diffusers, registers and grilles from construction dirt. Clean or replace those soiled or stained prior to turnover to Client.

END OF SECTION 233713

SECTION 237314 - PACKAGED AIR ROTATION UNITS

PART 1 GENERAL

1.1 SUBMITTALS

- A. Shop Drawings including, but not limited to, the following:
 - 1. Appropriate identification
 - 2. Complete drawings showing plans and sections including details of construction
 - 3. Overall unit dimensions and individual components and sections dimensions
 - 4. Shipping and operating weight of unit and/or sections
 - 5. Structural design load
 - 6. Details of component support
 - 7. Capacities/ratings
 - 8. Materials of construction
 - 9. Thermal performance of wall, roof and floor panels
 - 10. Pressure ratings and leakage ratings
 - 11. Each component manufacturer's name, model number and data.
 - 12. Fan balance report
 - 13. Wiring diagrams and terminal points for control panels provided with units
 - 14. Manufacturer's installation instructions
 - 15. Air rotation unit manufacturer's local representative and phone number
 - 16. All other appropriate data

1.2 DESIGN CRITERIA

- A. Manufacturer shall provide equipment as specified and install equipment furnished by others to result in complete and operational unit. Manufacturer shall assume single source responsibility for all components and accessories.
- B. Furnish units complete with fans, piping, valves, piping specialties, motors, coils, drain pans, and filter sections, meeting configuration and as shown on drawings, specified and as scheduled.
- C. Unit performance shall be in accordance with ANSI/AHRI Standard 430 and shall be Third Party certified and labeled.
- D. All materials shall meet NFPA 90A flame and smoke generation requirements.
- E. Unless otherwise indicated, galvanized steel shall be G90 according to ASTM A924 (formerly ASTM A525), A653 and ASTM A-90 and aluminum sheet shall be 3003-H14 alloy, conforming ASTM B209.
- F. Motor furnished with fan shall not operate into motor service factor in any cases.
- G. Wire brush all welds with solvent and wipe clean all bare metal before painting.

- H. Air Rotation Units shall be constructed for indoor application and shall be designed for mounting on housekeeping pad.

1.3 DELIVERY, STORAGE AND HANDLING

- A. Delivery: The Contractor upon receipt of the equipment shall immediately verify that the equipment has not received damage during shipping and that all items listed on the bill of lading and the equipment manufacturer Shipping Documents are included in the shipment. If damage has occurred or if items are missing, the Contractor must note this on the equipment manufacturer Shipping List before accepting delivery of the equipment.
- B. Storage and Protection: Store equipment, and protect it from exposure to harmful weather conditions and at temperature conditions as recommended by equipment manufacturer. See the equipment manufacturer Equipment Storage Instructions included in the Operations and Maintenance Manual, and raw material and component manufacturer's instructions and Operations and Maintenance Manuals.
- C. The equipment manufacturer shall seal fluid and air openings prior to shipment. Blow all coils free of water. Coils damaged by freezing to be replaced not repaired.
- D. The equipment manufacturer shall protect coils with sheet metal blank-offs secured to both upstream and downstream faces of coils.
- E. The equipment manufacturer shall deliver products to site with protective coverings and factory installed lifting lugs.

1.4 DOCUMENTATION

- A. Provide the following information within the unit as it ships for contractor use:
- B. As Built Electrical Drawings
- C. All O&M Information including coils, fans, damper actuators, pressure gauges, etc.
- D. Factory test results
- E. Control Points List
- F. Unit Submittal

1.5 INSPECTION AND CERTIFICATION

- A. Unit manufacturer's representative shall inspect and verify that installation is conforming to manufacturer's recommendations.
- B. Submit report to Engineer in writing certifying that installation is in accordance with manufacturer's recommendations.

PART 2 PRODUCTS

2.1 VERTICAL AIR ROTATION UNITS

- A. Manufacturers:
 - 1. Johnson Air Rotation, Trane, Powrmatic and AbsoluteAire
- B. Self-contained, packaged, pre-wired unit consisting of cabinet, supply fan, cooling coils, and accessories:
 - 1. The unit will have the capabilities of cooling, heating, filtering, and circulating as detailed on the drawings.
 - 2. The unit shall be completely factory assembled and tested prior to shipping and disassemble for shipping and reassembled on site by the awarded contractor as required.
 - 3. System and accessories to be UL listed and approved as a complete unit.
 - 4. Unit Configuration: Vertical with horizontal discharge. Units shall have control panel serviceable from ground level.
 - 5. Lifting Provisions: Lifting provisions shall be included on all units as an integral part of the equipment.
 - 6. Supply Voltage: 460V, 3ph., 60 Hz
 - 7. The unit shall have an electrical connection for the unit and an electrical connection for the heating coil.
 - 8. The unit shall have a maximum height of 9'-3"
- C. Frame Construction: Shall be angle iron framing and factory painted, suitably reinforced and braced to permit the loading, shipping, unloading and rigging to the unit location and general handling of completed sections without damage to external or internal components or misalignment of factory assembled components.
- D. Cabinet Construction: 18-gauge A-60 bonderized steel suitable for factory painting. Unit shall be factory painted using factory standard enamel finish.
- E. Access Panels: Hinged access doors in the unit housing shall be provided to permit ready access to all internal components. The access doors shall be a minimum of 18-gauge-galvanized steel. The doors shall be designed to swing out. The doors shall be provided with a continuous 16-gauge stainless steel piano hinge. The unit's wall panels shall be an integral part of the doorframe. The unit's fan compartment access for inspection and adjustment shall be UL approved. A warning placard shall be affixed at the access door indicating that the unit is to be shut off before opening the door and entering the fan compartment.
- F. Air Filter Frame and Air Filters: Return air filters will be as scheduled.
 - 1. Furnish units with 2" glass fiber throwaway filters in commercially available sizes with low velocity V bank type filter casing.
 - 2. In addition, furnish a set of 2" glass fiber throwaway filters to be used during construction and initial start-up periods and a set to be handed over to the owner.
- G. Insulation: All sections of the air rotation unit shall have double-wall insulation, 1" 1.5# density, with 22 gauge galvanized interior liner.

H. Supply Fans:

1. The supply fans shall be airfoil premium propeller type with low-noise marine alloy blades and a smooth inlet venturi. The pitch of the fan blades shall be field adjustable. The propeller blades shall be supported by two bearings, which shall be of a self-aligning, ball bearing type and shall be designed for at least 100,000 hours average life.
2. Blower Shafts - Blower shafts shall be solid ground and polished. The shafts shall not pass through their first critical speed when the unit comes up to the rated RPM. Shaft shall be coated with a rust inhibitor.
3. V-Belt Drives - All V-belt drives shall be standard capacity dual belt type, furnished in matched sets with reinforced rubber belts. The sheaves shall be of a cast iron type. Motors shall have drive sheaves of the fixed pitch type. The service factor used for V-belt drive selection shall be not less than 1.25.
4. Lubrication - Mount all grease fittings directly on the bearings.
5. Motors shall be open drip proof, 1800 RPM, 460 volt, 3 phase, 60 Hz. Motor horsepower shall be as indicated on the schedule. Motors will be manufacturer's premium efficiency design.

I. Cooling Coils:

1. Cooling coils shall use 0.035" copper tubes and 0.01" aluminum fins. Coil casings shall be galvanized steel.
2. Drain pans shall be pitched for complete drainage and be constructed of all welded 304 stainless steel. The under side of the drain pan shall be completely insulated with 1.5 inches of spray on foam insulation. Intermediate drain pans shall be stainless steel and have a copper downspout to the lower drain pan. The drain pan connection shall be about 4-6" above the unit base for trapping by the installing contractor.
3. Face velocity of cooling coils shall not exceed 500 fpm.

J. Heating Coils:

1. Heaters shall be UL Listed for zero clearance to combustible materials in horizontal air ducts and shall comply with all applicable provisions of the latest National Electric Code.
2. Heaters shall incorporate combination of automatic reset disc type thermal cutouts for primary protection and manual reset line duty disc type thermal cutouts with external reset for secondary protection.
3. Coil hardware shall be stainless steel
4. Open Coil Elements
 - a. Heating elements shall be GRADE A (80% nickel and 20% chromium alloy) corrosion-resistant wire, supported by fully-staked ceramic bushings in reinforced shelves.
 - b. Internal shelf spacing shall be no more than 4.5" apart. Heater body shall be of galvanized steel of not less than 20 ga, reinforced for full rigidity.
 - c. Coils shall be machine crimped into stainless steel terminals extending at least 1" into airstream. Mechanical fasteners or screws inside airstream will not be acceptable.
5. Heaters shall be rated for KW, voltage, phase and number of heating stages as scheduled.
6. Heaters shall have the following features:

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- a. Insulated frames and control box
- b. Magnetic contactors
- c. Control circuit transformer
- d. SCR Controller
- e. Fusing to comply with NEC
- f. Fused disconnect switch with interlock handle
- g. Airflow proving switch
- h. Pilot light to indicate that heater supply is “on”; one per step

K. Controls:

1. The power panel shall have a locking dead front main power cabinet with knife-blade disconnect and containing necessary fuses, sub-circuits, magnetic starters with 3-leg protection, relays and contactors. Main disconnect utilizing contactors controlled by a switch will not be acceptable.
2. Provide packaged ARU controller shall be integrated to the BAS.
3. Power/control panel shall be over-sized for field supplied controllers (to mount within factory-provided cabinet).
4. A terminal strip (factory-wired) shall be provided for adaptability to field provided controllers.

L. Accessories:

1. Air outlet extension(s), as required, to raise discharge level to 9’6”
2. Freight and factory-assisted start-up services shall be included with all bids.

M. Markings

1. The unit nameplate contain unit model number, serial number, full load amps, and supply voltage
2. The units shall be permanently marked with the equipment number ARU-# as identified in the performance section.
3. All matching pieces of units shipped in sections shall be marked for easy identification of adjoining sections.
4. Proper warning labels for high voltage and moving parts shall be permanently affixed to access doors.
5. An electrical ladder diagram shall be permanently affixed inside of the electrical control panel. The schematic shall be specific to the project and not be a generic type encompassing features or options not present on the unit. The schematic shall include the fuse replacement values and types.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install air handling units and accessories as indicated on drawings and/or as scheduled and according to manufacturer's installation instructions.

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- B. Mount units at proper height above floor so that proper trap depth is provided in condensate drain line.

3.2 PROTECTION OF OPENINGS

- A. Protect openings on unit housings during construction against entry of foreign matter and construction dirt until ductwork is connected.

3.3 START-UP

- A. Manufacturer's representative shall review the installation of the air handling units and provide signed acceptance of installation or written exceptions.

END OF SECTION 237314

SECTION 237400 - PACKAGED ROOFTOP UNITS

PART 1 - GENERAL

1.1 SUBMITTALS

- A. Shop Drawings including, but not limited to, the following:
 - 1. Manufacturer's name and model number
 - 2. Identification as referenced in the documents
 - 3. Capacities/ratings
 - 4. Materials of construction
 - 5. Filters; size, efficiency
 - 6. Fans; type, drives
 - 7. Motor data (refer to Section 230513 - Motors for Mechanical Equipment)
 - 8. Power and control wiring diagrams
 - 9. Vibration isolation furnished with units
 - 10. Dimensions and weights
 - 11. Manufacturer's installation instructions
 - 12. Other appropriate data
- B. Fan curves shall include a series of curves indicating relationship of airflowcfm and static pressure for various rpm and fan brake power curves. Indicate design operating point clearly on fan curves.

1.2 DESIGN CRITERIA

- A. Design units specifically for outdoor rooftop application.
- B. Units to be completely factory assembled and run tested, piped, internally wired, fully charged with refrigerant and compressor oil when specified, and shipped in one piece.
- C. Units shall be factory run tested to check cooling operation, fan and blower rotation and control sequence.
- D. Furnish units with components, accessories, and operating and safety controls to provide the intended performance as specified in this section, as shown on Drawings and/or as scheduled.
- E. Insulation and liners to meet NFPA 90A requirements.
- F. Unit shall be UL Listed and carry UL Label.
- G. V-belt drives shall be designed for 150% of motor rating.
- H. Cooling and/or heating coils shall be rated in accordance with AHRI 410.
- I. Heating system on gas-fired units shall be certified by AGA.

- J. Each fan and motor combination shall be capable of meeting both of the following conditions while maintaining stable fan performance:
 - 1. Deliver 110% of air quantity scheduled at scheduled static pressure.
 - 2. Unit static pressure shall take into consideration actual static pressure loss of components furnished within unit.
- K. Fan motor shall not operate into motor service factor in any case. Drive efficiency shall be considered in motor selection according to manufacturer's published recommendation, or according to AMCA Publication 203, Appendix L.
- L. Where inlet and outlet ductwork at any fan is changed from that shown on drawings, submit scaled layout of the change and system effect factor calculations, indicating increased static pressure requirement as described in AMCA Publication 201. Contractor shall be responsible for any motor, drive and/or wiring changes required as result of duct configuration changes at fan.

1.3 TEST REPORTS

- A. Manufacturer or manufacturer's representative shall field check, test and start units after they have been properly installed. Component systems to be run and adjusted to perform quietly and efficiently at capacities scheduled.
- B. Manufacturer or its representative shall provide services to field instruct and check unit operation and control of complete system. Instruction shall not take place until HVAC system has been field checked, tested, started and balanced. Manufacturer shall establish instruction dates, and give Engineer and Owner 10 days' written notice of the time. Instruction shall be deemed completed when affidavit of instruction has been signed by representative of manufacturer and Owner.

1.4 OPERATION AND MAINTENANCE DATA

- A. Refer to Section 230000 - General Mechanical Requirements.

1.5 GUARANTEE

- A. Manufacturer and Contractor shall provide warranty on rooftop units for a period of 1 yr after acceptance by Owner.
- B. Warranty shall include cost of parts and labor for work necessary to repair malfunctioning unit or piece of equipment furnished by unit manufacturer. Warranty need not cover normal maintenance such as changing of filters, cleaning of coils, replacement of belts and lubrication of bearings.
- C. Provide additional 4 yr warranty for refrigeration compressors.
- D. Provide additional 4 yr warranty for stainless steel heat exchangers.

PART 2 - PRODUCTS

2.1 ROOFTOP UNITS (5 TONS AND SMALLER)

A. Manufacturers:

1. Captiveaire, AAON, Carrier, Daikin, or Trane
2. Equal to manufacturer's model with capacity and operating characteristics as scheduled

B. Casings:

1. Weatherproof and constructed of heavy gauge galvanized steel phosphatized with baked enamel finish. Insulate interior surfaces of cabinet with minimum of 1/2" glass fiber insulation.
2. Access doors shall be heavy gauge galvanized or phosphatized zinc coated steel complete with hinges to secure door. Access doors and removable panels shall have neoprene gaskets.
3. Cabinet base shall be constructed so as to mate and seal with roof mounting curb. Furnish sealing gasket for positive, waterproof seal when unit is installed on curb.

C. Supply Air Fans:

1. Double width, double inlet centrifugal type with adjustable V-belt drives, statically and dynamically balanced and tested in factory.
2. Entire fan and drive assemblies to be mounted on common base and be isolated from unit by factory mounted vibration isolators .

D. Return-Exhaust Air Section:

1. Furnish exhaust hood with rain gutter to protect exhaust air openings.
2. Provide baffle in return air stream entering filter section to balance pressure drop between return air and outside air entering supply fan.

E. Filters:

1. Filter racks shall be integral part within unit and easily accessible from both sides of unit via hinged access doors.
2. Furnish units with 2" glass fiber throwaway filters in commercially available sizes with low velocity V bank type filter casing.
3. In addition, furnish a set of 2" glass fiber throwaway filters to be used during construction and initial start-up periods and a set to be handed over to the owner.

F. Electric Heating Section:

1. Furnish unit with factory assembled and wired electric resistance type heating coils. Heating element shall be heavy-duty nickel chromium. Provide distribution baffle to ensure even air distribution across coil.
2. Heater circuit current shall be 48 amps or less, each individually fused in accordance with National Electrical Code. Capacity control shall use SCR control for electric heating.
3. Provide main disconnect switch in main control panel for electric heating..

4. Provide safety and operating controls including manual reset thermal cutouts on each bank of electric heating element and flow switch.

G. Heat Pump Section:

1. Provide reversing type heat pump system with capacities indicated on schedules.
2. Provide outdoor coil defrost system to remove frost accumulation during heating cycle.
3. Defrost system shall activate reverse cycle defrost time and temperature initiated, temperature termination.
4. Defrost system shall have integral time override to limit defrost cycle to maximum of 5 minutes.

H. Cooling System:

1. Direct Expansion Cooling:

- a. Factory charged with refrigerant and fully tested. System shall include refrigeration compressor(s), evaporator coil, air cooled condenser assembly, thermal expansion valves, liquid line valves, sight glass, filter drier, liquid and suction line service valves, and insulated interconnecting refrigerant piping.
- b. Evaporator coils to be of non-ferrous construction with 5/8" OD seamless copper tubes mechanically bonded to configured aluminum fins.
- c. Provide fully insulated drain pan fabricated from zinc-coated steel with additional coat of insulating sealer.
- d. Compressor shall be hermetic type with spring isolators.
- e. Provide compressor with internal thermal overloads, crankcase sight glass and crankcase heater. Provide capacitor start kit for single phase units.
- f. Condenser coils shall be seamless copper tubing mechanically bonded to heavy duty configured aluminum fins. Condenser coils of aluminum tubes and aluminum fins constructed with Microchannel coil technology will be acceptable.
- g. Refrigeration safety controls shall include high and low pressure cutout, oil pressure cutout, compressor overload protections, magnetic contactors and low voltage control transformer.
- h. Provide system with necessary controls to maintain head pressure at ambient to 0°F.
- i. System shall be fully charged with refrigerant as scheduled on Drawings, ready for operation.

I. Condenser Fan:

1. Condenser fans to shall be direct drive propeller type with exposed fan and shaft surfaces suitably weatherproofed. Fan motors to shall be furnished with normal and current overload protection and permanently lubricated motor bearings.

J. Electrical:

1. Furnish each unit with factory mounted disconnect device with short circuit and over current protection, motor starter and contactor.
2. Each unit shall include low voltage control transformer.
3. Motor power and voltages shall be as scheduled.

K. Remote Control and Monitoring Panels:

1. Panels shall include system operation switches and indicator lights for supply fan operating, filter media dirty, heating malfunction, and cooling malfunction.
2. Unit manufacturer shall provide at panels 24 h, 7 day time clocks with night setback override. Arrange time clocks so individual units or group of units as shown on Drawings have independent night setback control.

L. Unit Controls:

1. Controls for unit temperature control system shall be provided by Control Contractor in accordance with requirements of 230901 - Control Systems Integration and 230993 - Control Sequences. Coordinate unit controls and temperature control systems to ensure efficient and safe operation.
2. Contractor shall provide temperature control and interlocking devices necessary to perform the specified control sequence.
3. Provide low voltage space thermostat to control stages of heating, cooling, automatic changeover and fan control. Provide matching heat-cool/fan on-off-auto sub-base.

2.2 ROOF MOUNTING CURBS:

- A. Manufacturers: Mason, Type RSC-db, RPS, or fabricated by Contractor
- B. Construct roof mounting curb to mate and seal with unit casing base. Curb to have minimum height of 12".
- C. Construct curb to support perimeter of entire unit. Form cross section of curb members to accept wood nailing strips and insulation. Form top curb members to provide counter flashing.
- D. Curbs Serving Units 7-1/2 tons and larger:
 1. Curb mounted roof top equipment shall be flexibly ducted. Units shall be supported by spring isolation curb, lower member of which is rigid steel tube or specially formed steel section containing adjustable and removable steel springs that support upper floating section. Upper frame must provide continuous support for equipment and must remain captive when resiliently resisting wind and seismic forces. Directional neoprene snubber bushings must be minimum of 1/4" (6 mm) thick. Steel springs shall rest on 1/4" (6 mm) neoprene acoustical pads. Hardware must be cadmium or zinc electroplated and springs similarly plated or provided with approved rust resistant finish.
 2. Curb waterproofing shall consist of continuous galvanized flexible counterflashing nailed over lower curb's waterproofing and joined at corners by EPDM bellows. Spring locations shall have access ports with removable waterproof covers. Lower curbs shall have provision for 2" insulation.
 3. Floating member of roof curb shall have perimeter angle and cross members to support 2 layers of 5/8" waterproof sheetrock laid on with staggered joints. Sheetrock must surround ducts to provide continuous sound break. This acoustical barrier shall be caulked to minimize sound transmission. Where mechanical arrangement makes attachment to the floating member unfeasible, barrier shall be attached at highest practical elevation of fixed curb with provision for 1" thick closed cell neoprene flexible seals around the ductwork. 4" layer of 1.5 lb/cubic foot density fiberglass shall cover entire solid roof surface under the unit. Complete instructions shall be provided by spring isolation curb manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install units as indicated on Drawings and according to unit manufacturer's instructions.
- B. Provide roof mounting curbs and set and install units on curbs.
- C. Install ductwork, electrical and piping connections to unit as shown on Drawings for complete installation.
- D. Coordinate with controls contractor for wiring between rooftop units, remote panels, time clocks and other temperature control devices.
- E. Manufacturer and/or manufacturer's representative shall calibrate control devices and adjust unit automatic dampers to ensure proper operation of system.
- F. Install space thermostats approximately 5 ft-0" above floor and as shown on drawings.
- G. Install remote control panels as indicated on Drawings.

END OF SECTION 237400

SECTION 238214 - HEATING AND COOLING TERMINAL DEVICES

PART 1 - GENERAL

1.1 SUBMITTALS

- A. Shop Drawings for all items in this Section including the following:
 - 1. Manufacturer's name and model number
 - 2. Identification as referenced in the documents
 - 3. Capacities/ratings
 - 4. Materials of construction
 - 5. Dimensions and weights
 - 6. Color selection chart where applicable
 - 7. Wiring diagrams
 - 8. Motor data (refer to Section 230513 - Motors for Mechanical Equipment)
 - 9. For chilled beams, submit performance data from independent testing agency. Performance data to include cooling capacity at supply water temperatures scheduled, air pressure drop, sound data, and water pressure drop for each beam length.
 - 10. All other appropriate data

1.2 REFERENCE STANDARDS AND DESIGN CRITERIA

- A. Duct Reheat Coils: Ratings shall be certified in accordance with AHRI 410 Standard for Forced-Circulation Air-Cooling and Air-Heating Coils for reheat coils, unit heaters, cabinet unit heaters and air curtain door heaters.
- B. AHRI 1410 Standard for Performance Rating of Commercial Finned-Tube Radiation.
- C. AHRI 440 Standard for Performance Rating of Fan-coil Units.
- D. AHRI 1240 Standard for Performance Rating of Active Chilled Beams.
- E. AHRI 210/240 Standard for Performance of Unitary Air-conditioning and Air-source Heat Pump Equipment.
- F. Units including electrical work shall be UL Listed.
- G. Electric Heaters: Shall be listed by UL, bear appropriate UL Label, contain the latest devices for protection of installation, and shall be installed in strict accordance with the latest revision of National Electric Code and other applicable State and Local Codes. Provide grounding lugs on all apparatus.

1.3 ELECTRICALLY COMMUTATED (EC) MOTORS

- A. Where EC motors are indicated in Part 2 of this Section, such motors shall comply with Section 230513 - Motors for Mechanical Equipment.

PART 2 - PRODUCTS

2.1 ELECTRIC REHEAT COILS

- A. Manufacturers: Indeeco, Berko, or Brasch
- B. Heaters shall be UL Listed for zero clearance to combustible materials in horizontal air ducts and shall comply with all applicable provisions of the latest National Electric Code.
- C. Units may be integral with air terminal devices
- D. Heaters shall incorporate combination of automatic reset disc type thermal cutouts for primary protection and manual reset line duty disc type thermal cutouts with external reset for secondary protection.
- E. Coil hardware shall be stainless steel
- F. Open Coil Elements
 - 1. Heating elements shall be GRADE A (80% nickel and 20% chromium alloy) corrosion-resistant wire, supported by fully-staked ceramic bushings in reinforced shelves.
 - 2. Internal shelf spacing shall be no more than 4.5" apart. Heater body shall be of galvanized steel of not less than 20 ga, reinforced for full rigidity.
 - 3. Coils shall be machine crimped into stainless steel terminals extending at least 1" into airstream. Mechanical fasteners or screws inside airstream will not be acceptable.
- G. Heaters shall be rated for KW, voltage, phase and number of heating stages as scheduled.
- H. Heaters shall have the following features:
 - 1. Insulated frames and control box
 - 2. Magnetic contactors
 - 3. Control circuit transformer
 - 4. SCR Controller
 - 5. Fusing to comply with NEC
 - 6. Fused disconnect switch with interlock handle
 - 7. Airflow proving switch
 - 8. Pilot light to indicate that heater supply is "on"; one per step
- I. Controls shall be factory wired with terminal connections for power and thermostat.

2.2 MINI-SPLIT SYSTEM

- A. Manufacturers: Mitsubishi, Toshiba, Carrier, Daikin or LG. Manufacturer shall be responsible for entire system consisting of DX cooling fan coil unit and condensing unit.
- B. Unit data shall be certified in accordance with AHRI Standard 210/240.

- C. Provide factory assembled and tested, outdoor mounted, air-cooled condensing unit suitable for installation on grade. Include compressor, air cooled condenser, refrigerant, lubrication system, interconnecting wiring, safety and operating controls, motor starting components and additional features as specified herein or required for safe, automatic operation. Capacity and operating characteristics as indicated in the equipment schedule. Coil performance data shall be in accordance with AHRI 410. Refrigerant shall be R-410A.
- D. Condensing unit cabinet is to be constructed of heavy gauge, galvanized steel coated with weather resistant paint. Provide removable access panels to facilitate full access to the compressor, fan and control components.
- E. Furnish head pressure control to operate compressor satisfactorily at ambient temperature to - 20°F at minimum compressor load.
- F. Provide factory assembled indoor fan coil unit. Cabinet shall be impact resistant and fully insulated. Supply fan shall be direct drive tangential blower. Motor shall be multi-speed, ODP with permanently lubricated bearings. Cooling coil shall be copper tube with aluminum fin and galvanized steel tube sheets. Drip pan under coil shall have drain connection with internal trap. Unit shall have filter rack with factory supplied cleanable filters. Unit shall be furnished with integral wall mounting bracket and mounting hardware.
- G. Indoor fan coil unit shall be powered by outdoor condensing unit.
- H. Provide with complete electronic microprocessor control system with shall control space temperature, determine optimum fan speed, and run self-diagnostics. The temperature shall be controlled by a programmable wired remote thermostat with integral temperature sensor and wall mounting bracket.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install units as indicated on drawings, and according to manufacturer's installation instructions.
- B. Install branch piping to each unit with minimum of 3 elbows to allow for expansion and contraction.
- C. Protect units during construction against entry of foreign matter and construction dirt.
- D. Unless otherwise shown on drawings, mount vertical type wall mounted heating units 12" above finished floor.

3.2 DUCT REHEAT COILS

- A. Comb out fins when bent or crushed before enclosing coils in ductwork. Clean dust and debris from each coil to ensure its cleanliness.
- B. Seal or gasket coil connection to ductwork to meet maximum allowable leakage rate specified in Section 233114 - Ductwork, Part 3.

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- C. Protect units during construction against entry of foreign matter and construction dirt.
- D. Unless otherwise specified, connect piping to coils with multiple rows for counter-flow arrangement.

END OF SECTION 238214

SECTION 260000 - GENERAL ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Intent of drawings and Specifications is to obtain complete systems tested, adjusted, and ready for operation.
- B. Except as otherwise defined in greater detail, the terms “provide”, “furnish” and “install” as used in Division 26 Contract Documents shall have the following meanings:
 - 1. “Provide” or “provided” shall mean “furnish and install”.
 - 2. “Furnish” or “furnished” does not include installation.
 - 3. “Install” or “installed” does not include furnishing.
- C. Include incidental details not usually shown or specified, but necessary for proper installation and operation.
- D. Check, verify and coordinate work with drawings and specifications prepared for other trades. Include modifications, relocations or adjustments necessary to complete work or to avoid interference with other trades.
- E. Included in this Contract are electrical connections to equipment provided by others. Refer to Architectural, Mechanical, Plumbing, and final shop drawings for equipment being furnished under other sections for exact locations of electrical outlets and various connections required.
- F. Information given herein and on drawings is as exact as could be secured but is not guaranteed. Do not scale drawings for dimensions.
- G. Where architectural features govern location of work, refer to Architectural Drawings.
- H. Perform work in “neat and workmanlike” manner as defined in ANSI/NECA 1, Standard Practices for Good Workmanship in Electrical Contracting.

1.2 RELATED WORK

- A. Utility Services:
 - 1. Determine utility connection requirements and include in Base Bid all costs to Owner for utility service.
 - 2. Include costs for temporary service, temporary routing of service or other requirements of a temporary nature associated with utility service.
- B. Continuity of Service:
 - 1. No service shall be interrupted or changed without permission from Architect and Owner. Obtain written permission before work is started.
 - 2. When interruption of services is required, Architect, Owner and other concerned parties shall be notified and shall determine a time.
- C. Demolition:

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1. Division 02 - Selective Demolition
2. Division 02 - Building Demolition
3. Perform required demolition to accomplish new work.
 - a. Remove abandoned wiring to source of supply.
 - b. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut conduit flush with walls and floors, and patch surfaces.
 - c. Disconnect abandoned outlets and remove devices.
 - d. Remove abandoned outlets if conduit servicing them is abandoned and removed.
 - e. Provide blank cover for abandoned outlets that are not removed.
 - f. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.
 - g. Disconnect and remove abandoned luminaires. Remove brackets, stems, hangers, and other accessories.
 - h. Disconnect electrical systems in walls, floors, and ceilings scheduled for removal.
4. Accomplish work in neat workmanlike manner to minimize interference; annoyance or inconvenience such work might impose on Owner or other Contractors.
5. Unless otherwise noted, remove from premises materials and equipment removed in demolition work.
6. Equipment noted to be removed and turned over to Owner, shall be delivered to Owner at place and time Owner designates.
7. Where materials are to be turned over to Owner or reused and installed by Contractor, it shall be Contractor's responsibility to maintain condition of materials and equipment equal to that existing before work began. Repair or replace damaged materials or equipment at no additional cost to Owner.
8. Where demolition work interferes with Owner's use of premises, schedule work through Architect, Owner and with other Contractors to minimize inconvenience to Owner. Architect must approve schedule before Contractor begins such work.

D. Concrete Work:

1. Provide cast-in-place concrete as required by Contract Documents unless otherwise noted.
2. Concrete shall comply with Division 03 - Concrete.
3. Provide anchor bolts, metal shapes and templates to be cast in concrete or used to form concrete as required for anchoring and supporting electrical equipment.

E. Painting:

1. Furnish equipment with factory-applied finish coats or paint equipment per Division 09 – Finishes unless specified otherwise.
2. Furnish equipment with factory applied prime finish unless otherwise specified.
3. If factory finish on equipment furnished by Contractor is damaged in shipment or during construction, refinish equipment to satisfaction of Architect.
4. Furnish one can of touch up paint for each final factory-applied finish coat of product.

1.3 REQUIREMENTS OF REGULATORY AGENCIES

- A. Rules and regulations of Federal, State and local authorities and utility companies, in force at time of execution of Contract shall become part of this specification.

1.4 REFERENCE STANDARDS

- A. Agencies or publications referenced herein refer to the following:

1. Association of Edison Illuminating Companies
2. American National Standards Institute
3. American Society of Mechanical Engineers
4. American Society for Testing and Materials
5. Building Industry Consulting Services International
6. Electronic Industries Association
7. Federal Information Processing Standards
8. Federal Communications Commission
9. Insulated Cable Engineers Association
10. Institute of Electrical & Electronics Engineers
11. Illuminating Engineering Society of North America
12. National Electrical Code
13. National Electrical Contractors Association
14. National Electrical Manufacturers Association
15. National Electrical Safety Code
16. National Electrical Testing Association
17. National Fire Protection Association
18. National Institute of Standards & Technology
19. Occupational Safety and Health Administration
20. Telecommunications Industries Association
21. Underwriters Laboratories, Inc.

- B. Work shall be in accordance with latest edition of codes, standards or specifications unless otherwise noted.

1.5 LISTING

- A. All electrical materials, devices, appliances and equipment shall be evaluated for safety and suitability for intended use. Evaluation shall be conducted by a Nationally Recognized Testing Laboratory (NRTL) and all markings, labels and other identification required by those listings and certifications shall be provided on those materials, devices, appliances and equipment.
 1. Third Party Agencies shall be amongst those accredited by the NCBCC (North Carolina Building Code Council) to Label Electrical and Mechanical Equipment. Refer to NC Department of Insurance web site (Office of State Fire Marshall / Engineering and Codes Division / Code Enforcement Resources / Third Party Testing Agencies) for current list of acceptable third party agencies.

1.6 ENCLOSURES

A. Typical NEMA Enclosures and Usage

1. NEMA 1 - Indoors. Falling dirt.
2. NEMA 3R - Outdoors. Rain, snow, sleet.
3. NEMA 4 - Outdoors. Rain, sleet, snow. Wind blown dust. Hose down.
4. NEMA 4X - Same as NEMA 4 - Outdoors plus corrosion resistant.
5. NEMA 12 - Indoors. Falling Dirt. Falling liquids. Flying dust, lint and fibers. Oil or coolant seepage.

1.7 SUBMITTALS

A. Shop Drawings (Product Data):

1. Refer to Division 01 - Submittal Procedures.
2. Note that for satisfying submittal requirements for Division 26, "Product Data" is usually more appropriate than true "Shop Drawings" as defined in Division 01. However, the expression "Shop Drawings" is generally used throughout the Specification.
3. Submit shop drawings for equipment and systems as requested in respective specification sections. Submittals which are not requested may not be reviewed.
4. Specifically mark general catalog sheets and drawings to indicate specific items submitted and its correlation to specific designation for product in drawings.
5. Specifically indicate proper identification of equipment by name and/or number, as indicated in specification and shown on drawings.
6. When manufacturer's reference numbers are different from those specified, provide correct cross-reference number for each item. Clearly mark and note submittal accordingly.
7. Submit complete record of required components when luminaires, equipment and items specified include accessories, parts and additional items under one designation.
8. Include wiring diagrams for electrically powered or controlled equipment.
9. Submit electrical equipment room layouts drawn to scale, including equipment, raceways, accessories and required working clearances. Submit electrical equipment room layouts concurrently with electrical distribution equipment submittals.
10. Where submittals cover products containing non-metallic materials, include "Material Safety Data Sheet" (MSDS) from manufacturer stating physical and chemical properties of components and precautionary considerations required.
11. Submit shop drawings or product data as soon as practicable after signing contracts. Submittals must be approved before installation of materials and equipment.
12. Submittals that are not complete, not permanent, or not properly checked by Contractor, will be returned without review.

13. Bidders shall provide a full compliance review of specifications. Compliance review shall accompany submittals. Compliance review shall include paragraph-by-paragraph review of specifications with the following information “C”, “D”, “E” marked in the margin of the specification section. Unless a deviation or exception is specifically noted in the compliance review, it is assumed that Bidder is in complete compliance with plans and specifications. Lack of these requirements in the submittal shall result in rejection of submittal. Text shall be provided accompanying compliance review as follows:
 - a. “C” – Comply with no exceptions
 - b. “D” – Comply with deviations. For each of the deviations, provide numbered footnote with reasons for proposed deviation
 - c. “E” – Exceptions; do not comply
- B. Bookmarks:
 1. Submitted documents greater than 50 pages in length shall include electronic bookmarks setup to quickly navigate and easily locate submitted information. Each major series of equipment shall have a bookmark.
 2. Hyperlinks can be used to enhance bookmark tools but are not an acceptable substitute for electronic bookmarks. If hyperlinks are used, they should be clearly identifiable as a hyperlink by using a different color text similar to how MS Office identifies hyperlinks.
- C. Certificates and Inspections:
 1. Contact the State Construction Office Electrical Inspector to schedule all required inspections.
 - a. Inspections will occur during normal business hours, Monday through Friday, at the discretion of the SCO electrical inspector.
 - b. All requests for electrical inspections must include confirmation from the Designer (engineer) that electrical work to be inspected is complete, in conformance with contract documents, and is ready for SCO inspection. Contractor must plan adequate time for scheduling designer inspections to verify work is complete prior to scheduling state inspections.
- D. Operation and Maintenance Manuals:
 1. Refer to Division 01 - Operation and Maintenance Data.
 2. Upon completion of work but before final acceptance of system, submit to Architect for approval, 3 copies of operation and maintenance manuals in loose-leaf binders. If “one copy” is larger than 2” thick or consists of multiple volumes, submit only one set initially for review. After securing approval, submit 3 copies to Owner.
 3. Organize manuals by specification section number and furnish table of contents and tabs for each piece of equipment or system.
 4. Manuals shall include the following:
 - a. Copies of shop drawings
 - b. Manufacturer's operating and maintenance instructions. Include parts lists of items or equipment, with component exploded views and part numbers. Where manufacturer's data includes several types or models, designate applicable type or model.
 - c. CD ROM's or flash/thumb drives of O&M data with exploded parts lists where available

- d. Phone numbers and addresses of local parts suppliers and service companies
 - e. Internet/WEB page addresses where applicable
 - f. Wiring diagrams
 - g. Start up and shut down procedure
 - h. Factory and field test records
 - i. Additional information, diagrams or explanations as designated under respective equipment or systems specification section
5. Instruct Owner's representative in operation and maintenance of equipment. Instruction shall include complete operating cycle on all apparatus.
6. Furnish O&M manuals and instructions to Owner prior to request for final payment.
7. Include bookmarks as indicated above.
- E. Record Documents:
- 1. Refer to General Conditions of Contract and Division 01 - Project Record Documents. Prepare complete set of record drawings in accordance with Division 01.
 - 2. Use designated set of prints of Contract Documents as prepared by Architect to mark-up for record drawing purposes.

1.8 JOB CONDITIONS

A. Building Access:

- 1. Arrange for necessary openings in building to allow for admittance of all apparatus.

B. Coordination:

- 1. Equipment provided under other Divisions of these specifications.
 - a. Motors
 - b. Electrically powered equipment
 - c. Electrically controlled equipment
 - d. Starters, where specified
 - e. Variable frequency drives, where specified
 - f. Control devices, where specified
 - g. Temperature Control wiring
- 2. Provide the following devices required for control of motors or electrical equipment, unless otherwise noted:
 - a. Starters
 - b. Disconnect devices
 - c. Control devices:
 - 1) Pushbuttons
 - 2) Pilot lights
 - 3) Contacts
 - d. Conduit, boxes and wiring for Power wiring
 - e. Conduit, boxes and wiring for Control wiring, except for control wiring systems as defined in Section 230901 - Control Systems Integration.

3. Connect and wire equipment complete and ready to operate according to wiring diagrams furnished by various trades.
 4. Wire starters or other similar control devices furnished by others.
 5. This Contractor's drawings and/or specifications show number and hp rating of motors furnished by others, together with their actuating devices. Should any change in size, hp rating, voltage, or means of control be made to any motor or other electrical equipment after Contracts are awarded, Contractor responsible for change shall immediately notify this Contractor. Additional costs due to these changes shall be responsibility of Contractor initiating change.
 6. Equipment and wiring shall be selected and installed for conditions in which it will be required to perform. (i.e., general purpose, weatherproof, rain tight, explosion proof, dust tight, or any other special type as required.)
 7. Comply with local utility motor starting requirements and provide starters for motors furnished by others as specified herein or under various trade sections of those specifications.
- C. Cutting and Patching:
1. Refer to General Conditions of the Contract and Division 01 - Cutting and Patching.
 2. Perform cutting and patching required for complete installation of systems, unless otherwise noted. Patch and restore work cut or damaged to original condition. This includes openings remaining from removal or relocation of existing system components.
 3. Provide materials required for patching unless otherwise noted.
 4. Do not pierce beams or columns without permission of Architect and then only as directed. If openings are required through walls or floors where no sleeve has been provided, hole shall be core drilled to avoid unnecessary damage and structural weakening.
 5. Where alterations disturb lawns, paving, walks, etc., replace, repair or refinish surfaces to condition existing prior to commencement of work. This may include areas beyond construction limits.
- D. Housekeeping and Cleanup:
1. Refer to Division 01 - Closeout Procedures.
 2. As work progresses or as directed by Architect, periodically remove waste materials from building and leave area of work broom clean. Upon completion of work, remove tools, scaffolding, broken and waste materials, etc. from site.

1.9 WARRANTY

- A. Refer to Division 01 for general warranty requirements.
- B. Refer to technical sections for warranty requirement for each system.
1. Where no warranty requirements are called out, warrant as called out in Division 01 equipment, materials, and workmanship to be free from defect.
- C. Repair, replace, or alter systems or parts of systems found defective at no extra cost to Owner.

- D. In any case, wherein fulfilling requirements of any guarantee, if this Contractor disturbs any work guaranteed under another contract, this Contractor shall restore such disturbed work to condition satisfactory to Architect and guarantee such restored work to same extent as it was guaranteed under such other contract.
- E. Warranty shall include labor, material, and travel time.

PART 2 - PRODUCTS

2.1 PRODUCT SUBSTITUTIONS

- A. Refer to Division 01 - Product Requirements.

PART 3 - EXECUTION

3.1 GENERAL

- A. Verify elevations and dimensions prior to installation of materials.
- B. Where conduits are shown on plans, they are shown for reference only. Conduit routes shown on plans may not show all required junction boxes, pull boxes, control conduits, or coordination with other trades. Contractor is responsible for coordination of all conduit routes with other trades, and providing junction boxes and pull boxes as required by code.

3.2 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to the site under provisions of Division 01.
- B. Store and protect products under provisions of Division 01.
- C. Store in clean, dry space.
- D. Maintain factory wrapping or provide cover to protect units from dirt, water, construction debris, and traffic.
- E. Handle in accordance with manufacturer's written instructions.
- F. Handle carefully to avoid damage to components, enclosure, and finish. Lift only with lugs provided for the purpose.
- G. Provide supplemental heat if required to prevent moisture contamination. Provide temporary circuits as required.

3.3 FLOOR, WALL, ROOF AND CEILING OPENINGS

- A. Coordinate location of openings, chases, furred spaces, etc. with appropriate Contractors. Provide sleeves and inserts that are to be built into structure during progress of construction.

- B. Remove temporary sleeves, if used to form openings, prior to installation of permanent materials. Utilize minimum 24 ga galvanized sheet metal for permanent sleeves unless otherwise noted.
- C. Provide Schedule 40 carbon steel pipe with integral water stop for steel sleeves required below grade or to exterior.
- D. Submit to Structural Engineer for review and approval size and location of core-drilled holes prior to execution.
- E. Submit product data and installation details for penetrations of building structure. Include schedule indicating penetrating materials, (steel conduit, PVC conduit, cables, cable tray, etc.), sizes of each, opening sizes and sealant products intended for use.
- F. Where penetrations of fire-rated assemblies are involved, seal penetrations with appropriate firestopping systems as specified in 260593 - Electrical Systems Firestopping.
- G. Provide 2" clearance around penetration openings intended for raceways and cables. Where fire resistant penetrations are required, size openings in accordance with written recommendations of firestopping systems manufacturer.
- H. Seal non fire-rated floor penetrations with non-shrink grout equal to Embeco by Master Builders, or urethane caulk, as appropriate.
- I. Seal non-rated wall openings with urethane caulk.
- J. Where penetrations occur through exterior walls into building spaces, use steel sleeves with integral water stop, similar to type "WS" wall sleeves by Thunderline Corporation. Seal annular space between sleeves and pipe with "Link-Seal" modular wall and casing seals by Thunderline Corporation, or sealing system by another manufacturer approved as equal by Engineer. Sealing system shall utilize Type 316 stainless steel bolts, washers and nuts.
- K. Finish and trim penetrations as shown on details and as specified.
- L. Provide chrome or nickel plated escutcheons where raceways pass through walls, floors or ceilings and are exposed in finished areas. Size escutcheons to fit raceways for finished appearance. Finished areas shall not include mechanical/electrical rooms, janitor's closets, storage rooms, etc., unless suspended ceilings are specified.
- M. In Wash down areas,
 - 1. Exposed conduit penetrations shall be sealed as follows:
 - a. Escutcheons shall not be used when conduits are exposed in finished areas and penetrate finished surfaces.
 - b. Cut and patch penetration to within 1/4" of conduit.
 - c. Seal openings around conduit and patch work with sealants specified in Division 07 – Joint Sealants.. Sealant shall be installed per manufacturer's application requirements.
 - 2. Penetrations other than conduits (junction boxes, light fixtures, etc.) including wiring devices shall be sealed as follows:
 - a. Seal non-rated opening with silicone sealant.

- b. See drawings for details.
- c. Confirm selected sealant is compatible with paint provided by others prior to application.
- d. Product: One-Part Mildew-Resistant Silicone Sealant: Type S; Grade NS; Class 25; Uses NT, G, A, and as applicable to nonporous joint substances indicated, O; formulated with fungicide; intended for sealing interior joints with nonporous substrates and subject to in-service exposure to conditions of high humidity and temperature extremes; subject to compliance with requirements. Provide one of the following:
 - 1) 786 Mildew Resistant Silicone Sealant; Dow Corning Corp.
 - 2) Sanitary 1700 Silicone Sealant; General Electric Co.
 - 3) 898 Silicone Sanitary Sealant; Pecora Corp.
 - 4) Tremsil 600; Tremco Corp.
 - 5) OmniPlus; Sonneborn Building Products Div., Rexnord Chemical Products, Inc.

3.4 EQUIPMENT ACCESS

- A. Install raceways, cable tray, junction and pull boxes, and accessories to permit access to equipment for maintenance. Relocate raceways or accessories to provide maintenance access at no additional cost to Owner.
- B. Install equipment with sufficient maintenance space for removal, repair or changes to equipment. Provide ready accessibility to equipment and wiring without moving other future or installed equipment.
- C. Access doors in walls, chases, or inaccessible ceilings will be provided under Division 08 - Access Doors and Frames, unless otherwise indicated. Access doors for equipment shall provide access for servicing, repairs and/or maintenance.
- D. Provide necessary coordination and information to the Trade Contractor under Division 08 - Access Doors and Frames. This information shall include required locations, sizes and rough-in dimensions.
- E. Provide access doors in walls, chases or inaccessible ceilings for equipment requiring access for servicing, repairs and maintenance, unless otherwise noted. Access frames and doors shall be as manufactured by Milcor, Incorporated, or similar, of style applicable to surface. Provide access doors used in fire-rated construction with UL label. Provide steel, prime-coated access doors in dry locations. Provide stainless steel access doors for use in ceramic tile walls, toilet rooms, locker rooms, and in areas subject to excessive moisture. Provide access doors of sufficient size to allow complete maintenance. Coordinate location of access doors with General Contractor and rough-in equipment accordingly.
- F. Locate electrical outlets and equipment to fit details, panels, decorating or finish at space. Architect reserves right to make minor position changes of outlet locations before work has been installed.
- G. Verify door swings before installing room light switch boxes. Install boxes on latch side of door unless otherwise noted

3.5 EQUIPMENT SUPPORTS

- A. Provide supporting steel not indicated on drawings as required for installation of equipment and materials including angles, channels, beams, hangers, etc.
- B. Provide steel shell with plug type concrete anchors for attaching equipment to concrete. Plastic, rawhide or anchors using lead are not allowed.
- C. Do not support equipment or luminaires from metal roof decking.

3.6 SUPPORT PROTECTION

- A. In occupied areas, mechanical and electrical rooms and areas requiring normal maintenance access, guard certain equipment to protect personnel from injury.
- B. Provide minimum 1/2" thick Armstrong Armaflex insulation or similar product applied with Armstrong 520 adhesive on lower edges of equipment, including bus duct, cable tray, pull boxes and electrical supporting devices suspended less than 7 ft above floors, platforms or catwalks in these areas.
- C. Protect threaded rods or bolts at supporting elements as described above. Trim threaded rods or bolts such that they do not extend beyond supporting element.

3.7 ELECTRICAL SYSTEMS IDENTIFICATION

- A. Refer to Section 260553 - Identification for Electrical Systems

3.8 ACCEPTANCE TESTING

- A. When testing is to be witnessed by Architect/Engineer or Inspector, notify them at least 10 days prior to testing date.
- B. When equipment or systems fail to meet minimum test requirements, replace or repair defective work or materials as necessary and repeat inspection and test until equipment or systems meet test requirements. Make repairs with new materials.
- C. Contractor is responsible for certifying in writing equipment and system test results. Certification shall include identification of portion of system tested, date, time, test criteria and name and title of person signing test certification documents.
- D. Maintain copies of certified test results, including those for any failed tests, at project site. At completion of project, include copies of test records and certifications in O&M Manuals.

3.9 START-UP

- A. Systems and equipment shall be started, tested, adjusted, and turned over to Owner ready for operation. This includes "Owner-Furnished, Contractor-Installed" (OFCI) and "Contractor-Furnished, Contractor-Installed" (CFCI) systems and equipment.
- B. Follow manufacturer's pre-start-up checkout, start-up, trouble shooting and adjustment procedures.

- C. Contractor shall provide services of technician/mechanic knowledgeable in start-up and checkout of types of systems and equipment on project.
- D. Provide start-up services by manufacturer's representative where specified or where Contractor does not have qualified personnel.
- E. Coordinate start-up with all trades.

3.10 CLEANING

- A. Clean systems after installation is complete.
- B. Vacuum debris from panelboards, switchboards, motor starter and disconnect switch enclosures, junction boxes and pull boxes two weeks before energization and again prior to completion.
- C. Where louvers are provided in switchgear or transformer enclosures, vacuum louvers free of dust and dirt.
- D. Clean luminaire lenses and lamps at time of installation and clean lens exteriors just prior to final inspection.
- E. Thoroughly clean equipment of stains, paint spots, dirt and dust. Remove temporary labels not used for instruction or operation.
- F. During construction, maintain indoor air quality per general contractors IAQ plan for LEED credit.

END OF SECTION 260000

SECTION 260516 - OWNER-FURNISHED EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Section includes electrical connection(s) to Owner-purchased pieces of equipment, which are required in construction.
- B. Owner-furnished equipment requiring work by the Contractor is shown on the drawings and schedules.
- C. Owner-furnished, Contractor-installed equipment is labeled OFCI.

1.2 SUBMITTALS

- A. Shop Drawings: Owner-supplied shop drawings of equipment furnished by Owner.
- B. Manufacturer's Installation Instructions:
 - 1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

1.3 QUALITY ASSURANCE

- A. Regulatory Requirements:
 - 1. Comply with NFPA 70 for components and installation.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Maintain factory unopened packaging until ready for installation.

PART 2 - PRODUCTS

2.1 (NOT APPLICABLE TO THIS SECTION)

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Provide labor, materials and electrical connections for Owner-furnished equipment in accordance with contract drawings.
- B. Install and connect Owner-furnished equipment as though it had been purchased by Contractor.
 - 1. This shall include:
 - a. Receiving equipment at jobsite
 - b. Rigging and setting equipment in place
 - c. Making electrical connections

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- d. Starting
- e. Testing
- C. Coordinate with owner equipment provider and start-up technician as required for a complete and working installation.
- D. Install equipment in accordance with manufacturer's installation instructions.
- E. Maintain equipment until facility is accepted by Owner.
- F. Review Owner-supplied shop drawings of Owner-furnished equipment to ascertain that necessary labor and materials have been provided to install equipment and complete the system it serves.

END OF SECTION 260516

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Section includes conductors and cables rated 600 V and less, connectors, splices, and terminations rated 600 V and less, sleeves and sleeve seals for cables.
- B. Conductor and conduit sizes in these contract documents are based on copper wire, and only copper wire shall be used.

1.2 REFERENCE STANDARDS

- A. ASTM B1 – Standard Specification for Hand-Drawn Copper Wire.
- B. ASTM B8 – Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
- C. NEMA WC 70 – Non-Shielded Power Cable 2000 V or less for the Distribution of Electrical Energy (ICEA S-95-658).
- D. NFPA 70 – National Electrical Code.
- E. UL 44 – Thermoset-Insulated Wires and Cables.
- F. UL 83 – Thermoplastic-Insulated Wires and Cables.
- G. UL 486A-486B – Wire Connectors.
- H. UL 486C – Splicing Wire Connectors.
- I. UL 486D – Standard for Insulated Wire Connector Systems for Underground Use or in Damp or Wet Locations.
- J. UL 486E – Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors.
- K. UL 1569 – Standard for Metal-Clad Cables.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation.
- C. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
- D. Closeout Submittals:

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1. Project Record Documents:
 - a. Record actual locations of components and circuits.
2. Operation and Maintenance Data:
 - a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.

1.4 QUALITY ASSURANCE

- A. Regulatory Requirements:
 1. Comply with NFPA 70 for components and installation.
 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
- B. Wire and cable boxes and reels shall bear the date of manufacture.
 1. Date of manufacture shall not precede contract date by more than one year.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Protect from dirt, fumes, water, corrosive substances, and construction debris.

1.6 WARRANTY

- A. Refer to Division 01 and Section 260000 - General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of final acceptance.

PART 2 - PRODUCTS

2.1 MANUFACTURERS (CONDUCTORS)

- A. General Cable Corporation
- B. Cerrowire
- C. Southwire Company
- D. Encore Wire Corporation
- E. Approved equals

2.2 MANUFACTURERS (VFD CABLE)

- A. Belden
- B. Nexans/Amercable

- C. Southwire
- D. Approved equals

2.3 DESCRIPTION

- A. NEMA WC 70; single copper conductor insulated wire; 600 V rated insulation; 90°C maximum operating temperature for dry and wet or damp locations.
 - 1. Thermoplastic-insulated wires and cables: NEMA WC 70, UL 83; Type THHN/THWN.
 - 2. Thermoset-insulated wires and cables: NEMA WC 70, UL 44; Type XHHW.
- B. VFD Cable:
 - 1. Cable
 - a. 2000V rated, high stranded tinned copper conductors, shielded, engineered for use with Variable Frequency Drives.
 - b. Insulation shall be rated for 90 degrees Celsius Wet/Dry operating temperature.
 - 2. Conductors
 - a. Conductor shall be annealed fine wire flexible high strand count tinned copper or standard Class B stranded bare copper.
 - b. Three (3) phase conductors, three (3) ground conductors. Each of the three ground conductors shall be the same size as the single ground conductor shown on the drawings.
 - 3. Insulation
 - a. Flame-Retardant Cross-Linked Polyethylene.
 - b. Conductors shall be cabled together. Ground conductors shall be symmetrical. Fillers shall be included as necessary to make the cable round.
 - 4. Shielding
 - a. The following are acceptable:
 - 1) Overall tinned copper braid plus aluminum/polyester tape foil, 100% coverage.
 - 2) 5mil helically applied copper tape.
 - 5. Jacket
 - a. Flame-retardant Thermoplastic, suitable for 90°C use.
 - 6. Termination Kit
 - a. Pre-sized and pre-formed specifically for VFD cable constructions. Obtain from VFD cable manufacturer.

2.4 REMOTE CONTROL AND SIGNAL CIRCUITS

- A. Class 1
 - 1. Copper conductor, single insulated wire.
 - 2. Insulation type THHN/THWN rated 90°C, 600 V insulation class.
 - 3. Type XHHW for ambient temperature less than 32°F.
 - 4. UL 83 listed, ASTM B1 for solid conductors; ASTM B 8 for stranded conductors.

B. Classes 2 and 3

1. Copper conductor, multiple twisted conductors covered with an overall non-metallic jacket unless otherwise noted.
2. Insulation type XLPE, rated 105°C, 300 V insulation class.
3. UL listed for use in space in which circuits will be installed.

2.5 CONNECTORS, SPLICES, AND TERMINALS

A. Manufacturers:

1. AFC Cable Systems, Inc.
2. Hubbell Power Systems, Inc.
3. O-Z/Gedney; EGS Electrical Group LLC.
4. 3M; Electrical Products Division
5. Tyco Electronics Corp.
6. Approved equal

- B. Description: UL 486A-486B, UL 486C, UL 486D, UL 486E; factory-fabricated connectors, splices, and terminals of size, ampacity rating, material, type, and class for application and service indicated.

2.6 TERMINATIONS

- A. Compression set, bolted or screw type lug, or direct to bolted or screw type terminal.

2.7 PLASTIC CABLE TIES

- A. Nylon or approved; locking type; metallic ties not permitted.
- B. Provide UL Listed materials for all cable ties used for electrical applications.

PART 3 - EXECUTION

3.1 INSTALLATION OF CONDUCTORS AND CABLES

- A. Install conductors in a raceway system, unless otherwise specified or indicated.
- B. Install conductors only after:
1. Building interior is enclosed and weather tight
 2. Mechanical work likely to damage conductors has been completed
 3. Raceway installation is complete and supported
- C. Pull conductors into raceway at same time.
- D. Neatly train and lace conductors inside boxes, equipment, and panelboards.
- E. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

- F. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- G. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- H. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible. Protect exposed cables from damage.
- I. Support cables above accessible ceiling using plastic cable ties to support cables from structure or ceiling suspension system. Do not rest cable on ceiling panels.
- J. Support cables and conductors in vertical raceways per requirements in Section 260529 - Hangers and Supports for Electrical Systems.
- K. Identify and color-code conductors and cables according to Section 260553 - Electrical Systems Identification.
- L. Wiring at Outlets: Install conductor at each outlet, with minimum 6" of slack.
- M. Limit conduit fill to a maximum of 9 current-carrying conductors.
- N. Install stranded conductors where conductors terminate in crimp type lugs. Do not place bare stranded conductors directly under screws.
- O. Install VFD input wiring, output wiring and control wiring in their own separate conduit systems.
- P. Provide dedicated neutrals for branch circuits unless otherwise noted on drawings.

3.2 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Copper. Solid for #10 AWG and smaller; stranded for #8 AWG and larger.
- B. Branch Circuits: Copper. Solid for #10 AWG and smaller; stranded for #8 AWG and larger.
- C. Minimum conductor sizes shall be as follows:
 - 1. #12 AWG – Branch circuits of any kind.
 - 2. #14 AWG – Fire alarm system.
 - 3. #16 AWG – Remote control and signal systems.
- D. Branch wiring length limitations:
 - 1. Where wire sizes are shown on project drawings and do not indicate they have been adjusted for voltage drop based on circuit length, they shall be increased as noted below depending on Contractor routing.
 - 2. 208Y/120 V circuits over 75 ft in length: Increase wire size one size for each 75 ft in length. Increase conduit size as required.
 - 3. 480Y/277 V circuits over 150 ft in length: Increase wire size one size for each 150 ft of length. Increase conduit size as required.

3.3 CONDUCTOR INSULATIONS AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type XHHW-2, rated 90°C for wet locations, single conductors in raceway.
- B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN/THWN-2, rated 90°C for wet locations, single conductors in raceway.
- C. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, rated 90°C for wet locations, single conductors in raceway.
- D. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN, rated 90C for dry locations, single conductors in raceway.
- E. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, rated 90°C for dry and wet or damp locations, single conductors in raceway.
- F. Motor Circuit Branch Wiring and Associated Control Wiring: Type THHN, rated 90°C for dry and wet or damp locations, single conductors in raceway, stranded.
 - 1. Where installed outdoors, provide type THWN insulation, rated for 90C for wet or damp locations, single conductors in raceway.
- G. Motor Circuit Branch Wiring Between Motor and VFD: VFD Cable
 - 1. Terminate VFD cable using pre-sized and pre-formed termination kits supplied by cable manufacturer. Install per manufacturer's recommendations.
- H. Wiring in Light Fixture Channels: Type THHN/THWN-2, rated 90°C for dry and damp locations, single conductors.
- I. Branch Circuits Single Conductors in Raceway: 90°C rated conductors sized at 75°C rating for connection to equipment and devices.
- J. Circuits 100A and less, utilize 60C for ampacity (unless both sides of the circuit are listed for 75C). Circuits 100A and over use 75C for ampacity. If the wire insulation ratings are higher, they may be utilized for de-rating purposes only and wire size shall be increased if the de-rated insulation rating is less than the required load current.
- K. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

3.4 REMOTE CONTROL AND SIGNAL CIRCUITS

- A. Sizing – #16 AWG minimum.
- B. Installation:
 - 1. Install cables in cable tray and cable rings.
 - 2. Provide protection for exposed cables where subject to damage.
 - 3. Support cables above accessible ceilings; do not rest on ceiling tiles.
 - 4. Use suitable cable fittings and connectors.

3.5 CONNECTORS, SPLICES, AND TERMINALS

A. Connectors:

1. Except where equipment is furnished with bolted or screw type lug, use compression set pressure connectors with insulating covers. Use compression tools and die compatible with connectors being installed.
 - a. Do not use compression set connectors for conductors #10 and smaller.
2. Use bolt or compression-set type with application of insulating tape, pre-stretched or heat-shrinkable insulating tubing for splices and taps of #8 AWG conductors and larger. Install with hydraulic compression tool.
3. Use pre-insulated "twist-on" connectors with integral spring for splices and taps of #10 AWG conductors and smaller.
4. 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.

B. Splices:

1. Splice wires and cable only in accessible locations such as within junction boxes.
2. Make splices to carry full capacity of conductors with no perceptible temperature rise.
3. Make below-grade splices in manholes and handholes watertight with pre-stretched or heat-shrinkable insulating tubing, or resin-filled insulator.
4. Use electrical tape to build up insulation level equivalent to cable insulation and cover with not less than two half-lapped layers of plastic electrical tape, for joints, taps, and splices of #1 AWG conductors and larger.
5. Plastic snap-on splice insulators are not allowed.
6. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Terminals:

1. Insulate ends of spare conductors with electrical tape and identify spare circuit number where appropriate.
2. Eye type crimped terminal for removable screw type terminal. Forked torque terminal when screw terminal cannot be removed.
3. Train wires to eliminate fanning of strands, crimp with proper tool and die.
4. Torque screw termination per manufacturer's recommended values.

3.6 CABLE TIES

- A. Neatly bundle conductors and cables together for support. Size cable ties sufficiently to accommodate the multiple cables being supported.

3.7 FIELD QUALITY CONTROL

- A. Test 600 volt conductors and cables per requirements in Sections 260812 - Power Distribution Acceptance Tests and 260813 - Power Distribution Acceptance Test Tables.

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- B. Interpret test results in writing and submit to Engineer.
- C. Replace conductors and cables that are found defective, at no expense to Owner.

END OF SECTION 260519

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Section includes methods and materials for grounding systems and equipment, as required by State Codes, NFPA 70 , applicable portions of other NFPA codes, as indicated herein, plus the following special applications:
 - 1. Underground distribution grounding.
 - 2. Common ground bonding with lightning protection system.
- B. Maximum resistance to ground shall be less than 5 ohms.
- C. Refer to Grounding Riser Diagram.

1.2 REFERENCE STANDARDS

- A. TIA-607 - C – Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
- B. ASTM B3 – Specification for Soft or Annealed Copper Wire
- C. ASTM B8 – Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard or Soft
- D. ASTM B33 – Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes
- E. IEEE C2 – National Electrical Safety Code (ANSI)
- F. IEEE 857 – Standard for Qualifying Permanent Connections Used in Substation Grounding
- G. NETA MTS – Maintenance Testing Specifications
- H. NFPA 70 – National Electrical Code
- I. NFPA 70B – Recommended Practice for Electrical Equipment Maintenance
- J. NFPA 780 – Lightning Protection Systems
- K. UL 96 – Lightning Protection Components
- L. UL 467 – Grounding and Bonding Equipment

1.3 TELECOMMUNICATIONS GROUNDING SYSTEM DEFINITIONS

- A. Grounding Equalizer (GE): Conductor that interconnects elements of telecommunications grounding infrastructure.

- B. Telecommunications Bonding Backbone (TBB): Conductor that interconnects telecommunications main grounding busbar (TMGB) to telecommunications grounding busbar (TGB).
- C. Telecommunications Bonding Conductor: Conductor that interconnects telecommunications bonding infrastructure to building's service equipment (power) ground.
- D. Telecommunications Grounding Busbar (TGB): Interface to building telecommunications grounding system, common point of connection for telecommunications system and equipment to ground, and located in telecommunications room or equipment room.
- E. Telecommunications Main Grounding Busbar (TMGB): Busbar placed in convenient and accessible location and bonded by means of bonding conductor for telecommunications to building service equipment (power) ground.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Other Informational Submittals:
 - 1. Plans showing dimensioned as-built locations of grounding features, including the following:
 - a. Test wells
 - b. Ground rods
 - c. Ground rings
 - 2. Photos of underground grounding and bonding
- C. Field Quality-Control Test Reports:
 - 1. Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
 - 2. Test reports of resistance to earth. Each test report shall include:
 - a. Date of test, soil moisture content, and soil temperature
 - b. Test operator
 - c. Instrument or other test equipment used
 - d. Electrode designation or location
 - e. Ground impedance in ohms
 - f. Assumptions made - if required
- D. Closeout Submittals:
 - 1. Operation and Maintenance Manuals: Include the following:
 - a. Instructions for periodic testing and inspection of grounding features at test wells based on NFPA 70B.
 - 1) Instructions to perform tests to determine if ground resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if they do not.
 - 2) Include recommended testing intervals.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70.
2. Comply with UL 467 for grounding and bonding materials and equipment.

1.6 DELIVERY, STORAGE, AND HANDLING

- ### A. Store products in clean, dry space. Protect from dirt, fumes, water, corrosive substances, and construction debris.

1.7 WARRANTY

- ### A. Refer to Division 01 and Section 260000 - General Electrical Requirements for general warranty requirements.
- ### B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of final acceptance.

PART 2 - PRODUCTS

2.1 CONDUCTORS

- #### A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction, insulation color: green.
- #### B. Bare Copper Conductors:
1. Solid Conductors: ASTM B3.
 2. Stranded Conductors: ASTM B8.
 3. Tinned Conductors: ASTM B33.
 4. Bonding Cable: 28 kcmil, 14 strands of #17 AWG conductor, 1/4" in diameter.
 5. Bonding Conductor: #4 AWG or #6 AWG, stranded conductor.
 6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8" wide and 1/16" thick.
 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8" wide and 1/16" thick.
- #### C. Bare Grounding Conductor and Conductor Protector for Wood Poles:
1. #4 AWG minimum, soft drawn copper.
 2. Conductor Protector: Half-round PVC or wood molding. If wood, use pressure-treated fir or cypress or cedar.
- #### D. Grounding Bus: Horizontal rectangular bars of annealed copper, physical size as indicated on drawings.

2.2 CONNECTORS

- A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Electro-tin plated copper or copper alloy, bolted pressure-type, with at least two bolts.
 - 1. Pipe connectors: Clamp type, sized for pipe.
- C. Welded Connectors: Exothermic welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- D. Compression Connectors: Irreversible type.

2.3 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel; 3/4" in diameter by 10' in length.

2.4 TELECOMMUNICATIONS BUSBARS

- A. Material: Copper
 - 1. 1/4" thick
- B. Pre-drilled
 - 1. 3/8" diameter
 - 2. Hole spacing per ANSI Joint Standard TIA-607-C
 - 3. Hole pattern shall accommodate two-hole lugs
- C. Insulators and stand-off brackets shall electrically isolate busbar from wall or other mounting surface.
- D. Provide busbars listed by nationally recognized testing laboratory.
- E. Size:
 - 1. Telecommunications Main Ground Busbar (TMGB) – 20" x 4" (minimum)

2.5 TELECOMMUNICATIONS GROUNDING CONDUCTORS

- A. Material: Stranded copper
- B. Provide insulated bonding conductors.
 - 1. Green Jacket or Black Jacket marked with Green Tape or Green adhesive labels per NEC Guidelines.
- C. Size:
 - 1. Bonding Conductor for Telecommunications (BCT; TMGB to Grounding Electrode) , Telecommunications Bonding Backbone (TBB; TMGB to TGB), Grounding Equalizer (GE; TBB to TBB): as indicated on drawings

2. Telecommunications Bonding Backbone (TBB; TMGB to TGB) as indicated on drawings

2.6 TELECOMMUNICATIONS GROUNDING CONNECTIONS

A. Mechanical Connectors:

1. Connector Body:
 - a. High-strength, high-conductivity cast copper alloy
 - b. 2-bolt type
2. Bolts, nuts, washers, and lock-washers: 300 series stainless steel
 - a. Supplied as part of connector body
 - b. Split-bolt connector types are not allowed.
3. Connector:
 - a. Meet or exceed UL 467
 - b. Clearly marked with catalog number, conductor size, and manufacturer

B. Compression Connectors:

1. Connector Body: Pure wrought copper.
2. Conductivity shall be no less than 99% by IACS Standards.
3. Connector:
 - a. Meet or exceed performance requirements of IEEE 837, latest revision.
 - b. Filled with an oxide-inhibiting compound.
 - c. Clearly marked with manufacturer, catalog number, conductor size, and required compression tool settings.
4. Connection shall be irreversible.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for. #8 AWG and smaller, and stranded conductors for #6 AWG and larger, unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare copper conductor. Sized as indicated on drawings.
 1. Bury at least 24" below grade.
 2. Ductbank Grounding Conductor: Bury 12" above ductbank when indicated as part of ductbank installation.
- C. Grounding Bus: Install in electrical and communications rooms, in rooms housing service equipment.
 1. Install bus on insulated spacers, 1" , minimum, from wall; 6" above finished floor.
 2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down to specified height above floor, and connect to horizontal bus.
- D. 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

3.2 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with feeders and branch circuits.
 1. Install for each branch circuit neutral originating from panelboards, including lighting circuits.
- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 1. Feeders and branch circuits
 2. Lighting circuits
 3. Receptacle circuits
 4. Single-phase motor and appliance branch circuits
 5. Three-phase motor and appliance branch circuits
 6. Flexible raceway runs
 7. Armored and metal-clad cable runs
- C. Air-Duct Equipment Circuits: Install a separate insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping. Ground ductwork of fans serving flammable liquid storage rooms or fume hoods. Install continuous ground around any flexible connections in this ductwork system. Bond lower end of exhaust ducts, vent stacks, etc., which pass through roof.
- D. Metallic Sleeves: Minimum #6 AWG
- E. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- F. Duplex receptacles and light switches of any amperage: Install separate jumper between grounding terminal on device and metallic box.
- G. Size of equipment grounding conductors for branch circuits: As indicated in NEC-70, except minimum size shall be #12 AWG.
- H. Size of branch panel feeder originating at switchboards/switchgear: As indicated in NEC-70, except in no instance smaller than #8 AWG.

- I. Signal and Communication Equipment: For alarm and other communication equipment (see Telecommunications Grounding System Installation section below for voice and data systems), install insulated grounding conductor (sized as indicated on drawings) in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
- J. Install grounding conductor from each standby-emergency generator to grounding electrode system. Provide flexible jumper between base and isolated generator.
- K. Install equipment grounding conductor from secondary side of each transformer to grounding electrode system as required for separately derived system.
- L. Install grounding for service entrance equipment room consisting of ground bus, ground conductors, and grounding rods arranged as indicated on drawings.
 - 1. Install ground bus per details on drawings.
- M. Install grounding conductor to luminaires hanging from conduit swivel hangers.
- N. Metal Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors to pole base. Grounding Conductor: Same size as phase conductors, but not smaller than #10 AWG.
 - 1. Install at each pole or standard a concealed driven 3/4" x 10'-0" ground rod, ground clamp and No. 3 stranded copper conductor concealed and attached to pole and base.

3.3 SEQUENCING, SCHEDULING

- A. Permanently attach service grounds before permanent building service is energized.
- B. Permanently attach equipment grounds prior to energizing equipment.

3.4 INSTALLATION

- A. Contractor shall take photographs of all underground grounding and bonding connections prior to covering. Furthermore, Contractor shall coordinate with the Authority Having Jurisdiction to confirm approval of installation prior to covering.
- B. Connections: Exposed and visible for inspection at all times. Do not install insulation over ground connections.
- C. Identify all grounding conductors by system and room number of termination at building grounding electrode point.
- D. Grounding Conductors: 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.

- E. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96A when interconnecting with lightning protection system. 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, and install in conduit.
- F. Ground Rods: Drive rods until tops are 12" below finished floor or final grade, unless otherwise indicated.
 - 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. For grounding electrode system, install at least 3 rods spaced at least one rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- G. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes shall be at least 12" deep, with cover. Drive rods until tops are 6" above bottom of inspection well or in-ground handhole gravel base. Connection to Ground rod shall be on the exposed portion above grade.
 - 1. Test Wells: 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.
- H. 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 so vibration is not transmitted to rigidly mounted equipment.
 - 3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.
- I. 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 bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Water pipe, by itself, is not an adequate grounding electrode and must be supplemented by another electrode system. Bond system together.
 - 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 - 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
 - a. Confirm application with local gas and electric utility ordinances and notify the engineer if restrictions do not allow bonding as required by the project documents.

- J. Grounding Electrode Conductors installed in metal conduit or sleeves shall be bonded at each end using grounding hubs. The bonding conductor shall be the same size as the grounding electrode conductor. Conduits terminated to grounding enclosures shall be secured to enclosure using grounding locknuts.
- K. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned copper bonding jumper to bond across flexible duct connections to achieve continuity.
- L. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60' apart.
- M. Bond steel columns at bases using copper conductor to column footing rebar sized as indicated on plans.
- N. Make grounding connections on surface that has been cleaned of paint, dirt, oil, etc., so that connections are bare metal to bare metal contact.
- O. Make grounding connections tight with UL listed grounding devices, fittings, bushings, etc.
- P. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around the perimeter of area or item indicated on drawings.
 - 1. Install copper conductor as indicated on drawings.
 - 2. Bury ground ring not less than 24" below grade.
- Q. Concrete-Encased Grounding Electrode: Fabricate according to NFPA 70, using a minimum of 20 ft of bare copper conductor not smaller than #4 AWG.
 - 1. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to grounding electrode external to concrete.
- R. Equipment Grounding Conductor: Terminate in panelboard at green wire ground bus.
- S. Multiple Conductors on Single Lug: Not permitted. Terminate each grounding conductor on its own terminal lug.
- T. Flexible Metallic Conduit, Non-Metallic Rigid Conduit, or Liquid Tight Flexible Conduit: Install green wire grounding conductor with phase conductors in conduit.

3.5 TELECOMMUNICATIONS BONDING AND GROUNDING SYSTEM INSTALLATION

- A. Provide required elements and miscellaneous hardware necessary to establish Telecommunication Bonding and Grounding infrastructure as specified.
- B. Install products in accordance with manufacturer's instructions. Install Compression Connectors with compression, tool-and-die system, as recommended by manufacturer of connectors.

- C. Telecommunications Bonding Conductor, Telecommunications Bonding Backbone (TBB), and Grounding Equalizer (GE): Compression or Exothermic type connections.
- D. Locate TGBs and TMGB per drawings.
- E. Telecommunications Bonding Backbone (TBB) shall be continuous and not interrupted by Telecommunications Grounding Busbars (TGB).
 - 1. TGBs shall be bonded to TBB via tap off of TBB. Exception: "last" TGB on TBB (e.g., furthest from TMGB).
 - 2. Grounding Equalizer(s) (GE) shall connect to TGBs to be interconnected.
- F. Insulate busbars from their support.
- G. Coordinate with Sections 271000 - Structured Cabling, 271100 - Communications Equipment Room Fittings, 271300 - Communications Backbone Cabling and 271500 - Communications Horizontal Cabling.

3.6 FIELD QUALITY CONTROL

- A. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 - 1. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal at ground test wells. Make tests at ground rods before any conductors are connected.
- B. Test grounding systems per requirements in Section 260812 - Power Distribution Acceptance Tests and 260813 - Power Distribution Acceptance Test Tables.
- C. Interpret test results in writing and submit to Engineer.
- D. Inspect completed system by commissioning authority, prior to backfilling.

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Section includes the following:
 - 1. Manufactured hangers and supports for individual raceways and cables, slotted channel and angle systems for multiple conduit runs, and most electrical equipment that is not floor mounted.
 - 2. Construction requirements for concrete housekeeping pads for floor-mounted electrical equipment.
 - 3. Equipment mounts for acoustical noise and vibration control.

1.2 REFERENCE STANDARDS

- A. AWS D1.1/D1.1M – Structural Welding Code-Steel.
- B. ASTM A36/A36M – Carbon Structural Steel.
- C. ASTM F3125/F3125M – Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength.
- D. ASTM A780/A780M – Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
- E. MSS SP-58 – Pipe Hangers and Supports - Materials, Design and Manufacture.
- F. MSS SP-69 – Pipe Hangers and Supports - Selection and Application.
- G. MFMA-4 – Metal Framing Standards Publication.
- H. NECA 1 – Standard Practices for Good Workmanship in Electrical Construction.
- I. NECA 101 – Standard for Installing Steel Conduits (Rigid, IMC, EMT).
- J. NFPA 70 – National Electrical Code.
- K. SSPC-PA 1 – Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel.
- L. ETL PVC-001 – PVC Coated Conduit

1.3 SUBMITTALS

- A. Product Data: For the following:
 - 1. Steel slotted support systems.
 - 2. Nonmetallic slotted support systems.

3. Raceway and cable supports.
 4. Support for conductors in vertical raceway.
 5. Structural steel for fabricated supports and restraints.
 6. Mounting, anchoring, and attachment components:
 - a. Mechanical-expansion anchors.
 - b. Concrete inserts.
 - c. Clamps for attachment to structural steel.
 - d. Through bolts.
 - e. Toggle bolts.
 - f. Hanger rods.
- B. Shop Drawings: Signed and sealed by an Engineer registered and licensed in the State of NC. Include concrete anchors application, size, and placement. Include concrete inserts application, size, loading, and placement. Show fabrications and installation details and include calculations for the following:
1. Trapeze hangers. Include product data for components.
 2. Steel slotted channel systems. Include product data for components.
 3. Nonmetallic slotted channel systems. Include product data for components.
 4. Fabricated metal equipment support assemblies.
- C. Drawings showing specific locations of any suspended loads which exceed 100 lbs within joist chord panel, to be attached to open web steel joist structural members. Include weight supported by such attachments. (Panel is length of chord between two adjacent diagonal web members at points of connection to chord.)
- D. Welding certificates and drawings showing specific locations of any weld attachments to structure including weight supported by such attachments.
1. Any proposed weld attachments to building structure shall be reviewed by Structural Engineer prior to execution of work. This review may result in use of other welding codes or standards, which may apply to “structural work”. Execution of this work may be assigned to General Trades responsible for building structural steel. Cost of this work, however, will remain the responsibility of this Contractor.
- E. Schedule of hangers and support devices with support spacing.

1.4 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, “Structural Welding Code – Steel.”
- B. Comply with NFPA 70.
- C. Certification:
 1. Installer of PVC-coated hangers and supports shall be certified by a PVC conduit manufacturer.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of 5 times the applied force.
- B. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
 - 1. Finishes
 - a. Metallic Coatings:
 - 1) Factory standard primed, galvanized or electroplated finish and applied according to MFMA-4, for indoor applications.
 - 2) Hot-dip galvanized after fabrication and applied according to MFMA-4, for outdoor applications.
 - b. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4, for corrosive environments.
 - c. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - 2. Channel Dimensions: Selected for applicable load criteria.
 - 3. Manufacturers:
 - a. Allied Support Systems; Power-Strut Unit.
 - b. Cooper B-Line, Inc.; A division of Cooper Industries.
 - c. ERICO International Corporation.
 - d. GS Metals Corporation.
 - e. Thomas & Betts Corporation.
 - f. Unistrut; Tyco International, Ltd.
 - g. Wesanco, Inc.
 - h. National Pipe Hanger Corporation.
 - i. Michigan Hanger Co., Inc.; O-Strut Division.
 - j. Approved equal.
- C. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16" diameter holes at a maximum of 8" o.c., in at least one surface.
 - 1. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
 - 2. Fitting and Accessory Materials: Same as channels and angles, except metal items may be stainless steel.
 - 3. Rated Strength: Selected to suit applicable load criteria.
 - 4. Manufacturers:
 - a. Allied Support Systems; Power-Strut Unit
 - b. Cooper B-Line, Inc.; A division of Cooper Industries

- c. Fabco Plastics Wholesale Limited
 - d. Seasafe, Inc.
 - e. Approved equal
- D. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- E. Raceway and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- F. PVC Raceway Support Devices: ANSI C80.1, UL 6, ETL PVC-001.
- G. Support for 600V and under Conductors in Vertical Raceway: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
 - 1. Manufacturers:
 - a. O-Z/Gedney
 - b. Approved equal
- H. Structural Steel for Fabricated Supports and Restraints: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.
- I. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
 - 1. Concrete Anchors
 - a. Anchors shall be selected, sized, and detailed by Contractor's structural engineer registered in project's jurisdiction, based on project conditions and in accordance with project building code. Calculations and drawings shall be submitted.
 - b. Anchors shall meet ICC Acceptance Criteria, and ICC-ES Evaluation Reports (ESRs) shall specifically list the current applicable codes.
 - c. Anchors installed in hardened concrete for purpose of transmitting structural loads from one connected element to another, or for safety related elements such as sprinkler pipes, heavy suspended pipes, and barrier rails shall have ICC-ES report demonstrating anchors have met requirements of AC 193 for mechanical anchors in concrete elements.
 - d. Post-installed expansion anchors and undercut anchors installed in hardened concrete shall be qualified for strength design and tested according to ACI 355.2. Designs shall be per the requirements of ACI 318, Appendix D.
 - e. Anchors shall be zinc plated in accordance with ASTM B633.
 - f. Select anchors with load ratings based on cracked concrete conditions.
 - g. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
 - 1) Manufacturers:
 - a) Cooper B-Line, Inc.; A division of Cooper Industries

- b) Empire Tool and Manufacturing Co., Inc.
 - c) Hilti Inc.
 - d) ITW Ramset/Red Head; A division of Illinois Tool Works, Inc.
 - e) MKT Fastening, LLC.
 - f) Approved equal
- 2. Concrete Inserts: Steel or malleable-iron, 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.
- J. Beam Clamps: C-clamps are allowed 3/8" or smaller and only for static loading such conduits. Provide locknut for hanging rod at clamp. C-clamps are not allowed for open web steel joist applications nor seismic applications.
- K. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
- L. Toggle Bolts: All-steel springhead type.
- M. Hanger Rods:
 - 1. MSS SP-58; threaded steel, with adjusting and lock nuts; hot-dipped galvanized finish.
 - 2. MSS SP-58; nonmetallic, with adjusting and lock nuts.

2.2 FABRICATED METAL FRAMING 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; not be lighter than 12 ga.
- C. Finish: Electro-galvanized
- D. Manufacturers: Same as in paragraph 2.1.B.3 above.

2.3 CONTINUOUS INSERT CHANNELS

- A. Length and support capabilities to be suitable for application.
- B. Brackets, inserts and accessories suitable for channel insert selected.
- C. Manufacturers:
 - 1. Unistrut; Tyco International, Ltd.
 - 2. Cooper B-Line, Inc.; A division of Cooper Industries
 - 3. Michigan Hanger Co., O-Strut Division
 - 4. Anvil International, Inc.
 - 5. Approved equal

2.4 EQUIPMENT MOUNTS FOR ACOUSTICAL NOISE AND VIBRATION CONTROL

A. Manufacturers:

1. Mason Industries, Inc. (Hauppauge, NY), Type ND.
2. Amber/Booth Co. (Houston, TX), Type RVD.
3. Kinetics Noise Control, Inc. (Dublin, OH), Type RD.
4. Vibration Eliminator Co., Inc. (Long Island City, NY), Type D44.
5. Vibration Mountings & Controls, Inc. (Butler, NJ), Series RD.

B. FN (floor neoprene) isolators shall be neoprene-in-shear type with steel reinforced top and base. All metal surfaces shall be covered with neoprene. The top and bottom surfaces shall be ribbed. Bolt holes shall be provided in the base and the top shall have a threaded fastener. The mounts shall include leveling bolts that may be rigidly connected to the equipment.

C. FN isolators shall be selected to achieve 1/10" minimum static deflection under load.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70.

1. Size steel hanger rods for individual hangers and trapeze supports as indicated in the following schedule. Total weight of equipment shall not exceed limits indicated.

Maximum Loads (lbs(kg))	Rod Diameter ("(mm))	Maximum Pipe Size
		With Single Rod
730lbs	3/8"	2"
1130lbs	1/2"	3"
1818lbs	5/8"	5"

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25% in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with 2-bolt conduit clamps.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 3/4" and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

E. Install PVC-coated hangers and supports in areas with corrosive atmosphere as noted on plans.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements, except as specified in paragraphs below.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT may be supported by openings through structure members, as permitted in NFPA 70.
- C. 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 plus 200 lb.
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor application size and placement shall be reviewed and approved by Structural Engineer prior to installation. 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.
 - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 4. To Existing Concrete: Expansion anchor fasteners.
 - 5. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
 - 6. To Light Steel: Sheet metal screws.
 - 7. Items Mounted 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 substrate by means that meet seismic-restraint strength and anchorage requirements.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.
- F. Do not support raceway by other raceway.
- G. Do not support equipment or raceway from metal roof decking or floor decking.
- H. Do not impose weight of electrical equipment, raceways, or lighting fixtures on support provided for other trades or systems.
- I. Top or bottom chords of open web steel joists may be used to support loads provided total load within panel does not exceed 100 lbs and load is placed concentric to joist (panel is length of chord between two adjacent diagonal web members at point of connection to chord).
 - 1. C-clamps are not permitted for use in open web steel joist applications.
- J. Suspend hangers by means of hanger rods. Perforated band iron and flat wire (strap iron) are not allowed.
- K. Use conduit-mounting pedestals for piping on roof. Install bottom of pedestal flat on roof deck and insulate exterior of pedestal, flashing and counter flashing.

- L. Minimize use of concrete anchors and inserts after concrete pour.
- M. Punching, drilling, welding of building structural steel or welding attachment to building structural steel is not allowed, unless approved by structural engineer.
- N. Use tools approved for use with PVC-coated conduits and fittings.

3.3 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.

3.4 CONCRETE HOUSEKEEPING PADS

- A. Construct concrete housekeeping pads for all floor-mounted electrical equipment.
- B. Dimensions: 4" high and not less than 2" larger in both directions than supported equipment, so anchors will be a minimum of 10 bolt diameters from edge of the base.
- C. Use 3000psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-Place Concrete."
- D. Anchor equipment to concrete housekeeping pad.
 - 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
- E. Coordinate with Architect installation of housekeeping pads on roof.

3.5 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Touchup: Comply with requirements in Division 09 Section "Painting" for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

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- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780/A780M.

END OF SECTION 260529

SECTION 260533 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Section includes raceways, fittings, wireways, wall ducts, indoor service poles, outlet boxes, pull and junction boxes, floor boxes, tap boxes and raceway seals.

1.2 REFERENCE STANDARDS

- A. ANSI/NECA 1 – Standard Practices for Good Workmanship in Electrical Contracting
- B. ANSI C80.1 – Rigid Steel Conduit-Zinc Coated (GRS)
- C. ANSI C80.3 – Electrical Metallic Tubing-Zinc Coated (EMT)
- D. ANSI C80.5 – Aluminum Rigid Conduit-Zinc Coated (ARC)
- E. ANSI C80.6 – Intermediate Metal Conduit-Zinc Coated (IMC)
- F. ASTM A53/A53M – Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
- G. BICSI TDMM – Telecommunications Distribution Methods Manual, Latest Edition
- H. ETL PVC-001 – PVC-Coated Conduit
- I. NEMA 250 – Enclosures for Electrical Equipment (1000 V Maximum)
- J. NEMA FB 1 – Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable
- K. NEMA OS 1 – Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports
- L. NEMA OS 2 – Nonmetallic Outlet Boxes, Device Boxes, Covers, and Box Supports
- M. NEMA RN 1 – Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
- N. NEMA TC 2 – Electrical Polyvinyl Chloride (PVC) Conduit
- O. NEMA TC 3 – PVC Fittings for Use with Rigid PVC Conduit and Tubing
- P. NEMA TC 13– Electrical Nonmetallic Tubing (ENT)
- Q. NFPA 70 – National Electrical Code
- R. TIA-569-B – Commercial Building Standard for Telecommunications Pathways and Spaces
- S. UL 1 – Flexible Metal Conduit

- T. UL 6 – Electrical Rigid Metallic Conduit-Steel
- U. UL 6A – Electrical Rigid Metallic Conduit-Aluminum and Stainless Steel
- V. UL 360 – Liquid-Tight Flexible Steel Conduit
- W. UL 514A – Metallic Outlet Boxes
- X. UL 514B – Conduit, Tubing, and Cable Fittings
- Y. UL 514C – Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
- Z. UL 651 – Schedule 40 and 80 Rigid PVC Conduit and Fittings
- AA. UL 797 – Electrical Metallic Tubing-Steel
- BB. UL 870 – Wireways, Auxiliary Gutters, and Associated Fittings
- CC. UL 1242 – Electrical Intermediate Metal Conduit-Steel
- DD. UL 1660 – Liquid-Tight Flexible Nonmetallic Conduit
- EE. UL 2024 – Optical Fiber and Communication Cable Raceway

1.3 SUBMITTALS

- A. Product Data:
 - 1. Raceways
 - 2. Fittings
 - 3. Wireways
 - 4. Outlet boxes
 - 5. Pull and junction boxes
 - 6. Floor boxes
- B. Sample of Floor box cover plate(s) for finish verification..
- C. Manufacturer's Installation Instructions:
 - 1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation and installation of product.
- D. Closeout Submittals:
 - 1. Project Record Documents:
 - a. Record actual routing of raceways 2.5" and larger.
 - b. Record actual location and mounting heights of wireways, wall ducts, indoor service poles, floor boxes, tap boxes, outlet, pull and junction boxes.
 - 2. Operation and Maintenance Data:
 - a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.

- b. Include spare parts data listing, source, and current prices of replacement parts and supplies.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements:

- 1. Comply with NFPA 70 .
- 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

B. Certification:

- 1. Installer of PVC-coated conduits and fitting shall be certified by a PVC conduit manufacturer.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.
- B. Protect PVC conduit from sunlight.
- C. Comply with manufacturer's written instructions.

1.6 WARRANTY

- A. Refer to Division 01 and Section 260000 - General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of final acceptance.

PART 2 - PRODUCTS

2.1 RIGID METAL CONDUIT (RMC)

- A. Rigid Steel Conduit (RSC): ANSI C80.1 , UL 6 ; heavy wall galvanized steel
- B. Fittings (couplings, connectors and bushings): NEMA FB 1, UL 514B B; steel (concrete-tight where applicable); threaded; connectors with double locknuts and steel insulating bushings, thermoplastic insulating bushings for conduits 2" and smaller.
- C. Fittings (conduit bodies): NEMA FB 1, UL 514B ; stainless-steel; cover: steel, with stainless steel screws and neoprene gaskets; coated to match conduit.
- D. Fittings Manufacturers: Cooper Crouse-Hinds; Carlon Electric Products/Prime Conduit Inc.; O-Z/Gedney; Appleton; Hubbell; or Approved equal

2.2 ELECTRICAL METALLIC TUBING (EMT)

- A. ANSI C80.3,UL 797; galvanized steel tubing

- B. Fittings (couplings and connectors): NEMA FB 1, UL 514B ; steel, (concrete tight) gland compression type connectors with double locknuts and insulated throat. Indentor, drive-on, zinc die-cast or pressure cast not permitted.
- C. Fittings (conduit bodies): NEMA FB 1, UL 514B : stainless-steel, with stainless steel screws and neoprene gaskets.
- D. Fittings Manufacturers: Same as manufacturers listed in 2.1.G.

2.3 FLEXIBLE METAL CONDUIT (FMC)

- A. UL 1; interlocked steel
- B. Fittings: NEMA FB 1, UL 514B ; steel, die-cast fittings not permitted

2.4 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)

- A. UL 360; interlocked steel or, with PVC jacket
- B. Fittings: NEMA FB 1, UL 514B ; steel

2.5 RIGID NONMETALLIC CONDUIT (RNC)

- A. NEMA TC 2, UL 651 ; Schedule 40 PVC
- B. Fittings: NEMA TC 3, UL 651

2.6 METAL WIREWAYS

- A. NEMA 250 , UL 870; sheet metal troughs with hinged or removable cover, Type 1, unless otherwise indicated.
- B. Size: length as indicated on drawings.
- C. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mated with wireways as required for complete system.
- D. Wireways Covers: Hinged type
- E. Knockouts: none
- F. Finish: Manufacturer's standard enamel finish
- G. Manufacturers: Hoffman; Square D Co.; Approved equal

2.7 OUTLET BOXES

- A. Sheet Metal Outlet Boxes: NEMA OS 1, UL 514A galvanized steel with stamped knockouts.
 - 1. Luminaire and Equipment Supporting Boxes: Rated for weight of equipment supported; 1/2" male fixture studs, where required.

2. Concrete Ceiling Boxes: Concrete type

- B. Cast-Metal Outlet Boxes: NEMA FB 1, ferrous alloy, Type FD, with gasketed cover and threaded hubs
 - 1. For applications requiring more than 2 gang boxes, provide stainless steel custom fabricated welded boxes with threaded hubs and coverplate. For applications including terminations and splicing of power conductors, a standard UL Listed box shall be used inside of the custom fabricated box.
- C. Nonmetallic Outlet Boxes: NEMA OS 2
- D. Gangable type boxes are not allowed.
- E. Manufacturers: O-Z/Gedney; Raco; Cooper Crouse-Hinds; Approved equal

2.8 OUTLET BOXES FOR COMMUNICATIONS

- A. Minimum outlet box size: 4-11/16" square by 2-1/8" deep minimum, with single-gang trim ring, unless otherwise noted on drawings.
 - 1. Total depth of the assembly including the trim ring shall not be less than 2-1/2".

2.9 PULL AND JUNCTION BOXES

- A. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1; galvanized steel
- B. Cast-Metal, Pull, and Junction Boxes: NEMA FB 1; galvanized, cast iron with ground flange, gasketed cover and stainless steel cover screws
- C. Minimum size: 4" square by 2-1/8" deep for use with 1" conduit and smaller; 4-11/16" square by 2-1/8" deep for use with 1-1/4" conduit and larger
- D. Sheet Metal Boxes Larger Than 12" in any direction: Hinged cover or a chain installed between box and cover
- E. Field-fabricated boxes not allowed without prior approval of local authority having jurisdiction.
- F. Manufacturers: O-Z/Gedney; Raco; Cooper Crouse-Hinds; Approved equal

2.10 PULL AND JUNCTION BOXES FOR COMMUNICATIONS

- A. Size: Per TIA-569-B, unless otherwise noted on drawings.
- B. Minimum pull box size: 4-11/16" square by 2-1/8" deep, where pull box is used with raceway(s) smaller than 1-1/4" trade size, unless otherwise noted on drawings.
- C. Minimum pull box size, where pull box is used with raceway(s) 1-1/4" trade size or larger:
 - 1. For straight pull through: Length of at least 8 times trade-size diameter of largest raceway.
 - 2. For angle and U pulls:
 - a. Have distance between each raceway entry inside box and opposite wall of box of at least 6 times trade-size diameter of largest raceway, this distance being increased by sum of trade-size diameters of other raceways on same wall of box; and

- b. Have distance between nearest edges of each raceway entry enclosing same conductor of at least:
 - 1) Six times trade-size diameter of raceway; or
 - 2) Six times trade-size diameter of larger raceway if raceways are of different sizes.
- c. For raceway entering wall of pull box opposite to removable cover, have distance from wall to cover of not less than trade-size diameter of largest raceway plus 6 times diameter of largest conductor.

2.11 FLOOR BOXES

- A. Metal Floor Boxes: NEMA OS 1 ; cast metal; fully adjustable; rectangular; Moisture-proof, with forged brass blank cover with each box and close up covers and/or carpet flanges as required for finished floor.
- B. Nonmetallic Floor Boxes: nonadjustable, round

2.12 MULTISERVICE FLOOR BOXES

- A. On Grade: Cast iron or steel pour box, watertight design approved for use in on-grade and above-grade concrete floor applications, with four independent wiring compartments and capacity for up to four duplex receptacles and/or communication devices. The box: fully adjustable providing pre-pour and after-pour adjustment, tunnel compartment, and two receptacle brackets. Conduit knockouts per drawing requirements. Comply with UL 514A and UL 514C scrub water exclusion test for tile, terrazzo, carpet and wood floors.
- B. Covers: Activation Covers – Die-cast aluminum with textured aluminum finish, and black or brass powder-coated paint finishes as selected by the Architect. Cover: flanged or flangeless, as required, with options for tile or carpet inserts, blank covers, or covers with one or two 1” liquid tight conduit openings for furniture feed applications.
- C. Communication Modules Mounting Accessories: Complete line of faceplates and bezels provided by floor box manufacturer to facilitate mounting of fiber optic, coaxial, high-performance twisted-pair cabling, and communication devices. Cabling type and faceplate configurations per requirements in Section 271500 - Communications Horizontal Cabling. The box shall accommodate workstation connectivity outlets and modular inserts and other system devices.
- D. Manufacturers:
 - 1. Hubbell - HBLCFB Series
 - 2. Spider - AFB/CFB Series
 - 3. Legrand/Wiremold - Evolution Series

2.13 RACEWAY PENETRATION SEALS

- A. Thruwall and Floor Seals.
- B. Manufacturers: New construction – OZ/Gedney FSK Series; existing construction – OZ/Gedney CSM Series; or equivalent by manufacturer listed in 2.1.F.

2.14 RACEWAY SEALING FITTINGS

- A. For one through four conductors: Manufacturers: OZ/Gedney CSB Series; Approved equal
- B. For greater than four conductors: Manufacturers: OZ/Gedney EYA Series with sealing compound; Approved equal
- C. Low-temperature or hazardous locations: Manufacturers: OZ/Gedney EYA Series with sealing compound; Approved equal

2.15 SLEEVES FOR RACEWAYS

- A. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends, with integral water stop.
- B. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052" or 0.138" thickness and of length to suit application.
- C. Integral Water Stop: Manufacturer: Thunderline Corporation; Approved Equal
 - 1. High density polyethylene (HDPE). Type Century-Line engineered sleeve with end caps.
 - 2. Steel. Type WS engineered sleeve.

PART 3 - EXECUTION

3.1 COORDINATION

- A. Coordinate with Architect/Engineer size and location of required built-in openings in building structure, including those sleeved, formed or core drilled.
- B. Coordinate with Architect/Engineer cutting, removing, or piercing general or mechanical insulation, fire-rated walls, ceilings or steelwork.
- C. Verify with Architect/Engineer all surface raceway installations except in mechanical, electrical, AV and communications rooms.
- D. Coordinate with Architect/Engineer exact locations of floor boxes, where shown on drawings, prior to rough-in.
- E. Coordinate routing of through-roof conduits.
- F. Coordinate sleeve selection and application with selection and application of firestopping specified in Section 260593 - Electrical Systems Firestopping.
- G. Verify that exterior wall or wet location boxes are gasketed type cast boxes with matching cover.
- H. Verify with manufacturer that "touch-up" paint kit and PVC-coating kit are available for use.

3.2 EXAMINATION

- A. Examine surfaces to receive raceways and boxes for compliance with installation tolerances and other conditions affecting performance of raceway's installation. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.3 INSTALLATION

- A. Raceways:
 - 1. Comply with ANSI/NECA 1 and NFPA 70 for installation requirements applicable to products specified in Part 2 except where requirements on drawings or in this Section are stricter.
 - 2. Arrange raceways to maintain headroom and present neat appearance.
 - 3. Raceway routing is shown in approximate locations, unless dimensioned. Route to complete raceway installation before starting conductor installation.
 - 4. Keep raceways at least 6 " away from parallel runs of flues, steam, hot-water pipes or ductwork. Install horizontal raceway runs above water and steam piping. Install raceways level and square and at proper elevations: 6'-6" minimum headroom, except in exit pathways 7'0" minimum headroom. Do not block access to junction boxes, mechanical equipment or prevent removal of ceiling panels, etc.
 - 5. Run raceways concealed in construction to avoid adverse conditions such as heat and moisture, to permit drainage, and to avoid materials and equipment of other trades, except where noted otherwise.
 - 6. Avoid exposed raceway runs. Run raceways exposed where impractical or impossible to conceal or where specific approval is obtained. Run exposed raceways grouped and parallel or perpendicular to construction. Do not route exposed raceways over boilers or other high-temperature machinery or in contact with such equipment. Offset exposed raceways at boxes.
 - 7. Route raceways installed above accessible ceilings parallel or perpendicular to construction.
 - 8. Do not install raceways in structural or topping floor slabs, except where noted on the plans. Install raceway in structural or topping floor slabs, where noted on plans, as follows:
 - a. Center raceways in structural slabs clear of reinforcing steel, except where crossing same, and spaced on centers equal or exceeding 3 times the raceway diameter. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement. Space raceways laterally to prevent voids in concrete.
 - b. Outside diameter of raceway shall not exceed 1/3 the structural slab thickness.
 - c. Obtain approval from Engineer for each run of raceway 1" or larger.
 - d. Do not install raceways in topping slabs of 2" or less.
 - e. Locate raceways to avoid conflict with equipment, door bucks, partitions and other equipment bolted to floor.

- f. Arrange stub-ups so curved portions of bends are not visible above finished slab. Install with an adjustable top or coupling threaded inside for plugs set flush with finished floor. Extend conductors to equipment with rigid steel conduit; use flexible metal conduit 6" above the floor. Install threaded plugs flush with floor for future equipment connections.
 - g. Change from nonmetallic raceway to RMC or IMC before rising above floor.
- 9. Cut raceways square using saw or pipecutter.
- 10. Use hydraulic one-shot raceway bender or factory elbows for bends in raceway larger than 2", unless sweep elbows required. Bend raceways according to manufacturer's recommendations. Do not use torches or open flame to aid in bend of PVC conduit.
- 11. Use raceway fittings compatible with raceways and suitable for use and environment.
- 12. Provide bushings on all raceways.
- 13. Raceways minimum sizes:
 - a. Minimum raceway size 3/4", except as noted on drawings.
 - b. Minimum home run size: 3/4", except as noted on drawings.
 - c. Minimum size for flexible metal conduit is 1/2" except 3/8" for luminaires.
 - d. Minimum size for liquidtight flexible metal conduit is 1/2"
- 14. Install empty raceways 2-1/2" and larger with 10 ga galvanized fishwire; install 200 lb nylon pull cord in raceways smaller than 2-1/2"; leave at least 12" of slack at each end of pull wire. Cap raceways at both ends.
- 15. Feed devices on same wall vertically from above or junction box in suspended ceiling.
 - a. Do not install horizontal bends in conduit around corners.
 - b. Feed devices in exterior or load-bearing walls by horizontal conduit runs.
- 16. Raceways Supports:
 - a. Independently support or attach raceway system to structural parts of construction. Suspended ceiling systems shall not be considered as structural parts of construction for raceway support. Do not attach raceways to piping system.
 - b. Raceway supports for horizontal or vertical single runs:
 - 1) Hot dipped galvanized heavy-duty sheet steel straps, mineralac clamps or steel slotted support channel system with appropriate components.
 - 2) Spring steel type pressure clamps for raceways 3/4" and smaller.
 - c. Raceway supports for horizontal and vertical multiple runs:
 - 1) Trapeze-type supports fabricated with steel slotted channel systems with appropriate components.
 - 2) Support horizontal runs with appropriately sized rods.
 - 3) Anchor vertical runs to structure.
 - 4) Spring-steel type pressure clamps for raceways 3/4" and smaller.
 - d. Vertical raceway runs 1-1/4" and larger passing through floors: Support at each floor with pipe riser clamps.
 - e. Do not support raceways with wire, perforated pipe straps or plastic tie-wrap. Remove wires used for temporary support.
 - f. Secure raceways in metal stud walls to prevent rattling.

- g. Arrange raceway supports to prevent misalignment during wiring installation.
 - h. Do not fasten raceways to corrugated metal roof deck.
 - i. For fasteners and supports, including steel slotted support systems, support devices, support spacing, support of conductors in vertical raceways, and hanger rod size, refer to Section 260529 - Hangers and Supports for Electrical Systems and NFPA 70.
17. Raceways Seismic Restraints:
- a. Avoid raceway runs crossing building seismic joints. Use flexible connections where crossings cannot be avoided.
 - b. Install rigid bracing and lateral restraints for suspended raceway runs per requirements in Section 260548 - Vibration and Seismic Controls For Electrical Systems.
18. Identify raceways per requirements in Section 260553 - Electrical Systems Identification.
19. Ground raceways per requirements in Section 260526 - Grounding and Bonding for Electrical Systems.
20. Flexible Conduit Connections: Use maximum of 72" of flexible conduit for recessed and semi-recessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for motors.
- a. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.
21. Communications Raceways:
- a. Minimum communications raceway size: 1", unless otherwise noted on drawings.
 - b. Install one raceway from each communications outlet box. Horizontal raceway runs between wall outlet boxes are not allowed.
 - c. Terminate raceway on cable tray.
 - d. Install insulated bushings on end of each raceway.
 - e. Use UL listed metallic grounding clamps, when terminating raceway on cable tray.
 - f. Install flush two-gang box with single-gang trim ring for each communications outlet or as noted on drawings. For classrooms, lecture halls, auditoriums, or designated multi-media rooms, the double-gang electrical box shall be equipped with a double-gang plaster ring with 1" radial conduit.
 - g. Install with no more than 180 degrees of bends between pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
 - h. Conduit bend radii (minimum) shall be:
 - 1) Six (6) times internal conduit diameter for conduit 2" or less internal diameter.
 - 2) Ten (10) times internal conduit diameter for conduit greater than 2" internal diameter.
 - i. Conduit bends shall be smooth, even, and free of kinks or other discontinuities that may have detrimental effects on pulling tension or cable integrity during or after installation.
 - j. Do not install 90-degree condulets. Install continuous radius sweeps of 45° minimum for 90-degree bends.
 - k. Do not install continuous sections longer than 100 ft.
 - l. Reference Legend for nurse call outlet box sizes.

- m. Install nylon pull cord in empty raceways. Leave at least 12" of slack at each end of pull wire. Cap raceways at both ends.

B. Boxes:

1. Install boxes to accommodate device indicated by symbol, in conformance with code requirements, number and size of conductors and splices and consistent with type of construction.
2. Install the appropriate cover on surface-mounted boxes:
 - a. Raised device covers on 4" square and 4-11/16" boxes and handy box covers on handy boxes, etc.
 - b. Device covers that are square drawn or square cut on boxes in block.
 - c. Tile covers on boxes in tile.
 - d. Round drawn device covers on boxes in lath and plaster walls or dry wall only.
 - e. Set front edge of device boxes flush with finished wall surfaces except on walls of non-combustible materials where boxes may have maximum set back of 1/4". Secure flush-mounted box to interior wall and partition studs. Accurately position to allow for surface finish thickness.
3. Set outlet boxes parallel to construction and independently attached to same.
4. Do not install back-to-back and through-the-wall boxes. Install with minimum 6" horizontal separation between closest edges of the boxes. Install with minimum 24" separation in acoustic-rated walls and fire-rated walls.
5. Install multi-ganged boxes where 2 or more devices are in same location, unless otherwise noted.
6. Box Support:
 - a. Mount boxes straight.
 - b. Install horizontal bracing at top or bottom of box for 3 or more gang device boxes in stud walls.
 - c. Install stud support one side, with short piece of stud, for up to 2 gang device boxes.
 - d. Do not support boxes with tie-wire.
 - e. For one and two gang box support, manufactured bracket supports shall be accepted alternate.
 - f. Support boxes independently of raceways.
 - g. Install adjustable steel channel fasteners for hung ceiling outlet box.
 - h. Install stamped steel bridges to fasten flush-mounted outlet box between studs.
 - i. Do not install boxes to ceiling support wires or piping systems.
7. Install partitions in multi-ganged boxes where different types of devices are installed, or devices installed operate at different voltages.
8. Mount boxes in block walls at block joint nearest to indicated height.
9. 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.

10. When boxes are installed in fire-resistive walls and partitions, provide 24" horizontal separation between boxes on opposite sides of a wall. In addition, limit penetrations to 16 sq in per penetration and not to exceed a total of 100 sq in per 100 sq ft of wall area. Apply fire stop putty pads acceptable to the fire marshal.
 11. Pull and junction boxes: Install as shown, or as necessary to facilitate pulling of wire and to limit number of bends within code requirements. Install above accessible ceilings and in unfinished areas.
 12. Install boxes to be permanently accessible.
 13. Do not intermix conductors from more than one system in same junction box or pull box, unless shown or specifically authorized otherwise.
 14. Adjust box location prior to rough-in to accommodate intended purpose.
 15. Orient boxes to accommodate wiring devices oriented as specified in Section 262726 - Wiring Devices .
 16. Inaccessible Ceiling Areas: Install outlet and junction boxes no more than 6" from ceiling access panel or from removable recessed luminaire.
 17. The drawings do not necessarily show every outlet, pull or junction box required. Add all required boxes as necessary.
- C. Outlet Boxes for Communications:
1. Install communications outlet boxes for each communications outlet, or as noted on drawings.
 2. Coordinate with other trades to maintain 8" clear space (minimum, measured from box centerline) on all sides of wall-mounted telephone outlet box.
- D. Pull and Junction Boxes for Communications:
1. Position Communications Pull and Junction Boxes:
 - a. In any section of conduit longer than 100 ft
 - b. Where there are bends totaling more than 180 degrees between pull points or pull boxes
 - c. Wherever there is a reverse bend in run
 2. Do not use pull boxes in place of bends on straight section of raceway, unless otherwise shown on drawings.
- E. Floor Boxes:
1. Set metal floor boxes level and flush with finished floor surface.
 2. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.
 3. Use cast floor boxes for installations in slab on grade.
 4. Install floor boxes and fittings to preserve fire-resistant rating of slabs and other elements, using materials and methods specified in Section 260593 - Electrical Systems Firestopping.
 5. Identify communication outlets per requirements in Section 270553 - Communications Systems Identification.
 6. Power and IT or AV conduits require a minimum 12" separation where routed parallel including entry into floor boxes.

F. Expansion Fittings:

1. Install raceway expansion and deflection fittings in all raceway runs embedded in or penetrating concrete where movement perpendicular to axis of the raceway may be encountered.
2. Install raceway expansion fittings complete with bonding jumpers in raceway runs that cross expansion joints in structure and raceway runs mechanically attached to 2 separate structures.
3. Use couplings and flexible connection made up of 24" length of flexible metal conduit, where EMT runs across expansion joints in ceiling spaces.
4. 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.

G. Raceway Penetration Seals:

1. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.
2. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint. Refer to Division 07 Section "Maintenance of Joint Protection" for materials and installation.
3. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials. Comply with Section 260593 - Electrical Systems Firestopping.
4. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.
5. Aboveground, Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1" annual clear space between pipe and sleeve for installing mechanical sleeve seals.
6. Underground, Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1" annual clear space between raceway and sleeve for installing mechanical sleeve seals.
7. Sleeve-Seal Installation: Use type and number of sealing elements recommended by manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
8. Provide chrome- or nickel-plated escutcheons where raceways pass through walls, floors or ceilings and are exposed in finished areas. Size escutcheons to fit raceways for finished appearance. Finished areas shall not include mechanical/electrical rooms, janitor's closets, storage rooms, etc., unless suspended ceilings are specified.
9. Remove temporary sleeves, if used for form wall openings, prior to installation of permanent materials.

H. Raceway Sealing Fittings:

1. Install listed watertight seals to prevent the passage of moisture and water vapor through raceway, where raceway passes from interior to exterior of the building, where raceway passes between areas of different temperatures such as into or out of cold rooms or freezers, where raceway enters room which at any time is subject to low or high temperatures and where raceway enters a room which at any time is subject to internal air pressures above or below normal.
2. Install watertight seals in interior of all raceways passing through building roof, ground floor slab (when the raceway does not extend beyond building footprint), or through outside walls of building above or below grade. Seal on the end inside building, using raceway sealing fittings manufactured for the purpose. Locate fittings at suitable accessible locations. For concealed raceways install each fitting in flush steel box with blank coverplate to match finish of adjacent plates or surfaces.
3. Seal raceways entering or passing through "hazardous (classified) areas" as defined in NFPA 70.

I. Sleeve Installation for Electrical Penetrations:

1. Coordinate sleeve selection and application with selection and application of firestopping specified in Section 260593 - Electrical Systems Firestopping.
2. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
3. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
4. Rectangular Sleeve Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50" and no side greater than 16", thickness shall be 0.052".
 - b. For sleeve cross-section rectangle perimeter equal to, or greater than, 50" and 1 or more sides equal to, or greater than, 16", thickness shall be 0.138".
5. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies, unless openings compatible with firestop system used are fabricated during construction of floor or wall.
6. Cut sleeves to length for mounting flush with both surfaces of walls.
7. Extend sleeves installed in floors 2" above finished floor level.
8. Size pipe sleeves to provide 1/2" annular clear space between sleeve and raceway, unless sleeve seal is to be installed or unless seismic criteria require different clearance.

3.4 APPLICATION

A. Provide raceways and boxes in accordance with the following table:

Application	Approved Raceways	Approved Boxes	Application Notes
Underground More than 5' outside Foundation Walls	Rigid steel conduit, Schedule 40 PVC.	Cast Metal Boxes or Nonmetallic Handholes	
In or Under Slab on Grade	Rigid steel conduit, Schedule 40 PVC	Cast of Nonmetallic Boxes	Use steel elbows with RNC when encased in concrete

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Outdoor Locations, Above Grade	Rigid steel conduit	Cast Metal or Nonmetallic	
In Slab Above Grade	Rigid steel conduit, Schedule 80 PVC	Cast	
Wet and Damp Locations	Rigid steel conduit	Cast Metal or Nonmetallic. Install flush mounting outlet boxes in finished areas.	
Concealed Dry Locations	Rigid steel conduit, electrical metallic tubing	Sheet Metal Boxes; Install flush mounting outlet boxes in finished areas. Install hinged enclosure for large pull boxes.	
Exposed Dry Locations	Rigid steel conduit	Cast boxes; Install flush mounting outlet boxes in finished areas; Install hinged enclosure for large pull boxes.	
Exposed Subject to Damage	Rigid steel conduit	Cast Metal	
Locations requiring Mechanical Protection	Rigid steel conduit		
Vibrating equipment (including transformers & hydraulic, pneumatic, electric solenoid or motor-driven equipment)	Flexible Metal Conduits (FMC) – Dry Locations Only Liquid Tight Flexible Metal Conduits (LFMC) – Wet Locations		Lengths for FMC & LFMC may range between 2 ft to
Instruments & control devices	Liquid Tight Flexible Metal Conduits		Lengths for LFMC may range between 2 ft to 6 ft

B. Special Conditions

1. 1/2" raceway permitted:
 - a. Between controller and its control or pilot device
 - b. Between lighting switch and nearest outlet for luminaire
 - c. Control wiring where mounted on equipment where conduit must follow contour of equipment

- d. Protective and signal systems where noted
- e. Where shown on plans

3.5 FIELD QUALITY CONTROL

- A. Inspect raceway, boxes, indoor service poles, and wireways for physical damage, proper alignment, supports and seismic restraints, where applicable.
- B. Replace any damaged component of the raceway system or install new raceway system.
- C. Inspect components, wiring, connections and grounding.

3.6 REPAINTING

- A. Repair damage to galvanized finishes with manufacturer-supplied zinc-rich paint kit. Leave remaining paint with Owner.
- B. Repair damage to PVC or paint finishes with manufacturer-supplied touch-up coating. Leave remaining coating with Owner.
- C. Wireways, indoor service poles: Remove paint splatters and other marks from surface; touch-up chips, scratches, or marred finished to match original finish using manufacturer-supplied paint kit. Leave remaining paint with Owner.

3.7 ADJUSTING

- A. Adjust flush-mounted boxes pre-pour and after-pour to be flush with finished materials.
- B. Install knockout closures in unused openings in boxes.
- C. Align adjacent wall-mounted outlet boxes for switches and similar devices.
- D. Adjust outlet boxes to allow luminaires to be positioned as indicated on drawings.

3.8 CLEANING

- A. Clean interior and exterior of boxes, wireways, and indoor poles to remove dust, debris and other material.

END OF SECTION 260533

SECTION 260543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Section includes conduits, ducts, and duct accessories for concrete encased underground distribution for electrical power and communications.
- B. The terms duct and duct bank, as used in this Section, are defined as follows:
 - 1. Duct: A single underground conduit, encased in concrete or direct buried.
 - 2. Duct Bank: Two or more ducts run together.

1.2 REFERENCE STANDARDS

- A. ANSI C2 – National Electrical Safety Code
- B. ANSI C80.1 – Rigid Steel Conduit-Zinc Coated (GRC)
- C. ASTM F512 – Specification for Smooth-Wall Poly (Vinyl Chloride) (PVC) Conduits and Fittings for Underground Installation
- D. ETL PVC-001 – PVC Coated Conduit
- E. NEMA RN 1 – Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
- F. NEMA TC 2 – Electrical Polyvinylchloride (PVC) Conduit
- G. NEMA TC 3 – PVC Fittings for Use with Rigid PVC Conduit and Tubing
- H. NEMA TC 6&8 – PVC Plastic Utilities Duct for Underground Installation
- I. NEMA TC 9 – Fittings for PVC Plastic Utility Duct for Underground Installation
- J. NFPA 70 – National Electrical Code
- K. UL 651 – Schedule 40 and 80 Rigid PVC Conduit
- L. UL 651A – Type EB and A Rigid PVC Conduit and HDPE Conduit
- M. UL E53373 – Underground Fiber Reinforced Epoxy Conduit (FRE)
- N. UL 6 – Electrical Rigid Metallic Conduit-Steel

1.3 SUBMITTALS

- A. Product data for the following:
 - 1. Duct bank materials, including spacers and miscellaneous components
 - 2. Ducts and conduits and their accessories, including elbows, end bells, bushings, seals, bends, fittings, plugs, pull tape, and solvent cement

3. Warning tape

B. Manufacturer's Installation Instructions:

1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

C. Closeout Submittals:

1. Project Record Documents:
 - a. Record actual routing of conduits and duct banks.
2. Operation and Maintenance Data:
 - a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
 - b. Include spare parts data listing, source, and current prices of replacement parts and supplies.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Comply with NFPA 70
2. Comply with ANSI C2
3. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.
- B. Deliver ducts to project site with end capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.

1.6 WARRANTY

- A. Refer to Division 01 and Section 260000 - General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.1 CONDUITS

- A. Rigid Steel Conduit (RSC): ANSI C80.1, UL 6, heavy wall, hot dipped, galvanized steel .

- B. Rigid Nonmetallic Conduit (RNC): NEMA TC 2 Type EPC-40-PVC, UL 651, with matching fittings by same manufacturer, complying with NEMA TC 3 and UL 651, listed for underground use, concrete encased.
- C. Size:
 - 1. As indicated on drawings

2.2 DUCT ACCESSORIES

- A. Duct Spacers:
 - 1. Rigid PVC interlocking spacers.
 - 2. Factory-fabricated, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling. Horizontal and vertical locking separation of 3" between ducts as shown on drawings.
- B. Elbows: Material to match conduit; minimum bend radius of 36".
- C. Bell Ends: Manufactured bell ends of appropriate sizes at each end of conduit; pre-manufactured system for PVC with conduit seals, provisions for roughing into the concrete pour and waste stops, when entering a new building or a new manhole.
- D. Bushings: Groundable steel bushings of appropriate sizes on all metal conduits where bell ends are not used; pre-manufactured system for PVC with conduit seals, provisions for roughing into concrete pour and water stops, when entering a new or existing building or a new or existing handhole.
- E. Seals: Mechanical interlocking assembly seal of modular synthetic rubber links properly sized to fit the pipe and tightened in place, in accordance with manufacturer's instructions, when entering an existing building or handhole below grade and concrete shall be core drilled for the appropriate size conduit and seal.
- F. Plugs: Closure plugs or caps of same material as conduit at ends of unused sections.
- G. Pull Tape: Nylon pull tape with measurement markings in uniform lengths in each empty duct.
- H. Grounding:
 - 1. Steel grounding bushings, where bell ends are not used.
 - 2. Bonding fitting with bonding strap on steel conduit with end bells.
- I. Warning Tape: Underground line warning tape specified in Section 260553 - Electrical Systems Identification .
- J. Concrete Dye Color: Red dye for electrical duct bank and orange dye for communications duct bank added to top of concrete immediately after pour.
- K. Solvent Cement: Recommended by conduit manufacturer.

PART 3 - EXECUTION

3.1 COORDINATION

- A. Coordinate layout and installation of ducts with final arrangement of other utilities, site grading, and surface features as determined in the field.
- B. Coordinate elevations of ducts and duct bank entrances into generator, pad-mounted exterior electrical equipment, handholes, and manholes 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 from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, away from the building and as approved by Architect. For manholes and handholes construction, refer to Section 260543.19 - Manholes and Hardware.
- C. Adjust the depth of electrical utilities to avoid existing utilities with no change to contract price.
- D. Utility Coordination: When duct lines are being constructed for use by a utility serving the project, consult with them for duct size and quantity, minimum bending radii, maximum distance between pulling points, grounding details, termination arrangement, and other criteria.
- E. Duct Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.
 - 1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
 - 2. Drawings shall be signed and sealed by a qualified professional engineer.

3.2 EXISTING UTILITIES

- A. The existing utilities shown on contract drawings have been plotted from available records. No guarantee is made as to accuracy of locations indicated, and is shown for the benefit of Contractor.
- B. Contact all serving utility companies and have them locate their lines prior to commencing work. Telephone "Call Before You Dig" prior to commencing work. Coordinate with Owner all existing utility lines prior to commencing work.
- C. Protect shown, visible and located utilities from damage. Promptly repair all active shown, visible and located utilities damaged by construction. This repair shall be made solely at the expense of the Contractor.
- D. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies to shut off services if lines are active.

3.3 PROJECT CONDITIONS

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Owner no fewer than 10 business days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without written permission from the Owner.

3.4 DUCT INSTALLATION

- A. 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.
- B. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends, both horizontally and vertically, at other locations, unless otherwise indicated. All 90-degree sweeps with radius 10 ft or less shall be rigid steel conduit.
- C. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane. Do not use conduit that requires the use of couplings for straight runs. Use acceptable PVC terminal adapters when joining PVC conduit to metallic fittings or rigid metal conduit.
- D. Duct Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10" o.c. for 5" ducts, and vary proportionately for other duct sizes.
 1. Begin change from regular spacing to end-bell spacing 10 ft 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 area of disturbed earth adjacent to manhole or handhole.
 3. Concrete Enclosed Duct Banks: Install watertight expansion fitting in each conduit, with internal bonding jumper to allow for 3/4" movement in any direction.
 4. Grout end bells into structure walls from both sides to provide watertight entrances.
- E. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 5 ft 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 duct-to-conduit transition. Install conduit penetrations of building walls as specified in Section 260533 - Raceway and Boxes for Electrical Systems .
- F. Expansion Fittings: Provide suitable expansion fittings or other suitable means to compensate for expansion and contraction for raceways crossing expansion joints in structures or concrete slabs between two adjacent structures and between a duct bank and structure. Provide for the high rate of thermal expansion and contraction of PVC conduit by providing PVC expansion joints as recommended by manufacturer and as required. Refer to structural drawings for location of expansion joints in structures.
- G. Sealing: Provide temporary closure at termination of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand minimum of 15 psig hydrostatic pressure. Provide watertight entrance sealing device where an underground conduit enters a structure through a concrete roof or membrane waterproofed wall or floor.

- H. Fire Stops: Provide fire stop openings around electrical penetrations to maintain fire-resistance rating, where underground raceways penetrate fire-rated walls or floors.
- I. Pulling Cord: Install 100 lb test nylon cord in ducts, including spares. Identify with tags at each end and at any intermediate pull point the origin and destination of each spare duct. Provide a removable permanent cap over each end of each spare duct.
- J. Concrete Encased Ducts: Support ducts on duct spacers.
 - 1. Spacer Installation:
 - a. Provide spacers close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 20 ft of duct. Secure spacers to earth and to ducts to prevent floating during concreting. Stagger spacers approximately 6" between tiers. Tie entire assembly together using tie wires and reinforcing steel. Install base and intermediate spacers at every coupling point of each duct line for a separation horizontally and vertically per NEC.
 - 2. 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. Terminate each pour in a vertical plane if more than one pour is necessary, and install 3/4" reinforcing rod dowels extending 18" into concrete on both sides of joint near corners of envelope. Obtain Architect's approval for the number and location of dowels.
 - 3. Pouring Concrete: Space concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct bank application.
 - 4. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing bars and ties without forming conductive or magnetic loops around ducts or duct groups. Size reinforcing bars and wire ties as indicated on drawings. Provide rebars with minimum of 2" of concrete on sides, top and bottom. Reinforcing bars shown in sections are required throughout.
 - 5. 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 of materials and in a manner acceptable to Architect.
 - 6. Minimum Space between Ducts: 3" between ducts and exterior envelope wall, 2" between ducts for like services, and 4" between power and signal ducts.
 - 7. Depth: Install top of duct bank at least 24" below finished grade in areas not subject to deliberate traffic, and at least 30" below finished grade in deliberate traffic paths for vehicles, unless otherwise indicated.
 - 8. Maintain a grade of at least 4" per 100 ft, either from one manhole or pull box to the next, or from a high point between them, depending on surface contour.

9. Warning Tape: Bury warning tape approximately 12" above all concrete-encased ducts and duct banks. Align tape parallel to and within 3" of the centerline of duct bank. Provide an additional warning tape for each 12" increment of duct bank width over a nominal 18". Space additional tapes 12" apart, horizontally.
10. Place duct banks on an undisturbed soil base if possible. Where concrete encased duct bank is installed over an extensive area of disturbed earth such that within the periphery of a building, provide a separate concrete base under the duct bank to ensure stability of raceways during installation. Allow this base to set before duct bank is installed.

K. Stub-Ups:

1. Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase couplings with 3" of concrete. Concrete encasement applies to concrete encased ducts.
 - b. Stub-Ups to Equipment: For equipment mounted on outdoor concrete pads, extend steel conduit horizontally a minimum of 5 ft from edge of equipment pad or foundation. Encase in concrete for concrete encased ducts. Install insulated grounding bushings on terminations at equipment.

L. Arrangement and Routing:

1. Arrange multiple duct runs substantially in accordance with details shown on drawings. Locate underground ducts where indicated on drawings and grade to the elevations shown on civil drawings.
2. Make minor changes in location or cross-section as necessary to avoid obstructions or conflicts. Where duct runs cannot be installed substantially as shown because of conditions not discoverable prior to digging of trenches, refer the condition to the Architect for written instructions before further work is done.
3. Maintain a 12" minimum vertical separation between ducts and other systems at crossings where other utility piping systems are encountered or being installed along a raceway route. Maintain a 12" minimum separation between ducts and other systems in parallel runs. Do not place ducts over valves or couplings in other piping systems. Refer conflicts with these requirements to the Construction Manager for written instructions before further work is done.
4. Provide markers at grade to indicate direction of underground conduits provided under this contract. Provide markers consisting of double-ended arrows, straight for straight runs and bent at locations where runs change direction. Provide markers at all bends and at intervals not exceeding 100 ft in straight runs. Use markers made of sheet bronze not less than 1/4" thick embedded in and secured to the top of concrete posts. User markers not less than 10" long and 3/4" wide and marked ELECTRIC CABLES in letters 1/4" high incised into the bronze to a depth of 3/32".
5. Enter manholes and structures with ducts at right angles.

3.5 UNDERGROUND DUCT APPLICATION

- A. Ducts for Electrical Feeders 600V and Less: RNC, NEMA Type EPC-40-PVC, in concrete encased duct bank, unless otherwise indicated.

- B. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-40-PVC, in direct buried duct bank, unless otherwise indicated.
- C. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: RNC, NEMA Type EPC-40-PVC, installed in concrete encased duct bank, unless otherwise indicated.

3.6 EARTHWORK

- A. Excavation and Backfill: Comply with Section 260543.13 - Excavation and Backfill, do not use heavy-duty, hydraulic-operated compaction equipment.

3.7 CONCRETE

- A. Concrete: 3000 psi, 28-day strength, complying with Division 03 – Concrete, where concrete encased.

3.8 GROUNDING

- A. Ground underground ducts according to Section 260526 - Grounding and Bonding for Electrical Systems.

3.9 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts.
 - 2. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80% fill of duct. If obstructions are indicated, remove obstructions and retest.
- B. Preparation for pulling in conductors:
 - 1. Do not install crushed or deformed raceways. Avoid traps in raceways where possible. Take care to prevent the lodging of plaster, concrete, dirt, or trash in raceways, boxes, fittings, and equipment during the course of construction. Make raceways entirely free of obstructions or replace them. Ream all raceways, remove burrs, and clean raceway interior before introducing conductors or pull wires.
 - 2. Immediately after installation, plug or cap all raceway ends with watertight and dust-tight seals until the time for pulling in conductors.
- C. Do not backfill underground direct buried and concrete encased ducts until the Designer and the State Construction Office Electrical Inspector has inspected them. Notify designer a minimum of .

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3.10 CLEANING

- A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

END OF SECTION 260543

SECTION 260543.19 - MANHOLES AND HARDWARE

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Section includes underground utility structures: manholes and handholes for power and communication cable systems.

1.2 REFERENCED STANDARDS

- A. AASHTO HB 17 – Standard Specifications for Highway Bridges
- B. ANSI C2 – National Electrical Safety Code
- C. ASTM A48/A48M – Specification for Gray Iron Castings
- D. ASTM C270 – Specification for Mortar for Unit Masonry
- E. ASTM C387/C387M – Specification for Packaged, Dry, Combined Materials for Mortar and Concrete
- F. ASTM C858 – Specification for Underground Precast Concrete Utility Structures
- G. ASTM C891 – Standard Practice for Installation of Underground Precast Concrete Utility Structures
- H. ASTM C1037 – Practice for Inspection of Underground Precast Concrete Utility Structures
- I. ASTM E329 – Standard Specification for Agencies Engaged in Construction Inspection and/or Testing
- J. ISO 9000 – Quality Management
- K. ISO 10012 – Measurement Management Systems
- L. NFPA 70 – National Electrical Code
- M. SCTE 77 – Specification for Underground Enclosure Integrity

1.3 SUBMITTALS

- A. Product Data:
 - 1. Accessories for underground utility structures.
- B. Shop Drawings for Precast or Factory-Fabricated Underground Utility Structures: Include plans, elevations, sections, details, attachments to other work, and accessories, including the following:
 - 1. Duct entry provisions, including locations and duct sizes
 - 2. Reinforcement details

3. Frame and cover design and vault frame support rings
 4. Grounding details
 5. Dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps
 6. Joint details
- C. Shop Drawings for Factory-Fabricated Handholes and Pull Boxes Other Than Precast Concrete: Include dimensioned plans, sections, and elevations, and fabrication and installation details, including the following:
1. Duct entry provisions, including locations and duct sizes
 2. Cover design
 3. Grounding details
 4. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons
- D. Product Certificates: For concrete and steel used in precast concrete _____, as required by ASTM C858.
- E. Qualification Data: For professional engineer and testing agency.
- F. Source quality-control test reports.
- G. Field quality-control test reports.
1. Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
- H. Manufacturer's Installation Instructions:
1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- I. Closeout Submittals:
1. Project Record Documents:
 - a. Record actual location of underground utility structures.
 2. Operation and Maintenance Data:
 - a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
 - b. Include spare parts data listing, source, and current prices of replacement parts and supplies.

1.4 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Qualified according to ASTM E329 for testing indicated
- B. Comply with ANSI C2
- C. Comply with NFPA 70

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Store manholes and handholes underground utility structures at project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.
- B. Lift and support precast concrete units only at designated lifting or supporting points.

1.6 WARRANTY

- A. Refer to Division 01 and Section 260000 - General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of final acceptance.

1.7 MAINTENANCE

- A. Extra Materials:
 - 1. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 2. Furnish cable-support stanchions, arms, and associated fasteners in quantities equal to 10 % of quantity of each item installed.

PART 2 - PRODUCTS

2.1 PRECAST CONCRETE MANHOLES

- A. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom. Frame and cover shall form top of enclosure and shall have load rating consistent with that of manhole.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Oldeastle Precast Group
 - 2. Riverton Concrete Products; a division of Cretex Companies, Inc.
 - 3. Utility Concrete Products, LLC.
 - 4. Utility Vault Co.
 - 5. Jensen Precast
 - 6. Approved equals
- C. Comply with ASTM C858 , with structural design loading as specified in Part 3 "Underground Enclosure Application" Article and with interlocking mating sections, complete with accessories, hardware, and features.
 - 1. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12" vertically and horizontally to accommodate alignment variations.

- a. Windows: Located not less than 6" from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
 - b. Window opening: Cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
- 2. Duct Entrances in Manhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
 - a. Type and size: Fittings matched to duct or conduit to be terminated.
- D. Concrete Knockout Panels: 1-1/2" to 2" thick, for future conduit entrance and sleeve for ground rod.
- E. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the groundwater level at grade.

2.2 CAST-IN-PLACE MANHOLES

- A. Description: Underground utility structures, constructed in place, complete with accessories, hardware, and features, with concrete knockout panels for conduit entrance and sleeve for ground rod.
- B. Materials: Comply with ASTM C858 and with Section 033000 - Cast-in-Place Concrete.
- C. Structural Design Loading: As specified in Part 3 "Underground Enclosure Application" Article.

2.3 PRECAST CONCRETE HANDHOLES AND PULL BOXES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Oldcastle Precast Group
 - 2. Riverton Concrete Products; a division of Cretex Companies, Inc.
 - 3. Utility Concrete Products, LLC.
 - 4. Utility Vault Co.
 - 5. Jensen Precast
 - 6. Approved equals
- B. Comply with ASTM C858 for design and manufacturing processes.
- C. Structural Load Ratings: As specified in Part 3 "Underground Enclosure Application."
- D. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or pull box.
 - 1. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
 - 2. Frame and Cover: Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.

3. Frame and Cover: Weatherproof steel frame, with hinged steel access door assembly with tamper-resistant, captive, cover-securing bolts.
 - a. Cover Hinges: Concealed, with hold-open ratchet assembly
 - b. Cover Handle: Recessed
4. Frame and Cover: Weatherproof aluminum frame with hinged aluminum access door assembly with tamper-resistant, captive, cover-securing bolts.
 - a. Cover Hinges: Concealed, with hold-open ratchet assembly
 - b. Cover Handle: Recessed
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.
7. Configuration: Units shall be designed for flush burial and have closed bottom, unless otherwise indicated.
8. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.
 - a. Slab: Same dimensions as bottom of enclosure, and arranged to provide closure.
9. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12" vertically and horizontally to accommodate alignment variations.
 - a. Windows: Located no less than 6" from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.
 - b. Window opening: Cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie-in to concrete envelopes of ductbanks.
 - c. Window openings: Framed with at least two additional NO. 4 steel reinforcing bars in concrete around each opening.
10. Duct Entrances in Handhole Walls:
 - a. Type and size: Fittings matched to duct or conduit to be terminated.
 - b. Fittings: Aligned with elevations of approaching ducts and located near interior corners of handholes to facilitate racking of cable.
11. Handholes 48" and larger: Inserts for cable racks and pulling-in irons installed before concrete is poured.

2.4 HANDHOLES AND PULL BOXES OTHER THAN PRECAST CONCRETE

- A. Description: Comply with SCTE 77.
 1. Color: Gray
 2. Configuration: Designed for flush burial and have open bottom, unless otherwise indicated.
 3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
 4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 5. Cover Legend: Molded lettering, As indicated for each service.

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6. Direct Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
 7. Duct Entrance Provisions: Duct-terminating fittings mated with entering ducts for secure, fixed installations in enclosure wall.
 8. Handholes 48" and larger: Factory-installed inserts for cable racks and pulling-in irons.
- B. Polymer Concrete Handholes and Pull Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armorcast Products Company
 - b. Carson Industries LLC.
 - c. CDR Systems Corporation
 - d. NewBasis
 - e. Quazite
 - f. Approved Equal

2.5 UTILITY STRUCTURE ACCESSORIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Bilco Company (The)
 2. Campbell Foundry Company
 3. Carder Concrete Products
 4. Christy Concrete Products
 5. East Jordan Iron Works, Inc.
 6. Elmhurst-Chicago Stone Co.
 7. Jensen Precast
 8. McKinley Iron Works, Inc.
 9. Neenah Foundry Company
 10. NewBasis
 11. Oldcastle Precast Group
 12. Osburn Associates, Inc.
 13. Pennsylvania Insert Corporation
 14. Riverton Concrete Products; a division of Cretex Companies, Inc.
 15. Strongwell Corporation; Lenoir City Division
 16. Underground Devices, Inc.
 17. Utility Concrete Products, LLC.
 18. Utility Vault Co.
 19. Wausau Tile, Inc.

- B. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.
 - 1. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48/A 48M, Class 30B with milled cover-to-frame bearing surface; diameter as indicated on drawings.
 - a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 - 2. Cover Legend: Cast in. Selected to suit system.
 - a. Legend: "ELECTRIC-LV" for duct system with power wires and cables for systems operating at 600 V and less.
 - b. Legend: "ELECTRIC-HV" for duct systems with medium-voltage cables.
 - c. Legend: "SIGNAL" for communications, data, and telephone duct systems.
 - 3. Manhole 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 C270, Type M, except for quantities less than 2.0 ft³ where packaged mix complying with ASTM C387/C387M, Type M, may be used.
- C. Manhole Sump Frame and Grate: ASTM A48/A48M, Class 30B, gray cast iron.
- D. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2" diameter eye, and 1x4" bolt.
 - 1. Working Load Embedded in 6", 4000 psi Concrete: 13000 lbf minimum tension.
- E. Pulling Eyes in Nonconcrete Walls: Eyebolt with reinforced fastening, 1-1/4" diameter eye, rated 2500 lbf minimum tension.
- F. Pulling-in and Lifting Irons in Concrete Floors: 7/8" 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 60000 lbf tension.
- G. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts for noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2" ID by 2-3/4" deep, flared to 1-1/4" minimum at base.
 - 1. Tested Ultimate Pullout Strength: 12,000 lbf minimum.
- H. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2" bolt, 5300 lbf rated pullout strength, and minimum 6800 lbf rated shear strength.
- I. Cable Rack Assembly: Nonmetallic. Components fabricated from nonconductive, fiberglass-reinforced polymer.
 - 1. Stanchions: Nominal 36" high by 4" wide, with minimum of 9 holes for arm attachment.
 - 2. Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall be available in lengths ranging from 3" with 450 lb minimum capacity to 20" with 250 lb minimum capacity. Top of arm shall be nominally 4" wide, and arm shall have slots along full length for cable ties.

- J. Duct-Sealing Compound: Non-hardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35°F. Capable of withstanding temperature of 300 °F without slump and adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

2.6 SOURCE QUALITY CONTROL

- A. Test and inspect precast concrete utility structures according to ASTM C1037.
- B. Nonconcrete Handhole and Pull Box Prototype Test: Test prototypes of manholes and pull 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 of tests of complete pull boxes and covers shall be by either an independent testing agency or the 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 UNDERGROUND ENCLOSURE APPLICATION

- A. Manholes: Precast or Cast-in-place concrete:
 - 1. Manholes Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating according to AASHTO HB 17.
 - 2. Manholes Not Located in Deliberate Traffic Paths by Heavy or Medium Vehicles: H-10 load rating according to AASHTO HB 17.
- B. Handholes and Pull Boxes for 600 V and Less, Including Telephone, Communications, and Data Wiring:
 - 1. Handholes and Pull Boxes in Roadways and Other Deliberate Traffic Paths: Precast concrete AASHTO HB 17, H-20 structural load rating.
 - 2. Handholes and Pull Boxes in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 structural load rating.
 - 3. Handholes and Pull Boxes in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Precast concrete, AASHTO HB 17, H-10 structural load rating.
 - 4. Handholes and Pull Boxes Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000 lbf vertical loading.

3.2 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND PULL BOXES

- A. Cast-in-Place Manhole Installation:

1. Finish interior surfaces with a smooth-troweled finish.
 2. Windows for Future Duct Connections: Form and pour concrete knockout panels 1-1/2" to 20" thick, arranged as indicated.
 3. Cast-in-place concrete, formwork, and reinforcement are specified in Section 033000 - Cast-in-Place Concrete.
- B. Precast Concrete Manhole and Handhole Installation
1. Comply with ASTM C891, 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" sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
 4. Concrete: 5000 psi 28-day strength, complying with Division 03 – Concrete.
- C. Elevations:
1. Manhole Roof: Install with rooftop at least 15" below finished grade.
 2. Manhole Frame: In paved areas and traffic-ways, set frames flush with finished grade. Set other manhole frames 1" above finished grade.
 3. Handhole Covers: In paved areas and traffic-ways set surface flush with finished grade. Set covers of other handholes 1" above finished grade.
 4. Where indicated, cast handhole cover frame integrally with handhole structure.
- D. Drainage: Install drains in bottom of manholes via drain lines where indicated. Coordinate with drainage provisions indicated.
- E. Manhole Access: Circular opening in manhole roof; sized to match cover size.
1. Install chimney, constructed of precast concrete collars and rings, to support frame and cover and to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for cast-iron frame to chimney.
- F. Waterproofing: Apply waterproofing to exterior surfaces of manholes after concrete has cured at least 3 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 3 days.
- G. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms, as required for installation and support of cables and conductors and as indicated.
- H. Pack and smooth non-shrink grout at all rough edges around duct entrances at each _____.
- 3.3 INSTALLATION OF HANDHOLES AND PULL BOXES OTHER THAN PRECAST CONCRETE
- A. Install handholes and pull boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use pull box extension if required to match depths of ducts, and seal joint between box and extension as recommended by the manufacturer.

- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2" sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas and traffic-ways, set so cover surface will be flush with finished grade. Set covers of other handholes 1" above finished grade.
- D. Install handholes and pull boxes with bottom below the frost line. Insert depth of frost line below grade at project site below grade.
- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.
- F. 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 penetration after fittings are sealed.
- G. For enclosures installed in _____ and subject to occasional, non-deliberate, heavy-vehicle loading, 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 _____.
 - 1. Concrete: 3000 psi, 28-day strength, complying with Section 033000 - Cast-in-Place Concrete, with a troweled finish.
 - 2. Dimensions: 10" wide by 12" deep.

3.4 GROUNDING

- A. Ground utility structures according to Section 260526 - Grounding and Bonding for Electrical Systems.

3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections and prepare test reports:
 - 1. Demonstrate capability and compliance with requirements on completion of installation of underground utility structures.
 - 2. Test manholes and handholegrounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 260526 - Grounding and Bonding for Electrical Systems.
- B. Correct deficiencies and retest as specified above to demonstrate compliance.
- C. Interpret test results in writing and submit to Engineer.

3.6 CLEANING

- A. Clean internal surfaces of manholes, including sump and remove foreign material, after completing the installation of all devices, equipment, cables and terminations.

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- B. Remove water from manholes. If manholes continue to fill up with water, Contractor shall pump them regularly until the source of water has been detected and corrected.

END OF SECTION 260543.19

SECTION 260553 - ELECTRICAL SYSTEMS IDENTIFICATION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Section includes the following:
 - 1. Identification for raceway
 - 2. Identification for conductors and communication and control cable
 - 3. Underground-line warning tape
 - 4. Warning labels and signs
 - 5. Instruction signs and posted drawings
 - 6. Equipment identification nameplates
 - 7. Wiring devices identification
 - 8. Miscellaneous identification products
- B. Refer to the respective Division 26 Sections, and Sections in other Divisions that specify electrical components, for additional electrical identification requirements.

1.2 REFERENCE STANDARDS

- A. ANSI A13.1 – Scheme for the Identification of Piping Systems
- B. ANSI C2 – National Electrical Safety Code
- C. ANSI Z535.4 – National Standards for Product Safety Signs and Labels
- D. 29 CFR 1910 – Labor, Part 1910 – Occupational Safety and Health Standards, Section 1910.145 – Specifications for Accident Prevention Signs and Tags
- E. NFPA 70 – National Electrical Code

1.3 SUBMITTALS

- A. Product Data: For each electrical identification product indicated.
- B. Torque log for all terminations 100A and over. Log shall identify target torque values, as they are found via manufacturer documentation and individual locations.
- C. Nameplate Schedule: Prior to making nameplates, submit a complete schedule to Architect for approval indicating nameplate size, lettering size, color and actual nameplate information.
- D. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

1.4 QUALITY ASSURANCE

- A. Comply with ANSI A13.1 and ANSI C2.

- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.145.

1.5 COORDINATION

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout project.
- B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identifying devices with location of access panels and doors.
- D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend.
- B. Manufacturers: Brady USA, Ideal, Marking Services, Inc. (MRI), Seton, or approved equal.
- C. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2" wide.
- D. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- E. Aluminum Wraparound Marker Labels: Cut from 0.014" thick aluminum sheet, with stamped, embossed, or scribed legend, and fitted with tabs and matching slots for permanently securing around wire or cable jacket or around groups of conductors.
- F. Metal Tags: Brass or aluminum, 2" x 2" x 0.05", with stamped legend, punched for use with self-locking nylon tie fastener.
- G. Write-On Tags: Polyester tag, 0.010" thick, with corrosion-resistant grommet and polyester or nylon tie for attachment to conductor or cable.
 - 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
- H. Plasticized Card-Stock Tags: Vinyl cloth with preprinted and field-printed legends. Orange background, unless otherwise indicated, with eyelet for fastener.

2.2 UNDERGROUND-LINE WARNING TAPE

- A. Manufacturers: Ideal, Marking Services, Inc. (MRI), Seton, or approved equal.

- B. Description: Permanent, bright-colored, continuous-printed, polyethylene tape.
 - 1. Not less than 6" wide by 4 mils thick.
 - 2. Compounded for permanent direct-burial service.
 - 3. Embedded continuous metallic strip.
 - 4. Printed legend shall indicate type of underground line.
 - 5. Red tape for electrical and orange tape for communications / controls installations.

2.3 WARNING LABELS AND SIGNS

- A. Comply with NFPA 70 and 29 CFR 1910.145.
- B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.
- C. Self-Adhesive Arc Flash Warning Labels: Industrial grade, made of durable polyester with over-laminate to withstand harsh environments (UV rays, scratches and most chemicals).
 - 1. Manufacturer: Seton or approved equal
- D. Engraved Plastic Signs: Engraving stock, melamine plastic laminate, minimum 1/16" thick for signs up to 20 sq inch and 1/8" thick for larger sizes.
 - 1. Engraved legend with black letters on white face.
 - 2. Punched or drilled for mechanical fasteners.
- E. Baked-Enamel Warning Signs for Interior Use: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 1/4" grommets in corners for mounting. Nominal size, 7x10".
- F. Metal-Backed, Butyrate Warning Signs for Exterior Use: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396" galvanized-steel backing; and with colors, legend, and size required for application. 1/4" grommets in corners for mounting. Nominal size, 10x14".
- G. Warning label and sign shall include, but are not limited to, the following legends:
 - 1. Multiple Power Source Warning: "DANGER – ELECTRICAL SHOCK HAZARD – EQUIPMENT HAS MULTIPLE POWER SOURCES."
 - 2. Workspace Clearance Warning: "WARNING – OSHA REGULATION – AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36'."
 - 3. Arc Flash Labels: Per ANSI Z535.4, the signal word WARNING appearing in black letters on an orange background, with second line below (Arc Flash and Shock Hazard) in black letters on white background and third line below (Appropriate PPE Required) in black letters on white background. Include the following information on the label:
 - a. Arc flash label information will be furnished by the Designer, in PDF format, for printing and installation by the contractor.

2.4 TORQUE MARKING

- A. Contractor shall keep a log of torque values used for project. This record shall incorporate name of installer for each specific location with date/time.
- B. Torque marks shall be made on nut side and extend to a non-rotating surface. Torque marks shall be made at time of torquing – placing torque marks after the fact is not permitted, but instead must be re-torqued and marked.
- C. Permanent marker: Contractor shall confirm torque requirements with manufacturer and use tools calibrated within past 6 months. Terminations over 100A shall have black permanent marker utilized for visual confirmation.
- D. Torque seal: (Blue) Cross-Check or similar manufacturer shall be used for terminations 100A and over. Use of permanent black marker is not acceptable.

2.5 INSTRUCTION SIGNS AND POSTED DRAWINGS

- A. Instruction Signs: Engraved, laminated acrylic or melamine plastic, minimum 1/16" thick for signs up to 20 sq inch and 1/8" thick for larger sizes.
 - 1. Engraved legend with black letters on white face.
 - 2. Punched or drilled for mechanical fasteners.
 - 3. Mounting Frames: Extruded aluminum, 4-point screw mount with 1/8" clear plexiglass cover.
- B. Posted Drawings: Print electrical riser diagrams on 20 lb bond paper. (Blueprint paper is not acceptable.) Reduce drawings to approximately 1/2 size using Xerox reduction process. Contact Engineer to obtain updated original plans for printing.

2.6 EQUIPMENT IDENTIFICATION NAMEPLATES

- A. Engraved, three-layer, laminated acrylic or melamine nameplate: punched or drilled for screwmounting

2.7 WIRING DEVICES IDENTIFICATION

- A. Refer to Section 262726 - Wiring Devices for requirements.

2.8 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, type 6/6 nylon cable ties.
 - 1. Minimum Width: 3/16"
 - 2. Tensile Strength: 50 lb minimum
 - 3. Temperature Range: -40°F to 185°F
 - 4. Color: Black, except where used for color-coding
- B. Paint: Paint materials and application requirements are specified in Division 09 – Finishes painting Sections.

- C. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Accessible Raceways 600 V or Less, for Service, Feeder, and Branch Circuits More Than 100 A: Identify with orange self-adhesive vinyl tape applied in bands.
 - 1. Identify 4" round, 4" square and 4-11/16" junction boxes concealed above ceiling or exposed with neat lettering on cover with permanent black marking pen. Identify source, circuit number, phase, and control circuit number.
- B. Accessible Raceways and Cables of Auxiliary Electrical Systems: Identify the following systems with color-coded, self-adhesive vinyl tape applied in bands:
 - 1. Fire Alarm System (including covers of pull and junction boxes): Red
- C. Power-Circuit Conductor Identification: For primary and secondary conductors No. 10 AWG and larger in vaults, pull and junction boxes, manholes, and handholes use continuous color insulation for the entire run. No marking tape is allowed.. Identify source and circuit number of each set of conductors or other appropriate number or letter to expedite future tracing and troubleshooting. For single conductor cables, identify phase in addition to the above. Phase identification shall be consistent throughout the system.
- D. Branch-Circuit Conductor Identification: Where there are conductors for more than three branch circuits in same junction or pull box, use color-coding conductor tape. Identify each ungrounded conductor according to source and circuit number.
- E. Conductors to Be Extended in the Future and Spare Conductors: Attach write-on tags to conductors and list source and circuit number.
- F. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.
 - 1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
 - 2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
 - 3. Coordinate identification with project drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.
- G. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable. Install underground-line warning tape for both direct-buried cables and cables in raceway.
- H. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply self-adhesive warning labels. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access to equipment.

1. Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, the following:
 - a. Power transfer switches
 - b. Controls with external control power connections
 2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.
 3. Arc Flash Warning Labels: install per NFPA 70 for each switchgear, switchboard, panelboard, motor control center, industrial control panel (every enclosure that may contain energized conductors or components). Locate labels so they are visible to the personnel before examination, adjustment, servicing, or maintenance of the equipment.
 4. Available Fault Current Labels: install per NFPA 70 for each piece of service entrance equipment. Locate labels so they are visible to the personnel before examination, adjustment, servicing or maintenance of the equipment.
- I. Instruction Signs and Posted Drawings:
1. Operating Instructions: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend printed in all capital letters of 12 pt size minimum where instructions are needed for system or equipment operation.
 2. Emergency Operating Instructions: Install instruction signs with white legend on a red background with minimum 3/8" high letters for emergency instructions at equipment used for power transfer.
- J. Equipment Identification Nameplates: On each unit of equipment, install unique designation nameplate that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply nameplates to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
1. Nameplate Instructions:
 - a. Indoor Equipment: Engraved, laminated acrylic or melamine nameplate. Unless otherwise indicated, provide a single line of text with 1/2" high letters 1/4" where space is limited) on 1-12" high nameplate; where 2 lines of text are required, use nameplates sized 2" high.
 - b. Outdoor Equipment: Stenciled Legend: In nonfading, waterproof. Adhesive backed and pop rivet to enclosure, seal penetrations with silicone. Minimum letter height shall be 1/2 inch.
 - c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
 - d. System Identification labeling colors as follows:
 - 1) 277/480 Volt – Black background with white letters.
 - 2) 120/208 (120/240) Volt – Blue background with white letters.
 - 3) Fire Alarm Systems – Bright red surface with white core
 - 4) Security Systems – Dark red (burgundy) surface with white core

- 5) Emergency Systems – Green surface with white core
 - 6) Optional Standby Systems - Yellow surface with Black core
 - 7) Telephone Systems – Orange surface with white core
 - 8) Data Systems – Brown surface with white core
 - 9) Letters shall be 1/2" high.
2. Install nameplates for equipment including, the following:
 - a. Panelboards, electrical cabinets, and enclosures
 - b. Access doors and panels for concealed electrical items
 - c. Electrical switchgear, switchboards, and distribution panelboards including each feeder device within the equipment enclosures.
 - d. Transformers
 - e. Electrical substations
 - f. Emergency system boxes and enclosures
 - g. Motor-control centers, including each device
 - h. Disconnect switches
 - i. Enclosed circuit breakers
 - j. Motor controllers
 - k. Pushbutton stations
 - l. Power transfer equipment
 - m. Contactors
 - n. Remote-controlled switches, dimmer modules, and control devices
 - o. Battery inverter units
 - p. Battery racks
 - q. Power-generating units
 - r. Voice and data cable terminal equipment
 - s. Master clock and program equipment
 - t. Intercommunication and call system master and staff stations
 - u. Television/audio components, racks, and controls
 - v. Fire alarm control panel and annunciators
 - w. Security and intrusion-detection control stations, control panels, terminal cabinets, and racks
 - x. Monitoring and control equipment
 - y. Uninterruptible power supply equipment
 - z. Terminals, racks, and patch panels for voice and data communication and for signal and control functions
 - aa. Non-concealed junction box covers of auxiliary electrical systems
3. Provide the following information on each nameplate:
 - a. Equipment name/tag:
 - 1) Matching the designation from the contract documents, or identifying the load controlled or function of the equipment where no specific tag is shown on the contract documents.

- 2) For disconnect switches, use the prefix “SW-” followed by the name of the equipment served, example: “SW-PMP-201.”
- 3) For panels, labels shall include panel designation, voltage and phase, and all sources feeding the panel including circuit numbers and room location.
- 4) For transformers, labels shall include transformer designation, primary source, and secondary fed equipment designation.
- b. Equipment operating voltage, phase, wiring configuration, and ampacity:
 - 1) Example: “208V/3PH/4W/225A”
- c. Source of power supply, including circuit number:
 - 1) Example: “FED FROM LP-2/45”
- K. For service entrance equipment, provide a nameplate identifying the maximum available fault current and “as of” effective date.
 - 1. Example: “MAXIMUM AVAILABLE FAULT CURRENT 33,500A AS OF 2017/06/15.”
- L. Access Panel Identification: Furnish typewritten charts with identification and location of access panels serving equipment and incorporate in O&M Manuals.

3.2 INSTALLATION

- A. Verify identity of each item before installing identification products.
- B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- C. Apply identification devices to surfaces that require finish after completing finish work.
- D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- E. Install non-adhesive signs and plastic nameplates parallel to equipment lines; attach with screws and auxiliary hardware appropriate to the location and substrate. Secure to inside surface of door or panelboard that is recessed in finished locations.
- F. Posted Drawings and Operating Instructions: Mount drawings and operating procedures on the wall immediately adjacent to the piece of equipment for which the instructions apply. If sufficient wall space is available, mount directly to one of the sheet metal panels of the equipment.
- G. Warning Signs: Install warning signs where there is hazardous exposure or danger associated with access to or operation of electrical facilities. Provide text of sufficient clarity and lettering of sufficient size to convey adequate information at each location; mount permanently in an appropriate and effective location. Comply with ANSI A13.1 standard color and design.
 - 1. Operational Tags: Where needed for proper and adequate information on operation and maintenance of electrical systems, provide tags of plasticized card stock, either preprinted or hand printed to convey the message; example: “DO NOT OPEN THIS SWITCH WHEN BREAKER IS CLOSED.”

- H. System Identification Color Banding for Raceways and Cables: Each color band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50 ft maximum intervals in straight runs, and at 25 ft maximum intervals in congested areas.
- I. Color-Coding for Phase Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder, and branch-circuit conductors.
 - 1. Color shall be factory applied, or, for sizes larger than No. 10 AWG if authorities having jurisdiction permit, field applied.
 - 2. Colors for 208/120 V Circuits:
 - a. Phase A (left bus in panelboard): Black
 - b. Phase B (center bus in panelboard): Red
 - c. Phase C (right bus in panelboard): Blue
 - d. Neutral: White
 - e. Equipment Ground: Green
 - 3. Colors for 480/277 V Circuits:
 - a. Phase A (left bus in panelboard): Brown
 - b. Phase B (center bus in panelboard): Orange
 - c. Phase C (right bus in panelboard): Yellow
 - d. Neutral: Gray
 - e. Equipment Ground: Green
 - 4. Field-applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6" from terminal points and in boxes where splices or taps are made. Apply last two runs of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
- J. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6" to 8" below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16" overall.
- K. Painted Identification: Prepare surface and apply paint according to Division 09 – Finishes painting Sections.

END OF SECTION 260553

SECTION 260573 - POWER SYSTEM STUDIES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Section includes computer based, fault current, arc flash, and overcurrent protective device coordination studies for an electrical distribution system, based on actual equipment supplied. Set protective devices based on results of the protective device coordination study.
 - 1. Intent of this study is to ensure equipment supplied meets the selective coordination requirements for Emergency (NEC 700) Systems prior to equipment procurement.
 - 2. The scope of this section is limited to the evaluation and coordination of Emergency (NEC 700) system components to ensure electrical distribution equipment manufacturer provides equipment that will comply with NEC requirements.
- B. Furnish field information and data needed for the studies.
- C. Available fault current and electrical equipment interrupting capacity indicated on drawings are based on the short circuit study performed during design as part of the construction documents.

1.2 REFERENCE STANDARDS

- A. IEEE C57.12.10 – American National Standard for Transformers-230 kV and Below 833/958-8333/10 417 kVA, Single-Phase, and 750/862-60 000/80 000/100 000 kVA, Three-Phase, w/o Load Tap Changing; and 3750/4687-60 000/80 000 kVA with Load Tap Changing-Safety Requirements
- B. ANSI C57.12.22 – American National Standard for Transformers-Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers with High-Voltage Bushings, 2500 kVA & Smaller: High-Voltage, 34 500 GrdY/19 920 V & Below; Low Voltage, 480 V & Below-Requirements
- C. ANSI C57.12.40 – American National Standard for Secondary Network Transformers-Subway and Vault Types (Liquid Immersed)-Requirements
- D. ANSI C57.12.90 – General Requirements for Liquid-Immersed Distribution Power and Regulating Transformers
- E. IEEE C57.96 – Distribution and Power Transformers, Guide for Loading Dry-Type (Appendix to ANSI C57.12 Standards)
- F. IEEE 141 – Recommended Practice for Electric Power Distribution for Industrial Plants
- G. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings
- H. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
- I. IEEE 399 – Recommended Practice for Power System Analysis

- J. IEEE 620 – Guide for the Presentation of Thermal Limit Curves for Squirrel Cage Induction Machines
- K. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems
- L. IEEE 1584 – Guide for Performing Arc-Flash Hazard Calculations
- M. IEEE C37.010 – Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
- N. IEEE C37.20.1 – IEEE Standard for Metal-Enclosed, Low-Voltage Power Circuit Breaker Switchgear
- O. ANSI C37.46 – American National Standard Specifications for Power Fuses and Fuse-Disconnecting Switches
- P. IEEE C57.12.00 – General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers
- Q. IEEE C57.96 – IEEE Guide for Loading Dry-Type Distribution and Power Transformers
- R. ICICEA P-32-382 – Short-Circuit Characteristics of Insulated Cable
- S. ICEA P-45-482 – Short-Circuit Performance of Metallic Shielding and Sheaths of Insulated Cable
- T. NEMA MG 1 – Motors and Generators
- U. NFPA 70 – National Electrical Code (NEC)
- V. NFPA 70B – Recommended Practice for Electrical Equipment Maintenance
- W. NFPA 70C – Hazardous Locations Classification
- X. NFPA 70E – Standard for Electrical Safety in Workplace

1.3 SUBMITTALS

- A. Product Data: Computer software program to be used for studies. Include specific software version for owner record.
- B. Product Certificates:
 - 1. Coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399.
 - 2. Arc flash calculations computer software programs, certifying compliance with IEEE 1584.
- C. Qualification Data: For coordination study specialist.
 - 1. Submit qualifications of the organization proposed for performing the study. Include description of the equipment and computer-based computation methods or programs used and the names and experience histories of the personnel who will perform the study.

2. Study must be prepared by or under the direct supervision of an engineer licensed in the state of North Carolina. Submittals must bear the stamp of
- D. Other Action Submittals: Subsequent to having approval for system protective devices submit the following in digital format:
 1. Electrical one-line drawing drafted in computer software program with component names.
 - a. Drawing minimum text height of 3/32". Maximum paper size 30"x42". Provide multiple drawing sheets as required.
 2. Fault current study report
 3. Equipment evaluation report
 4. Coordination study input data, including completed computer program input data sheets
 5. Coordination Study Report
 6. Serving utility information with utility letterhead, including:
 - a. Protective device part numbers/settings
 - b. Maximum available 1P and 3P fault
 - c. Line conductor sizes/lengths
 - d. Transformer impedance
 - e. Serving voltage

1.4 QUALITY ASSURANCE

- A. Perform studies using computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.
- B. Coordination Study Specialist Qualifications: An organization experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
 1. Perform study under the direct supervision and control of a Registered Professional Electrical Engineer licensed in the State of North Carolina, with a minimum of 5 yrs recent experience in performing protective device coordination studies, arc flash calculations, and electrical system analysis. Final report shall be signed and sealed by said engineer.
- C. Comply with IEEE 242 for short circuit currents and coordination time intervals.
- D. Comply with IEEE 399 for general study procedures.
- E. Comply with IEEE 1584 for arc flash calculations.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

- A. Computer Software Developers: Subject to compliance with requirements, provide products by one of the following:
- B. Basis of Design Product:

1. CYME International, Inc.
 2. EDSA Micro Corporation
 3. SKM Systems Analysis, Inc.
 4. ETAP
- C. Designer's power system study will be performed using SKM Systems Analysis, for turnover and integration into ECU's master system model.

2.2 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

- A. Comply with IEEE 399 and IEEE 1584.
- B. Analytical features of fault current study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399 Table 7-4.
- C. Computer software program shall be capable of plotting and diagramming time-current characteristic curves as part of its output. Computer software program reports device settings and ratings of all overcurrent protective devices and demonstrates selective coordination by computer-generated, time-current coordination plots.
- D. Arc Flash Calculations: Software program capable of calculating Arc Flash Incident Energy (AFIE) levels and flash protection boundary distances.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices for coordination are indicated on drawings.
- B. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.
- C. Provide the study based on the actual electrical equipment supplied for the project.

3.2 POWER SYSTEM DATA

- A. Gather and tabulate the following input data to support coordination study:
1. Product Data for overcurrent protective devices specified in other Division 26 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with power riser diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
 2. Impedance of utility service entrance(s).
 3. Power Riser Diagrams: In hard copy and electronic copy formats, showing the following:
 - a. Circuit breaker and fuse-current ratings and types
 - b. Relays and associated power and current transformer ratings and ratios

- c. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios
 - d. Generator kilovolt amperes, size, voltage, and source impedance
 - e. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length
 - 1) Prior to equipment purchase, utilize conservative lengths (up/down included) based on planned conduit routing to validate equipment ratings. Final study to utilize contractor provided as-built lengths to confirm equipment ratings.
 - f. Busway ampacity and impedance
 - g. Motor horsepower and code letter designation according to NEMA MG 1
 - h. Load current that is the basis for sizing continuous ratings of circuits for cables and equipment
4. Data sheets to supplement power riser diagrams, cross-referenced with tag numbers on diagrams, showing the following:
- a. Special load considerations, including starting inrush currents and frequent starting and stopping
 - b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability
 - c. Motor full-load current, locked-rotor current, service factor, starting time, type of start, and thermal-damage curve
 - d. Generator thermal-damage curve
 - e. Ratings, types, and settings of utility company's overcurrent protective devices
 - f. Special overcurrent protective device settings or types stipulated by utility company
 - g. Time-current characteristic curves of devices indicated to be coordinated
 - h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers
 - i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays
 - j. Panelboards, switchboards, automatic transfer switch, switchgear ampacity, and interrupting rating in amperes rms symmetrical
 - 1) Automatic transfer switch withstand rating to comply with UL 1008. Equivalent trip curves are not accepted for specific breaker rated equipment – exact breaker and associated trip unit must be listed on UL certification.

3.3 FAULT CURRENT STUDY

- A. Calculate maximum available short circuit current in amperes rms symmetrical at circuit breaker positions of electrical power distribution system. Provide calculation for a current immediately after initiation and for a three-phase bolted short circuit at the following:
- 1. switchboard bus
 - 2. Distribution panelboard
 - 3. Branch circuit panelboard

4. Disconnect switches
 5. Automatic transfer switch
 6. Manual transfer switch
 7. Equipment fed by Variable Frequency Drive (VFD)
 8. Industrial control panels including air handling equipment, elevator controllers, etc.
- B. For standard non-bypass Pulse Width Modulation VFDs, a line short circuit condition may be ignored.
- C. Verify mechanical equipment served meets or exceeds maximum short circuit available.
- D. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for project. Include studies of system switching configurations and alternate operations that could result in maximum fault conditions.
1. Model the entire electrical distribution system from utility company point of connection to circuit breakers in 208 V distribution panels at secondary side of distribution transformers. Include mechanical HVAC equipment, motor driven equipment feeder circuits, and elevator feeder circuits.
 2. Model shall include components of the distribution system which would be exposed to fault current levels of 10,000 A symmetrical on a calculated basis.
 3. Study shall include closed transition operation of automatic transfer switches _____ and worst-case short circuit rating shall be included in analysis for each piece of equipment as defined above. The closed transition and normal operation short circuit ratings shall both be used to explore the worst-case arc fault rating for each piece of electrical equipment as defined above.
- E. Calculate momentary and interrupting duties on basis of maximum available fault current.
- F. Perform calculations to verify interrupting ratings of overcurrent protective devices in compliance with IEEE 141 and IEEE 242.
1. Transformers:
 - a. IEEE C57.12.10
 - b. ANSI C57.12.22
 - c. ANSI C57.12.40
 - d. IEEE C57.12.00
 - e. IEEE C57.96
 2. Medium-Voltage Circuit Breakers: IEEE C37.010
 3. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.20.1
 4. Low-Voltage Fuses: ANSI C37.46
- G. Study Report:
1. Show calculated X/R ratios and equipment interrupting rating (5-cycle) fault currents on power riser diagrams in report. List other output values from computer analyses, including momentary (1/2-cycle), interrupting (5-cycle), and 30-cycle fault current values for 3-phase, 2-phase, and phase-to-ground faults.

2. Show interrupting (5-cycle) and time-delayed currents (6 cycles and above) on medium- and high voltage circuit breakers to set relays and assess the sensitivity of overcurrent relays.

H. Equipment Evaluation Report:

1. Prepare report on adequacy of overcurrent protective devices and conductors by comparing fault current ratings of devices with calculated fault current momentary and interrupting duties.
2. For 600V overcurrent protective devices, ensure interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
3. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in standards to 1/2-cycle symmetrical fault current.
4. Verify adequacy of phase conductors at maximum 3-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure short circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
5. Notify Owner/Engineer promptly of discrepancies, problem areas, or inadequacies and provide recommendations for problem resolution.

3.4 COORDINATION STUDY

- A. Perform coordination study using approved computer software program. Prepare a written report using results of fault current study. Comply with IEEE 399.
 1. Calculate maximum and minimum 1/2-cycle short circuit currents.
 2. Calculate maximum and minimum interrupting duty (5 cycles to 2 seconds) short circuit currents.
 3. Calculate maximum and minimum ground-fault currents.
- B. Comply with NFPA 70 for overcurrent protection of circuit elements and devices.
- C. Comply with IEEE 242 recommendations for fault currents and time intervals.
- D. Note that the State of NC, Department of Insurance Electrical division has published a formal interpretation indicating that selective coordination applies to the time starting at 0.1 seconds. Coordinating for all time or from 0.01 seconds is not required.
- E. Transformer Primary Overcurrent Protective Devices:
 1. Devices non-operational in response to the following:
 - a. Inrush current when first energized
 - b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
 - c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
 2. Protect transformers according to IEEE C57.12.00, for fault currents by device settings.
- F. Protect motors served by voltages more than 600 V according to IEEE 620.

- G. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate equipment withstands the maximum short circuit current for a time equivalent to tripping time of primary relay protection or total clearing time of fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short circuit current. Verify adequacy of phase conductors at maximum three-phase bolted fault currents, equipment grounding conductors, and grounding electrode conductors at maximum ground-fault currents.
- H. Include voltage classes of equipment from utility's incoming line protective device down to and including each panelboard. The phase and ground overcurrent protection shall be included as well as settings for other adjustable protective devices.
- I. Selective Coordination: Overcurrent devices installed upstream and downstream of automatic transfer switches and/or associated with NEC Article 700 Emergency loads shall be selectively coordinated from source of supply (both normal and emergency sources) through final device. Change specific circuit breakers (type, frame, trip-unit, etc.) and equipment bus rating as necessary to meet this requirement. Selective coordination of the system indicated on the one-line diagram is based on (list manufacturer) equipment.
 - 1. Additionally, provide selective coordination for ground fault through-out.
- J. Coordination Study Report: Prepare a written report indicating results of coordination study:
 - 1. Tabular Format of Settings Selected for Overcurrent Protective Devices:
 - a. Device tag
 - b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values
 - c. Circuit breaker sensor rating; and long-time, short-time, and instantaneous settings
 - d. Fuse-current rating and type
 - e. Ground-fault relay-pickup and time-delay settings
 - f. Manufacturer and type of device
 - g. Range of adjustments and recommended settings
 - 2. Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate adequate time separation exists between devices installed in series, drawn to show the boundaries of device operation on log-log scale graphs, including power utility company's upstream devices. Where time current curves do not explicitly illustrate selective coordination but breakers have been tested and documented as being selectively coordinated, submit manufacturer's literature to substantiate device coordination. Include on curve sheet a title and legend identifying portion of the system covered. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
 - a. Device tag
 - b. Voltage and current ratio for curves
 - c. Three-phase and single-phase damage points for each transformer
 - d. No damage, melting, and clearing curves for fuses
 - e. Cable damage curves

- f. Transformer inrush points, full-load amps, and damage curves
 - g. Maximum fault current cutoff point
 - h. Generator decrement curve and full-load amps
- 3. Plot characteristics where applicable:
 - a. Low-voltage fuses including minimum melt, total clearing and damage bands
 - b. Low-voltage circuit breaker trip devices
 - c. Transformer full-load current, magnetizing inrush current, and ANSI transformer withstand parameters
 - d. Ground-fault protective devices
 - e. Motor starting characteristics and motor damage points
 - f. Generator short circuit decrement curve and generator damage point
 - g. Conductor damage curves
 - h. Electric utility's protective devices
 - i. Medium-voltage equipment relays
- 4. Energy-reducing maintenance switch: Where a circuit breaker is equipped with an energy reducing maintenance switch, provide both normal and "maintenance mode" settings for the breaker. Include both settings in tabular format and in coordination curves.
- 5. Notify Owner/Engineer promptly of discrepancies, problem areas, or inadequacies and provide recommendations for problem resolution. Propose approaches to effectively protect the underrated equipment. Present technical evaluation with discussion of logical compromises for best coordination.

K. Completed data sheets for setting of overcurrent protective devices.

3.5 FIELD QUALITY CONTROL

- A. Inspect, set, test, and calibrate the protective relays, circuit breakers, fuses, and other applicable devices per requirements in Section 260812 - Power Distribution Acceptance Tests and Section 260813 - Power Distribution Acceptance Test Tables.
- B. Upon final approval of study, provide weatherproof vinyl or polyester arc flash label for all electrical equipment defined above. Label shall include calculated flash protection boundary, incident energy in cal/cm² at working distance (mm working distance based on equipment class, per IEEE 1584), required PPE level, limited approach, restricted approach, equipment name, company name/logo who performed the study, available fault current, and date label was produced.
 - 1. Label to comply with ANSI Z535. Use "WARNING" (ANSI safety orange background with an orange exclamation point safety symbol) for all arc flash levels.
 - 2. Per NFPA 70E 130.5(C), due to use of incident energy analysis method, PPE categories shall not be provided on labels unless site specific standard PPE categories differ from incident energy levels noted in NFPA 70E Table 130.7(C)(16).
 - 3. Include verbiage on label noting study should be re-examined once every (5) years or upon modifications to electrical system.

3.6 ADJUSTING

- A. Make modifications to equipment, as required, to accomplish conformance with equipment evaluation study.
- B. Adjust relay and overcurrent protective device settings according to recommended settings table provided by overcurrent protective device coordination study.
- C. Notify Owner/Engineer in writing of any required major modifications.

3.7 INSTALLATION

- A. Install PPE labels on each piece of equipment that requires inspection, testing, or maintenance prior to energizing equipment.
- B. PPE labels shall be protected by clear plastic cover, weatherproof type material, or laminated and mounted on front of equipment. Taping of PPE label to front of equipment is unacceptable.
- C. PPE label shall be clearly visible upon approach to equipment.
- D. For large pieces of equipment, label shall be placed near main overcurrent device or incoming feeder to equipment. For equipment such as switchboards, UPS, or switchgear, with multiple vertical sections, provide (1) label per vertical section. Rear-accessible equipment shall have label provided for the rear as well as the front.
- E. Contractor to provide one-line diagrams (meet IEEE/ANSI standard 141), mounted on 24"x36" (minimum) Styrofoam backboard. These one-line diagrams shall be mounted in each electrical room.
- F. Label shall be mounted at a minimum of 42" to bottom and maximum 66" to top above finished floor.

END OF SECTION 260573

SECTION 260593 - ELECTRICAL SYSTEMS FIRESTOPPING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Section includes through-penetration firestop systems for penetrations through fire-resistance-rated constructions (walls, partitions, floors, and ceilings) including both empty openings and openings containing electrical penetrating items, including raceways, cables, cable trays, busways, and wireways.

1.2 REFERENCE STANDARDS

- A. ASTM E814 – Standard Test Method for Fire Tests of Through-Penetration Firestops
- B. UL 1479 - Fire Tests of Through-Penetration Firestops

1.3 PERFORMANCE REQUIREMENTS

- A. Provide firestop system to resist spread of fire, resist passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated.
- B. Firestop systems shall be UL Classified for the application and correspond to those indicated by reference to designations listed by UL Fire Resistance Directory.
- C. Conform to applicable Code requirements of Authority Having Jurisdiction.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For each through-penetration firestop system, show each type of construction condition penetrated, relationships to adjoining construction, and type of penetrating item. Include firestop design designation of qualified testing and inspecting agency that evidences compliance with requirements for each condition indicated.
 - 1. Submit documentation, including illustrations, from a qualified testing and inspecting agency that is applicable to each through-penetration firestop system configuration for construction and penetration items, including documentation of UL certification for firestop systems.
- C. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- D. Material Safety Data Sheets provided with product delivered to job site.
- E. Inspection reports

- F. Onsite Training Letter: Firestop manufacturer to provide and contractor to submit letter stating the names(s) of the companies, person(s) in attendance and date of onsite training as required in section 1.7.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: A firm experienced in installing through-penetration firestop systems similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful performance.
- B. Firestopping tests shall be performed by a qualified testing and inspecting agency, or another agency performing testing and follow-up inspection services for firestop systems acceptable to Authorities Having Jurisdiction.
- C. Manufacturer's representative shall be on-site during initial installation of firestop systems to train appropriate Contractor personnel in proper selection and installation procedures.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Deliver through-penetration firestop system products to Project site in original, unopened containers or packages with intact and legible manufacturers' labels identifying product, type and manufacturer, and UL Label where applicable.
- B. Store and handle materials for through-penetration firestop systems to prevent their deterioration or damage due to moisture, temperature changes, contaminants, or other causes.
- C. Handle in accordance with recommended procedures, precautions, or remedies described in material safety data sheets as applicable.

1.7 PROJECT CONDITIONS

- A. Do not install through-penetration firestop systems when ambient or substrate temperatures are outside limits permitted by through-penetration firestop systems' manufacturers or when substrates are wet due to rain, frost, condensation, or other causes.
- B. Ventilate through-penetration firestop systems per manufacturers' written instructions by natural means or, where this is inadequate, forced-air circulation.

1.8 COORDINATION

- A. Coordinate construction of openings and penetrating items to ensure that through-penetration firestop systems are installed according to specified requirements.
- B. Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate through-penetration firestop systems.
- C. Notify Owner's inspecting agency at least 7 days in advance of through-penetration firestop system installations; confirm dates and times on days preceding each series of installations.

- D. Do not cover up through-penetration firestop system installations that will become concealed behind other construction until each installation has been examined by Owner's inspecting agency and building inspector, if required by Authorities Having Jurisdiction.

1.9 SEQUENCING

- A. Sequence work to avoid interferences with building finishes and installation of other products.

1.10 WARRANTY

- A. Refer to Division 01 and Section 260000 - General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of final acceptance.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. 3M (Fire Protection Products Division), Hilti Inc, Tremco (Sealant/Weatherproofing Division), Nelson Firestop Products, Specified Technologies Inc, RectorSeal Corporation, _____.

2.2 MATERIALS

- A. Firestop Products: UL 1479, ASTM E814 tested for specific fire-rated construction conditions conforming to construction assembly type, penetrating item type, annular space requirements and fire-rating involved for each separate instance; materials shall not contain flammable solvents.
- B. Firestop Systems: Produced by the same manufacturer.
- C. VOC Content: Penetration firestopping sealants and sealant primers shall comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
 - 1. Sealants: 250 g/L
 - 2. Sealant Primers for Nonporous Substrates: 250 g/L
 - 3. Sealant Primers for Porous Substrates: 775 g/L

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for opening configurations, penetrating items and other conditions affecting performance of firestopping.
- B. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Clean out openings immediately prior to installing through-penetration firestop system to comply with firestop system manufacturer's written instructions.
- B. Provide masking and temporary covering to prevent soiling of adjacent surfaces by firestopping materials.
- C. Comply with manufacturer's recommendations for temperature and humidity conditions before, during and after installation of firestopping.

3.3 INSTALLATION

- A. Comply with "System Performance Requirements" Article in Part 1 and with firestop system manufacturer's written installation instructions and drawings for products and applications indicated.
- B. Install forming/damming/backing materials and other accessories of types required to support fill materials during application as required. After installing fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not indicated as permanent components of firestop systems.
- C. Each conduit penetration through a fire rated assembly is to be dedicated to a single conduit. Multiple conduits penetrating a single opening is not acceptable unless a UL listed, multi-conduit assembly is used.

3.4 IDENTIFICATION

- A. Identify through-penetration firestop systems with pressure-sensitive, self-adhesive, preprinted vinyl labels. Attach labels permanently to surfaces of penetrated construction on both sides of each firestop system installation where labels will be visible to anyone seeking to remove penetrating items or firestop systems. Include label(s) complying with 1 or 2 below.
 - 1. Custom label with the following information:
 - a. The words: "Warning—Through-Penetration Firestop System—Do Not Disturb. Notify Building Management of Any Damage."
 - b. Contractor's name, address, and phone number
 - c. Through-penetration firestop system designation of applicable testing and inspecting agency
 - d. Date of installation
 - e. Through-penetration firestop system manufacturer's name
 - f. Installer's name
 - 2. Manufacturer's preprinted labels with similar information per 1 above.

3.5 FIELD QUALITY CONTROL

- A. Inspecting Agency: Owner will engage a qualified independent inspecting agency to inspect through-penetration firestop systems and to prepare test reports.

1. Inspecting agency will state in each report whether inspected through-penetration firestop systems comply with or deviate from requirements.
- B. Provide certification by Installer that all through-penetration firestop systems have been firestopped in accordance with applicable Building Codes of the _____ of Project location.
- C. Proceed with enclosing through-penetration firestop systems with other construction only after inspection reports are issued and firestop installations comply with requirements.
- D. Where deficiencies are found, repair or replace through-penetration firestop systems so they comply with specifications.

3.6 CLEANING

- A. Clean surfaces adjacent to sealed holes and joints to be free of excess firestop materials and soiling as work progresses.

END OF SECTION 260593

SECTION 260812 - POWER DISTRIBUTION ACCEPTANCE TESTS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Section includes acceptance testing requirements for assessing the suitability for service and reliability of the power distribution system.
- B. Contractor to ensure all tested electrical equipment, both Contractor and Owner supplied, is operational and within industry and manufacturer's tolerances and is installed in accordance with design specifications.
- C. Tests and inspections shall be performed after installation.
- D. Tests and inspections shall determine suitability for energization.
- E. Electrical systems shall pass tests prior to substantial completion or Owner occupancy.
- F. This specification requires Contractor to engage services of testing agency.
- G. All tests tables referenced in this specification provided in Section 26 0813 – Power Distribution Acceptance Test Tables.
- H. Items to be tested and inspected as follows:
 - 1. 600-volt conductors and cables
 - 2. Electrical metering
 - 3. Engine generator
 - 4. Dry type transformers (small)
 - 5. Switchboard
 - 6. Low-voltage insulated-case/molded-case circuit breakers
 - 7. Low-voltage disconnect switches
 - 8. Automatic transfer switches
 - 9. Motor control and motor control center
 - 10. Ground fault protection systems
 - 11. Grounding systems
 - 12. Thermographic survey

1.2 REFERENCE STANDARDS

- A. ANSI/IEEE C2 – National Electrical Safety Code
- B. ANSI/IEEE C37 – Guides and Standards for Circuit Breakers, Switchgear, Relays, Substations, and Fuses
- C. ANSI/IEEE C37.04 – Standard Rating Structure for AC High Voltage Circuit Breaker
- D. ANSI/IEEE C57 – Distribution, Power, and Regulating Transformers

- E. ANSI/IEEE C57.13.1 – Guide for Field Testing of Relaying Current Transformers
- F. ANSI/IEEE C57.13.3 – Grounding of Instrument Transformer Secondary Circuits and Gases
- G. ANSI/IEEE C62 – Surge Protection
- H. ANSI/IEEE 43 – IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery
- I. ANSI/IEEE 48 – Standard Test Procedure and Requirements for High-Voltage Alternating-Current Cable Terminations
- J. ANSI/IEEE 81 – Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
- K. ANSI/IEEE 141 – IEEE Recommended Practice for Electrical/Power Distribution for Industrial Plants (IEEE Red Book)
- L. ANSI/IEEE 142 – IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems (IEEE Green Book)
- M. ANSI/IEEE 241 – IEEE Recommended Practice for Electrical Power Systems in Commercial Buildings (IEEE Gray Book)
- N. ANSI/IEEE 242 – IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (IEEE Buff Book)
- O. ANSI/IEEE 399 – IEEE Recommended Practice for Power Systems Analysis (IEEE Brown Book)
- P. ANSI/IEEE 400 – Guide for Making High-Direct-Voltage Tests on Power Cable Systems in the Field
- Q. ANSI/IEEE 446 – IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications (IEEE Orange Book)
- R. ANSI/IEEE 493 – IEEE Recommended Practice for the Design of Reliable Industrial and Commercial Power Systems (IEEE Gold Book)
- S. ANSI/IEEE 1100 – IEEE Recommended Practice for Powering and Grounding Sensitive Electronic Equipment (IEEE Emerald Book)
- T. NETA ATS – Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems
- U. NEMA AB 4 – Guidelines for Inspection and Preventive Maintenance of Molded-Case Circuit Breakers Used in Commercial and Industrial Applications
- V. NEMA MG 1 – Motors and Generators
- W. NFPA 70 – National Electrical Code

- X. NFPA 70B – Recommended Practice for Electrical Equipment Maintenance
- Y. NFPA 70E – Electrical Safety Requirements for Employee Workplaces
- Z. NFPA 101 – Life Safety Code
- AA. NFPA 110 – Emergency and Standby Power Systems
- BB. NIST – National Institute of Standards and Technology
- CC. OSHA – Part 1910 – Subpart S – 1910.308 – Special Systems

1.3 SUBMITTALS

- A. Test Reports: Include the following:
 - 1. Summary of project
 - 2. Description of equipment tested
 - 3. Equipment used to conduct the test
 - 4. Description of test
 - 5. Test results, as compared to manufacturers' or industry accepted standards and tolerances
 - 6. Conclusions and recommendations
 - 7. Signature of responsible test organization authority
- B. List of equipment used to perform tests. Identify the following:
 - 1. Type
 - 2. Manufacturer
 - 3. Model number
 - 4. Serial number
 - 5. Date of last calibration
 - 6. Documentation of calibration leading to NIST standards

1.4 QUALITY ASSURANCE

- A. Qualifications of Testing Agency:
 - 1. Testing firm shall be a corporately and financially independent testing organization that can function as an unbiased testing authority, professionally independent of the manufacturer, supplier, and installers of equipment or system evaluated by the testing firm.
 - 2. Testing firm shall be regularly engaged in testing of electrical equipment, devices, installations and systems.
 - 3. Testing firm shall meet Federal Occupational Safety and Health Administration (OSHA) requirements for accreditation of independent testing laboratories.
 - 4. On-site technical person shall be currently certified by the International Electrical Testing Association in electrical power distribution system testing.
 - 5. Testing firm shall use technicians who are regularly employed by the firm for testing services.

6. Testing firm shall submit proof of above qualifications with bid documents when requested.

PART 2 - PRODUCTS

2.1 NOT APPLICABLE TO THIS SECTION.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Documentation: Deliver the following to testing firm, minimum two weeks prior to commencement of testing:
 1. Complete set of electrical plans and specifications, with available short circuit indicated on power riser diagrams.
 2. Approved submittals and shop drawings of equipment being tested.
 3. Pertinent change orders.
 4. Evaluation, overcurrent protective device coordination and arc flash studies, per requirements in Section 260573 - Power System Studies.
- B. Schedule: Notify Owner and Engineer 10 working days prior to performance of any tests.
- C. Coordination: Coordinate with Construction Manager/Owner/Engineer the testing schedule and availability of equipment ready for testing.
- D. Test Power: Provide test power (including specialized) for equipment testing before and after service energizing.

3.2 FIELD QUALITY CONTROL

- A. Inspection and Test Procedures: Comply with NETA.
 1. 600 V Conductors and Cables:
 - a. Visual and Mechanical Inspection:
 - 1) Compare cable data with drawing and specifications.
 - 2) Inspect exposed sections of cables for physical damage.
 - 3) Verify tightness of accessible bolted electrical connections by calibrated torque wrench in accordance with manufacturer's published data or Table 12.
 - 4) Perform thermographic survey of bolted electrical connections in accordance with paragraph "Thermographic Survey."
 - 5) Inspect compression-applied connectors for correct cable match and indentation.
 - 6) Verify visible cable bends meet or exceed ICEA and manufacturer's minimum allowable bending radius.
 - 7) For cables are terminated through window-type current transformers, provide an inspection to verify neutral and ground conductors are correctly placed for operation of protective devices.
 - 8) Inspect for correct identification and arrangements.

- 9) Inspect jacket and insulation condition.
- b. Electrical Tests:
 - 1) Perform insulation-resistance test using megohm meter. Applied potential to be 1000 VDC. Individually test each conductor with other conductors grounded. Test duration shall be one minute.
 - 2) Perform continuity tests to ensure correct cable connection.
- c. Test Values:
 - 1) Insulation-resistance values should not be less than 50 megohms.
2. Electrical Metering:
 - a. Visual and Mechanical Inspection:
 - 1) Compare equipment nameplate data with drawings and specifications.
 - 2) Inspect physical and mechanical condition.
 - 3) Verify tightness of electrical connections.
 - 4) Inspect cover gasket, cover glass, condition of spiral spring, disc clearance, contacts, and case-shorting contacts, as applicable.
 - 5) Verify freedom of movement, correct travel and alignment, and tightness of mounting hardware.
 - b. Electrical Tests:
 - 1) Check calibration of meters at cardinal points.
 - 2) Calibrate watt-hour meters according to manufacturer's published data.
 - 3) Verify instrument multipliers.
 - 4) Electrically confirm current transformer and voltage transformer secondary circuits are intact.
3. Engine Generator:
 - a. Visual and Mechanical Inspection:
 - 1) Compare equipment nameplate data with drawings and specifications.
 - 2) Inspect physical and mechanical condition.
 - 3) Inspect correct anchorage and grounding.
 - 4) Inspect air baffles, filter media, and cooling fans.
 - 5) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 12.
 - 6) Confirm correct application of manufacturer's recommended lubricants.
 - b. Electrical and Mechanical Tests:
 - 1) Perform insulation-resistance test on generator winding with respect to ground in accordance with ANSI/IEEE 43. Calculate polarization index.
 - 2) Test protective relay devices in accordance with paragraph "Protective Relays."
 - 3) Perform phase-rotation test to determine compatibility with load requirements.
 - 4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
 - 5) Perform vibration baseline test. Plot amplitude versus frequency for each main bearing cap.

- 6) Conduct performance test in accordance with NFPA 110, Section 7-13 (Installation Acceptance).
 - 7) Verify correct functioning of governor and regulator.
 - 8) Verify function and temperature regulation for battery and engine heaters.
 - c. Test Values:
 - 1) Polarization index values shall be in accordance with ANSI/IEEE 43.
 - 2) Vibration levels shall be in accordance with manufacturer's published data.
 - 3) Performance tests shall conform to manufacturer's published data and NFPA 110.
 - 4) Vibration amplitudes shall not exceed values shown in Table 10.
 - 5) Bolt-torque levels shall be in accordance with Table 12, unless otherwise specified by manufacturer.
4. Dry Type Transformers (Small):
 - a. Visual and Mechanical Inspection:
 - 1) Compare equipment nameplate data with drawings and specifications.
 - 2) Inspect physical and mechanical condition.
 - 3) Inspect anchorage, alignment, and grounding.
 - 4) Verify that resilient mounts are free and that any shipping brackets have been removed.
 - 5) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 12.
 - 6) Verify that as-lift tap connections are as specified.
 - b. Electrical Tests:
 - 1) Perform insulation-resistance tests winding-to-winding and each winding-to-ground with test voltage in accordance with Table 5. Calculate dielectric absorption ratio or polarization index.
 - c. Test Values:
 - 1) Bolt-torque levels should be in accordance with Table 12, unless otherwise specified by manufacturer.
 - 2) Insulation-resistance test values at one minute should be in accordance with Table 5.
 - 3) The dielectric absorption or polarization index shall be greater than 1.0 and shall be recorded for future reference.
5. Low-Voltage Switchgear and Switchboard Assemblies:
 - a. Visual and Mechanical Inspection:
 - 1) Compare equipment nameplate data with drawings and specifications.
 - 2) Inspect physical and mechanical condition.
 - 3) Confirm correct application of manufacturer's recommended lubricants.
 - 4) Verify appropriate anchorage, required area clearances, grounding and correct alignment.
 - 5) Inspect doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.

- 6) Verify fuse and/or circuit breaker sizes and types correspond to drawings and coordination study as well as to circuit breaker's address for microprocessor-communication packages.
 - 7) Verify that current and potential transformer ratios correspond to drawings.
 - 8) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench. Refer to manufacturer's published data or Table 12 for proper torque values.
 - 9) Perform thermographic survey of bolted electrical connections in accordance with paragraph "Thermographic Survey."
 - 10) Confirm correct operation and sequencing of electrical and mechanical interlock systems.
 - a) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
 - b) Make key exchange with devices operated in off-normal positions.
 - 11) Inspect insulators for evidence of physical damage or contaminated surfaces.
 - 12) Verify correct barrier and shutter installation and operation.
 - 13) Exercise active components.
 - 14) Inspect mechanical indicating devices for correct operation.
 - 15) Verify filters are in place and/or vents are clear.
 - 16) Perform visual and mechanical inspection of instrument transformers, in accordance with paragraph "Instrument Transformers."
 - 17) Inspect control power transformers.
 - a) Inspect physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
 - b) Verify that primary and secondary fuse ratings or circuit breakers match drawings.
 - c) Verify correct functioning of draw-out disconnecting and grounding contacts and interlocks.
- b. Electrical Tests:
- 1) Perform tests on all instrument transformers in accordance with paragraph "Instrument Transformers."
 - 2) Perform resistance tests through bus joints with low-resistance ohmmeter. Joints that cannot be directly measured due to permanently installed insulation wrap shall be indirectly measured from closest accessible connection.
 - 3) Perform insulation-resistance tests in each bus section, phase-to-phase and phase-to-ground for one minute in accordance with Table 1.
 - 4) Perform over-potential test on each bus section, each phase-to-ground with phases not under test grounded, in accordance with manufacturer's published data. In the absence of any published data, Table 2 shall apply. Test voltage shall be applied for one minute.
 - 5) Perform insulation-resistance tests at 1000 VDC on control wiring. Test duration shall be one minute. Do not perform this test on wiring connected to solid-state components. Follow manufacturer's recommendation.

- 6) Perform current injection tests on the entire current circuit in each section of switchgear.
 - a) Perform current tests by primary injection, where possible, with magnitudes such that minimum of 1.0 amp flows in secondary circuit.
 - b) Where primary injection is impractical, utilize secondary injection with minimum current of 1.0 amp.
 - c) Test current at each device.
 - 7) Determine accuracy of meters and calibrate watt-hour meters in accordance with paragraph "Electrical Metering." Verify multipliers.
 - 8) Perform phasing check on double-ended switchboard/switchgear to ensure correct bus phasing from each source.
 - 9) Perform the following tests on control power transformers:
 - a) Perform insulation-resistance tests. Perform measurements from winding-to-winding and each winding-to-ground. Test voltages shall be in accordance with Table 1 unless otherwise specified by manufacturer.
 - b) Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to correct secondary voltage. Confirm potential at all devices.
 - c) Verify correct secondary voltage by energizing primary winding with system voltage. Measure secondary voltage with secondary wiring disconnected.
 - d) Verify correct function of control transfer relays located in switchboard/switchgear with multiple control power sources.
 - 10) Potential Transformer Circuits:
 - a) Perform insulation-resistance tests. Perform measurements from winding-to-winding and each winding-to-ground. Test voltages shall be in accordance with Table 1, unless otherwise specified by manufacturer.
 - b) Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to correct secondary voltage.
 - c) Verify secondary voltage by energizing primary winding with system voltage. Measure secondary voltage with secondary wiring disconnected.
 - 11) Verify operation of switchgear/switchboard space heaters.
- c. Test Values:
- 1) Bolt-torque levels shall be in accordance with Table 12, unless otherwise specified by manufacturer.
 - 2) Compare bus connection resistances to values of similar connections.
 - 3) Insulation-resistance values for bus, control wiring, and control power transformers shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 1. Values of insulation resistance less than this table or manufacturer's minimum should be investigated. Over-potential tests should not proceed until insulation-resistance levels are raised above minimum values.
 - 4) Bus insulation shall withstand the over-potential test voltage applied.

- 5) Contact resistance values shall not exceed high limit of normal range as indicated in manufacturer's published data. If manufacturer's data is not available, investigate values that deviate from similar bus by more than 50% of lowest value.
6. Low-Voltage Insulated-Case/Molded-Case Circuit Breakers, 225A and Larger:
 - a. Visual and Mechanical Inspection:
 - 1) Compare nameplate date with drawings and specifications.
 - 2) Inspect circuit breaker for correct mounting.
 - 3) Check cell fit, element alignment and racking mechanism for draw-out breakers.
 - 4) Operate circuit breaker to ensure smooth operation.
 - 5) Inspect case for cracks or other defects.
 - 6) Verify tightness of accessible bolted electrical connections and/or cable connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 12.
 - 7) Inspect mechanism contacts and arc chutes in unsealed units.
 - b. Electrical Tests:
 - 1) Perform a contact-resistance test.
 - 2) Perform insulation-resistance test at 1000 VDC from pole-to-pole and from each pole-to-ground with breaker closed and across open contacts of each phase. Test duration shall be one minute. Use a minimum test voltage in accordance with Table 1 or manufacturer's published data.
 - 3) Perform insulation-resistance test at 1000 VDC on all control wiring. Test duration shall be one minute. Do not perform the test on wiring connected to solid-state components. Follow manufacturer's recommendation.
 - 4) Perform adjustments for final trip settings in accordance with overcurrent protective device coordination study.
 - 5) Perform long-time delay time-current characteristic tests by passing 300% rated current through each pole separately, unless series testing is required to defeat ground fault functions.
 - 6) Determine short-time pickup and delay by primary current injection.
 - 7) Determine ground-fault pickup and time delay by primary current injection.
 - 8) Determine instantaneous pickup current by primary injection using run-up or pulse method.
 - 9) Verify correct operation of auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and anti-pump function.
 - 10) Verify trip unit calibrations by secondary injection.
 - 11) Determine minimum operation voltage on shunt trip and close coils in accordance with Table 20.
 - 12) Check charging mechanism.
 - c. Test Values:
 - 1) Bolt-torque levels shall be in accordance with Table 12, unless otherwise specified by manufacturer.

- 2) Compare microhm or millivolt drop values to adjacent poles or similar breakers. Investigate deviations of more than 50% of lowest value. Investigate any value exceeding manufacturer's recommendations.
 - 3) Circuit breaker insulation-resistance shall be in accordance with Table 1.
 - 4) Control wiring insulation-resistance shall comply with manufacturer's published data. In the absence of manufacturer's published data, use Table 1. Values of insulation resistance less than this table or manufacturer's minimum shall be investigated.
 - 5) Trip characteristic of breakers shall fall within manufacturer's published time-current characteristic tolerance band, including adjustment factors. If manufacturer's curves are not available, trip times shall not exceed the value shown in Table 7. Circuit breakers exceeding specified trip time at 300% of pickup shall be tagged defective.
 - 6) For molded-case circuit breakers, instantaneous pickup values shall be within manufacturer's published data or tolerances shown in Table 8.
 - 7) Minimum operation voltages on shunt trip and close coils shall be in accordance with manufacturer's published data. In the absence of manufacturer's data, refer to Table 20.
7. Low-Voltage Disconnect Switches:
- a. Visual and Mechanical Inspection:
 - 1) Compare equipment nameplate data with drawings and specifications.
 - 2) Inspect physical and mechanical condition.
 - 3) Inspect anchorage, alignment, grounding, and required clearances.
 - 4) Verify correct blade alignment, blade penetration, travel stops, and mechanical operation.
 - 5) Verify that fuse sizes and types are in accordance with drawings, short-circuit and overcurrent protective device coordination studies.
 - 6) Verify that each fuse has adequate mechanical support and contact integrity.
 - 7) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 12.
 - 8) Perform thermographic survey of accessible bolted electrical connection in accordance with paragraph "Thermographic Survey."
 - 9) Verify operation and sequencing of interlocking systems.
 - 10) Verify correct phase barrier installation.
 - 11) Verify correct operation of all indicating and control devices.
 - 12) Confirm correct application of manufacturer's recommended lubricants.
 - b. Electrical Tests:
 - 1) Measure contact resistance across each switchblade and fuseholder.
 - 2) Perform insulation-resistance test at 1000 VDC from pole-to-pole and from each pole-to-ground. Test duration shall be one minute. Use a minimum test voltage in accordance with Table 1 or manufacturer's published data.
 - 3) Measure fuse resistance.
 - 4) Perform ground fault test, if applicable.

- c. Test Values:
 - 1) Compare bolted connection resistances to values of similar connections.
 - 2) Bolt-torque levels should be in accordance with Table 12, unless otherwise specified by the manufacturer.
 - 3) Compare microhm or millivolt drop values to adjacent poles or similar switches. Investigate deviations of more than 50% of lowest value. Investigate any value exceeding manufacturer's recommendations.
 - 4) Minimum insulation-resistance shall be in accordance with manufacturer's published data or Table 1.
 - 5) Investigate fuse-resistance values that deviate from each other by more than 15%.
- 8. Automatic Transfer Switches:
 - a. Visual and Mechanical Inspection:
 - 1) Compare equipment nameplate data with drawings and specifications.
 - 2) Inspect physical and mechanical condition.
 - 3) Confirm correct application of manufacturer's recommended lubricants.
 - 4) Verify manual transfer warnings are attached and visible.
 - 5) Verify tightness of control connections.
 - 6) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 12.
 - 7) Perform thermographic survey of accessible bolted electrical connections in accordance with paragraph "Thermographic Survey."
 - 8) Perform manual transfer operation.
 - 9) Verify positive mechanical interlocking between normal and alternative sources.
 - 10) Inspect anchorage, alignment, grounding and required clearances.
 - b. Electrical Tests:
 - 1) Measure contact resistance.
 - 2) Perform insulation-resistance tests, phase-to-phase and phase-to-ground, with switch in both source positions. Test duration shall be one minute. Use a test voltage in accordance with Table 1 or manufacturer's published data. For control devices that cannot tolerate test voltage, follow manufacturer's recommendation.
 - 3) Verify settings and operation of control devices.
 - 4) Calibrate and set relays and timers in accordance with paragraph "Protective Relays."
 - 5) Verify phase rotation, phasing and synchronized operation as required by the application.
 - 6) Perform automatic transfer tests:
 - a) Simulate loss of normal power.
 - b) Return to normal power.
 - c) Simulate loss of emergency power.
 - d) Simulate all forms of single-phase conditions.
 - 7) Verify correct operation and timing of following functions:
 - a) Normal source voltage-sensing relays.

- b) Engine start sequence.
 - c) Time delay upon transfer.
 - d) Alternate source voltage-sensing relays.
 - e) Automatic transfer operation.
 - f) Interlocks and limit switch function.
 - g) Time delay and retransfer upon normal power restoration.
 - h) Engine cool down and shutdown feature.
 - c. Test Values:
 - 1) Bolt-torque levels shall be in accordance with Table 12, unless otherwise specified by manufacturer.
 - 2) Insulation-resistance test voltage and minimum values shall be in accordance with Table 1.
 - 3) Compare microhm values to adjacent poles or similar switches. Investigate deviations of more than 50% of lowest value. Investigate any value exceeding manufacturer's recommendations.
9. Motor Control and Motor Control Center:
- a. Visual and Mechanical Inspection:
 - 1) Compare equipment nameplate data with drawings and specifications.
 - 2) Inspect physical and mechanical condition.
 - 3) Inspect anchorage, alignment and grounding.
 - 4) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 12.
 - 5) Verify controller mechanical operations. Inspect gap, wipe, alignment, and pressure are in accordance with manufacturer's published data.
 - 6) Verify motor running protection installed and properly sized.
 - 7) Confirm correct application of manufacturer's recommended lubricants.
 - b. Electrical Tests:
 - 1) Perform resistance tests through all bus joints with low-resistance ohmmeter. Any joints that cannot be directly measured due to permanently installed insulation wrap shall be indirectly measured from closest accessible connection.
 - 2) Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground with controller closed and across each open pole. Test duration shall be one minute. Use a test voltage in accordance with Table 1 or manufacturer's published data. For control devices that cannot tolerate test voltage, follow manufacturer's recommendations.
 - 3) Perform insulation-resistance tests at 1000 VDC on control wiring. Test duration shall be one minute. Do not perform this test on wiring connected to solid-state components. Follow manufacturer's recommendations.
 - 4) Test motor protection devices in accordance with manufacturer's published data. In the absence of manufacturer's data, use paragraph "Protective Relays."
 - 5) Test circuit breakers in accordance with paragraph "Low-Voltage Insulated-Case/Molded-Case Circuit Breakers."
 - 6) Perform operational tests by initiating control devices.

- c. Test Values:
 - 1) Bolt-torque levels shall be in accordance with Table 12, unless otherwise specified by manufacturer.
 - 2) Compare bus connection resistances to values of similar connections.
 - 3) Insulation-resistance values for bus, control wiring, and control power transformers shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 1. Values of insulation-resistance less than this table or manufacturer's minimum should be investigated.
 - 4) Motor protection parameters shall be in accordance with manufacturer's published data.
- 10. Ground Fault Protection Systems:
 - a. Visual and Mechanical Inspection:
 - 1) Compare equipment nameplate data with drawings and specifications.
 - 2) Visually inspect components for damage and errors in polarity or conductor routing:
 - a) Verify ground connection is made ahead of neutral disconnect link and on line side of any ground fault sensor.
 - b) Verify neutral sensors are connected with correct polarity on both primary and secondary.
 - c) Verify all phase conductors and neutral pass through sensor in same direction for zero sequence systems.
 - d) Verify grounding conductors do not pass through zero sequence sensors.
 - e) Verify grounded conductor is solidly grounded.
 - 3) Verify tightness of accessible bolted electrical connections, including control circuits, by calibrated torque-wrench method in accordance with manufacturer's published data or Table 12.
 - 4) Verify correct operation of self-test panel.
 - 5) Set pickup and time-delay settings in accordance with settings provided on drawings and in specifications. Record operation and test sequences as required by NFPA 70.
 - 6) Verify the control power transformer has adequate capacity for the system.
 - b. Electrical Tests:
 - 1) Measure system neutral-to-ground insulation resistance with neutral disconnect link temporarily removed. Replace neutral disconnect link after testing.
 - 2) Perform insulation-resistance test of control wiring at 1000 VDC for one minute. Do not perform this test on wiring connected to solid-state components. Follow manufacturer's recommendations.
 - 3) Perform the following pickup tests using primary injection:
 - a) Verify relay does not operate at 90% of pickup setting.
 - b) Verify pickup is less than 125% of setting or 1200 amp, whichever is smaller.

- 4) For summation type systems using phase-neutral current transformers, verify correct polarities by applying current to each phase-neutral current transformer pair. This test also applies to molded-case breakers using external neutral current transformer.
 - a) Relay should operate when current direction is the same relative to polarity marks in the two current transformers.
 - b) Relay should not operate when current direction is opposite relative to polarity marks in the two current transformers.
 - 5) Measure time delay of the relay at 150% or greater of pickup.
 - 6) Verify reduced voltage tripping capability: 55% for AC systems and 80% for DC systems.
 - c. Test Values:
 - 1) System neutral-to-ground insulation shall be minimum of one megohm.
 - 2) Insulation resistance values shall be in accordance with Table 1.
 - 3) Relay timing shall be in accordance with manufacturer's specifications but must also be no longer than one second at 3000 amp.
 - 4) Bus bolt-torque levels shall be in accordance with Table 12, unless otherwise specified by manufacturer.
11. Grounding Systems:
 - a. Visual and Mechanical Inspection:
 - 1) Verify ground system is in compliance with drawings, specifications, and NFPA 70.
 - 2) Inspect physical and mechanical condition.
 - 3) Inspect anchorage.
 - b. Electrical Tests:
 - 1) Perform fall-of-potential or alternative test in accordance with ANSI/IEEE 81 on the main grounding electrode or system.
 - 2) Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and/or derived neutral points.
 - 3) Make resistance measurements in dry weather not earlier than 48 hours after rainfall.
 - c. Test Values:
 - 1) The resistance between the main grounding electrode and ground should be no greater than five ohms. (Reference ANSI/IEEE 142.) Investigate any values above five ohms and notify Engineer immediately for further instructions.
 - 2) Investigate point-to-point resistance values that exceed 0.5 ohm.
12. Thermographic Survey:
 - a. Visual and Mechanical Inspection:
 - 1) Inspect physical, electrical, and mechanical conditions.
 - 2) Remove all necessary covers prior to thermographic inspection.
 - 3) Equipment to be inspected shall include all current-carrying devices. Provide report including the following:

- a) Discrepancies.
 - b) Temperature difference between area of concern and reference area.
 - c) Cause of temperature difference.
 - d) Areas inspected. Identify inaccessible and unobservable areas and equipment.
 - e) Identify load conditions at time of inspection.
 - f) Provide photographs and thermogram of deficient area.
- b. Test Parameters:
- 1) Inspect distribution systems with imaging equipment capable of detecting minimum temperature difference of 2°F at 86°F.
 - 2) Equipment shall detect emitted radiation and convert detected radiation to visual signal.
 - 3) Thermographic surveys should be performed during periods of maximum possible loading but not less than 40% of rated load of the electrical equipment being inspected. Refer to NFPA 70B, Section 20.17 (Infrared Inspection).
- c. Test Results:
- 1) Temperature differences of 2°F to 5°F indicate possible deficiency and warrant investigation.
 - 2) Temperature differences of 7°F to 27°F indicate deficiency; repair as time permits.
 - 3) Temperature differences of 29°F and above indicate major deficiency; repair immediately.
 - 4) Suggested actions based on temperature rise can be found in Table 18.
- B. Test Reports:
- 1. Testing firm shall do the following:
 - a. Prepare test report, including description of equipment tested, description of test, test results, conclusions and recommendations, retesting results, list of test equipment used and calibration date.
 - b. Show test results in comparison to industry and manufacturer's values and tolerances.
 - c. Interpret test results in writing and give recommendations for acceptance or rejection upon consultation with Engineer and prior to energizing equipment.
 - d. Assure electrical equipment is operational and within industry and manufacturer's tolerances, and is installed in accordance with contract documents.
 - e. Assure suitability of energization.
 - f. Report to the Owner and Engineer any system, material, or workmanship that is found defective on the basis of acceptance tests.
 - g. Retest equipment when required.
 - h. Maintain written record of tests.
 - i. Utilize safety practices during the tests in accordance with:
 - 1) Acceptable state and local safety operating procedures
 - 2) Owner's safety practices
 - 3) OSHA

- 4) NFPA 70E
- j. Perform tests with apparatus de-energized and grounded, except where otherwise specifically required ungrounded by test procedures.
- k. Assemble and certify final test report.
- l. Provide 4 copies of complete test report.
- m. Attach label to all tested equipment with indication of date tested and testing firm name.
- 2. Contractor shall do the following:
 - a. Investigate, replace, or repair any fault in material or in any part of the installation revealed by the tests.
 - b. Deliver one copy of each test report directly to Engineer within 30 days after completion of testing, unless directed otherwise. Insert a copy of each test report in the equipment operation and maintenance manuals.
- C. Test Equipment:
 - 1. Test Instrument Calibration:
 - a. Testing firm shall have calibration program that assures test instruments are maintained with rated accuracy.
 - b. Instruments shall be calibrated in accordance with the following frequency schedule:
 - 1) Field instruments: Analog, 6 months maximum; Digital, 12 months maximum
 - 2) Laboratory instruments: 12 months
 - 3) Leased specialty equipment: 12 months where accuracy is guaranteed by lessor
 - c. Dated calibration labels shall be visible on test equipment.
 - d. Records, which show date and results of instruments calibrated or tested, must be kept up-to-date.
 - e. Up-to-date instrument calibration instructions and procedures shall be maintained for test instrument.
 - f. Equipment used for field testing shall be more accurate than instrument being tested.
 - g. Calibrating standard applied to testing equipment shall be of higher accuracy than instrument tested.

END OF SECTION 260812

SECTION 260813 - POWER DISTRIBUTION ACCEPTANCE TEST TABLES

TABLE 1
INSULATION RESISTANCE TEST VALUES
ELECTRICAL APPARATUS AND SYSTEMS

Voltage Rating	Minimum DC Test Voltage	Recommended Minimum Insulation Resistance In Megohms
250	500	25
600	1,000	100
1,000	1,000	100
2,500	1,000	500
5,000	2,500	1,000
8,000	2,500	2,000
15,000	2,500	5,000
25,000	5,000	20,000
34,500 and above	15,000	100,000

See Table 14 for temperature correction factors.

TABLE 2
Switchgear Low-Frequency Withstand Test Voltages

Type of Switchgear	Rated kV	Maximum Test Voltage kV	
		AC	DC
Low-Voltage Power Circuit Breaker Switchgear	.254	1.6	2.3
	.508	1.6	2.3
	.635	1.6	2.3
MC (Metal-Clad Switchgear)	4.76	14.0	20.0
	8.25	27.0	37.0
	15.0	27.0	37.0
	27.0	45.0	+
	38.0	60.0	+
SC (Station-Type Cubicle)	15.5	37.0	+
	38.0	60.0	+

Switchgear)	72.5	120.0	+
MEI (Metal-Enclosed Interrupter Switchgear)	4.76	14.0	20.0
	8.25	19.0	27.0
	15.0	27.0	37.0
	15.5	37.0	52.0
	25.8	45.0	+
	38.0	60.0	+

Derived from ANSI/IEEE C37.20.2-1993, Paragraph 5.5, Metal-Clad and Station-Type Cubicle Switchgear and C37.20.3-1993, Paragraph 5.5, Metal-Enclosed Interrupter Switchgear, and includes 0.75 multiplier with fraction rounded down.

The column headed “DC, Maximum Test Voltage kV” is given as a reference only for those using DC tests to verify the integrity of connected cable installations without disconnecting the cables from the switchgear. It represents values believed to be appropriate and approximately equivalent to the corresponding power frequency withstand test values specified for voltage rating of switchgear. The presence of this column in no way implies any requirement for a DC withstand test on AC equipment or that a DC withstand test represents an acceptable alternative to the low-frequency withstand tests specified in this specification, either for design tests, production tests, conformance tests, or field tests. When making DC tests, the voltage should be raised to the test value in discrete steps and held for a period of one minute.

Because of the variable voltage distribution encountered when making DC withstand tests, the manufacturer should be contacted for recommendations before applying DC withstand tests to the switchgear. Voltage transformers above 34.5kV should be disconnected when testing with DC. Refer to ANSI/IEEE C57.13-1993 (IEEE Standard Requirements for Instrument Transformers) paragraph 8.8.2.

+ Consult Manufacturer

TABLE 3
RECOMMENDED DISSIPATION FACTOR/POWER FACTOR AT 20°C
LIQUID FILLED TRANSFORMERS, REGULATORS, AND REACTORS
ACCEPTANCE TEST VALUES

Oil, Silicone, and Less-Flammable Hydrocarbon Maximum Value (Percent)	
New Power Transformers and Reactors	0.5%
New Distribution Transformers and Regulators	1.0%
Remanufactured Power Transformers and Reactors	1.0%
Remanufactured Distribution Transformers and Regulators	1.5%

TABLE 4
INSULATING FLUID LIMITS

Table 4.1		
Test Limits for New Insulating Oil Received in New Equipment		
Mineral Oil		
Test	ASTM Method	# 69 kV and Below
Dielectric breakdown, kV minimum	D877	30
Dielectric breakdown, kV minimum @ 0.04" gap	D1816	25
Dielectric breakdown, kV minimum @ 0.08" gap	D1816	45
Interfacial tension mN/m minimum	D971 or D2285	38
Neutralization number, mg KOH/g maximum	D974	0.015
Water content, (ppm) maximum	D1533	20
Power factor at 25°C, %	D924	0.05
Power factor at 100°C, %	D924	0.40
Color	D1500	1.0
Visual condition	D1524	Bright and clear
Table 4.2		
Test Limits for Silicone Insulating Liquid in New Transformers		
Test	ASTM Method	Acceptable Values
Dielectric breakdown, kV minimum	D877	30
Visual	D2129	clear, free of particles
Water content, (ppm) maximum	D1533	50
Dissipation/power factor, 60 Hz, % max. @ 25°C	D924	0.1
Viscosity, cSt @ 25°C	D445	47.5 – 52.5
Fire point, °C, minimum	D92	340
Neutralization number, mg KOH/g max.	D974	0.01

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ANSI/IEEE C57.111-1989 (R1995), Guide for Acceptance of Silicone Insulating Fluid and Its
Maintenance in Transformers, Table 2.

TABLE 4 (CONT.)

INSULATING FLUID LIMITS

<p>Table 4.3 Typical Values for Less-Flammable Hydrocarbon Insulating Liquid Received in New Equipment</p>			
ASTM Method	Test	Results	
		Minimum	Maximum
D1816	Dielectric breakdown voltage for 0.08" gap, kV	34.5 kV class and below	---
		60 Desirable	
D1816	Dielectric breakdown voltage for 0.04" gap, kV	34.5 kV class and below	---
		30 Desirable	
D974	Neutralization number, mg KOH/g	----	0.03
D877	Dielectric breakdown voltage kV	30	----
D924	AC loss characteristic (dissipation factor), %		
	25°C	----	0.1
	100°C	----	1
D1533B	Water content, (ppm)	----	25
D1524	Condition-visual	Clear	
D92	Flash point (°C)	275	----
D92	Fire point (°C)	300a	----
D971	Interfacial tension, mN/m, 25°C	38	----
D445	Kinematic viscosity, mm ² /s. (cSt), 40°C	1.0 X 10 ² (100)	1.3 X 10 ² (130)
D1500	Color	----	L2.5

ANSI/IEEE C57.121-1998, IEEE Guide for Acceptance and Maintenance of Less-Flammable Hydrocarbon Fluid in Transformers, Table 3.

The test limits shown in this table apply to less-flammable hydrocarbon fluids as a class. Specific typical values for each brand of fluid should be obtained from each fluid manufacturer.

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- A. If the purpose of the HMWH installation is to comply with the NFPA 70 National Electrical Code, this value is the minimum for compliance with NEC Article 450.23.

TABLE 5
TRANSFORMER INSULATION-RESISTANCE

ACCEPTANCE TEST VOLTAGE AND MINIMUM RESULTS

Transformer Coil Rating Type in Volts	Minimum DC Test Voltage	Recommended Minimum Insulation Resistance in Megohms	
		Liquid Filled	Dry
0 - 600	1000	100	500
601 - 5000	2500	1000	5000
5001 - 15000	5000	5000	25000

See Table 14 for Temperature Correction Factors.

NOTE: Since insulation resistance depends on insulation rating (kV) and winding capacity (kVA), values obtained should be compared to manufacturer's test data.

TABLE 6
MEDIUM-VOLTAGE CABLES
ACCEPTANCE TEST VALUES

Table 6.1					
DC Test Voltages					
Rated Voltage Phase-to-Phase kV	Conductor Sizes AWG or kcmil (mm)	Nominal Insulation Thickness mils (mm)		Maximum DC Field Test Voltages, kV During/After Installation	
		100% Insulation Level	133% Insulation Level	100% Insulation Level	133% Insulation Level
5	8-1000 (8.4-507)	90 (2.29)	115 (2.92)	28	36
	Above 1000 (507)	140 (3.56)	140 (3.56)	28	36
8	6-1000 (13.3-507)	115 (2.92)	140 (3.56)	36	44
	Above 1000 (507)	175 (4.45)	175 (4.45)	36	44
15	2-1000 (33.6-507)	175 (4.45)	220 (5.59)	56	64
	Above 1000 (507)	220 (5.59)	220 (5.59)	56	64
25	1-2000 (42.4-1013)	260 (6.60)	320 (8.13)	80	96
28	1-2000 (42.4-1013)	280 (7.11)	345 (8.76)	84	100
35	1/0-2000 (53.5-1013)	345 (8.76)	420 (10.7)	100	124

Tables derived from ANSI/ICEA S-93-639/NEMA WC 74-2000, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy; ANSI/ICEA S-94-649-2000, Standard for Concentric Neutral Cables Rated 5,000 – 46,000 Volts; ANSI/ICEA S-97-682-2000, Standard for Utility Shielded Power Cables Rated 5,000 – 46,000 Volts; and The Okonite Company, High-Voltage Proof Testing.

The DC field test voltages listed above are intended for cable designed in accordance with ICEA specifications. When older cables or other types/classes of cables or accessories are connected to the system, voltages lower than those shown may be necessary. Consult the manufacturers of the cables and/or accessories before applying the test voltage.

TABLE 6 (CONT.)
MEDIUM-VOLTAGE CABLES
ACCEPTANCE TEST VALUES

Table 6.2					
AC Test Voltages					
Rated Voltage Phase-to-Phase kV	Conductor Sizes AWG or kcmil (mm)	Nominal Insulation Thickness mils (mm)		AC Test Voltage, kV	
		100% Insulation Level	133% Insulation Level	100% Insulation Level	133% Insulation Level
5 kV	8-1000	90 (2.29)	115 (2.92)	18	23
	1001-3000	140 (3.56)	140 (3.56)	28	28
8 kV	6-1000	115 (2.92)	140 (3.56)	23	28
	1001-3000	175 (4.45)	175 (4.45)	35	35
15 kV	2-1000	175 (4.45)	220 (5.59)	35	44
	1001-3000	220 (5.59)	220 (5.59)	44	44
25 kV	1-3000	260 (6.60)	320 (8.13)	52	64
28 kV	1-3000	280 (7.11)	345 (8.76)	56	69
35 kV	1/0-3000	345 (8.76)	420 (10.7)	69	84

Tables derived from ANSI/ICEA S-93-639/NEMA WC 74-2000, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy; ANSI/ICEA S-94-649-2000, Standard for Concentric Neutral Cables Rated 5,000 – 46,000 Volts; ANSI/ICEA S-97-682-2000, Standard for Utility Shielded Power Cables Rated 5,000 – 46,000 Volts.

All AC voltages are RMS values.

TABLE 6 (CONT.)

MEDIUM-VOLTAGE CABLES

ACCEPTANCE TEST VALUES

Table 6.3 Partial Discharge Requirements		
for Semiconducting Coating and Tape Designs Only		
Rated Circuit Voltage Phase-to-Phase Volts	Minimum Partial Discharge Extinction Level, kV	
	100% Insulation Level	133% Insulation Level
2001-5000	4	5
5001-8000	6	8
8001-15000	11	15

ANSI/ICEA S-93-639/NEMA WC 74-2000, 5-56 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.

Table 6.4 Very Low Frequency Testing Levels	
0.1 Hz Test Voltage (RMS)	
System Voltage Phase-to-Phase (kV) (RMS)	Proof Phase-to-Ground (kV) (RMS)
5	10
15	22
25	33
35	47

TABLE 7
MOLDED-CASE CIRCUIT BREAKERS
VALUES FOR INVERSE TIME TRIP TEST

(AT 300% OF RATED CONTINUOUS CURRENT OF CIRCUIT BREAKER)

<u>Range of Rated Continuous Current</u> <u>Amperes</u>	<u>Maximum Trip Time in Seconds</u> <u>For Each Maximum Frame Rating¹</u>	
	<u>250V</u>	<u>251 - 600V</u>
0-30	50	70
31-50	80	100
51-100	140	160
101-150	200	250
151-225	230	275
226-400	300	350
401-600	-----	450
601-800	-----	500
801-1000	-----	600
1001-1200	-----	700
1201-1600	-----	775
1601-2000	-----	800
2001-2500	-----	850
2501-5000	-----	900

Reproduction of Table 5-3 from NEMA AB 4-1996.

¹ For integrally-fused circuit breakers, trip times may be substantially longer if tested with the fuses replaced by solid links (shorting bars).

TABLE 8
INSTANTANEOUS TRIP SETTING TOLERANCES FOR FIELD TESTING
OF MARKED ADJUSTABLE TRIP CIRCUIT BREAKERS

	Tolerances of High and Low Settings	
	High	Low
Ampere Rating		
Adjustable	+40%	-30%
Non-adjustable	+25%	-25%

For circuit breakers with nonadjustable instantaneous trips, tolerances apply to the manufacturer's published trip range, i.e., +40% on high side, -30% on low side.

TABLE 9
INSTRUMENT TRANSFORMER DIELECTRIC TESTS

FIELD ACCEPTANCE

Nominal System (kV)	BIL (kV)	Applied Potential Tests	
		Field Test Voltage (kV)	
		AC	DC ¹
0.6	10	3	4
1.2	30	7.5	10
2.4	45	11.25	15
5.0	60	14.25	19
8.7	75	19.5	26
15	95	25.5	34
15	110	25.5	34
25	125	30	40
25	150	37.5	50
34.5	150	37.5	50
34.5	200	52.5	70

Derived from Paragraph 8.8.2 and Tables 2 and 7 of ANSI/IEEE C57.13-1993 (Standard Requirements for Instrument Transformers).

¹ DC potential tests are not recommended for transformers rated higher than 200 kV BIL. DC tests may prove beneficial as a reference for future testing. In such cases the test direct voltage should not exceed the original factory test RMS alternating voltages.

TABLE 10

MAXIMUM ALLOWABLE VIBRATION AMPLITUDE

RPM @	Velocity	Velocity	RPM @	Velocity	Velocity
60 Hz	in/s peak	mm/s	60 Hz	in/s peak	mm/s
3600	0.15	3.8	3000	0.15	3.8
1800	0.15	3.8	1500	0.15	3.8
1200	0.15	3.8	1000	0.13	3.3
900	0.12	3.0	750	0.10	2.5
720	0.09	2.3	600	0.08	2.0
600	0.08	2.0	500	0.07	1.7

Derived from NEMA publication MG 1-1998, Section 7.8.1, Table 7-1. Table is unfiltered vibration limits for resiliently mounted machines. For machines with rigid mounting, multiply the limiting values by 0.8.

TABLE 11

**OVERPOTENTIAL TEST VOLTAGES FOR ELECTRICAL APPARATUS OTHER THAN
INDUCTIVE EQUIPMENT**

Nominal			Maximum	Maximum
System (Line)	Insulation	AC Factory	Field Applied	Field Applied
Voltage¹ (kV)	Class	Test (kV)	AC Test (kV)	DC Test (kV)
1.2	1.2	10	6.0	8.5
2.4	2.5	15	9.0	12.7
4.8	5.0	19	11.4	16.1
8.3	8.7	26	15.6	22.1
14.4	15.0	34	20.4	28.8
18.0	18.0	40	4.0	33.9
25.0	25.0	50	30.0	42.4
34.5	35.0	70	42.0	59.4
46.0	46.0	95	57.0	80.6
69.0	69.0	140	84.0	118.8

¹ Intermediate voltage ratings are placed in the next higher insulation class.

TABLE 12

U.S. STANDARD

BOLT TORQUES FOR BUS CONNECTIONS

HEAT-TREATED STEEL – CADMIUM OR ZINC PLATED

Grade	SAE 1 & 2	SAE 5	SAE 7	SAE 8
Minimum Tensile (psi)	64K	105K	133K	150K
Bolt Diameter In Inches	Torque (Foot Pounds)			
1/4	4	6	8	8
5/16	7	11	15	18
3/8	12	20	27	30
7/16	19	32	44	48
1/2	30	48	68	74
9/16	42	70	96	105
5/8	59	96	135	145
3/4	96	160	225	235
7/8	150	240	350	380
1.0	225	370	530	570

BOLT TORQUES FOR BUS CONNECTIONS

SILICON BRONZE FASTENERS¹

TORQUE (FOOT POUNDS)

Bolt Diameter in (Inches)	Nonlubricated	Lubricated
5/16	15	10
3/8	20	14
1/2	40	25
5/8	55	40
3/4	70	60

¹ BRONZE ALLOY BOLTS SHALL HAVE A MINIMUM TENSILE STRENGTH OF 70,000 PSI.

TABLE 12 (CONT.)
BOLT TORQUES FOR BUS CONNECTIONS
ALUMINUM ALLOY FASTENERS²

TORQUE (FOOT POUNDS)

Bolt Diameter in Inches	Lubricated
5/16	8.0
3/8	11.2
1/2	20.0
5/8	32.0
3/4	48.0

A. ² Aluminum alloy bolts shall have a minimum tensile strength of 55,000 psi.

BOLT TORQUES FOR BUS CONNECTIONS

TORQUE (FOOT POUNDS)

Bolt Diameter in Inches	Uncoated
5/16	14
3/8	25
1/2	45
5/8	60
3/4	90

³ Bolts, cap screws, nuts, flat washers, locknuts: 18-8 alloy.

Belleville washers: 302 alloy.

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TABLE 14
INSULATION RESISTANCE CONVERSION FACTORS FOR
CONVERSION OF TEST TEMPERATURE TO 20°C

Temperature		Multiplier	
°C	°F	Apparatus Containing Immersed Oil Insulations	Apparatus Containing Solid Insulations
0	32	0.25	0.40
5	41	0.36	0.45
10	50	0.50	0.50
15	59	0.75	0.75
20	68	1.00	1.00
25	77	1.40	1.25
30	86	1.98	1.58
35	95	2.80	2.00
40	104	3.95	2.50
45	113	5.60	3.15
50	122	7.85	3.98
55	131	11.20	5.00
60	140	15.85	6.30
65	149	22.40	7.90
70	158	31.75	10.00
75	167	44.70	12.60
80	176	63.50	15.80

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TABLE 18
THERMOGRAPHIC SURVEY

SUGGESTED ACTIONS BASED ON TEMPERATURE RISE

Temperature difference (TD) based on comparisons between similar components under similar loading	Temperature difference (TD) based upon comparisons between component and ambient air temperatures	Recommended action
1°C to 3°C	1°C to 10°C	Possible deficiency; warrants investigation
4°C to 15°C	11°C to 20°C	Indicates probably deficiency; repair as time permits
-- -- --	21°C to 40°C	Monitor until corrective measures can be accomplished
>15°C	>40°C	Major discrepancy; repair immediately

TABLE 19
OVERPOTENTIAL TEST VOLTAGES

ELECTRICAL APPARATUS OTHER THAN INDUCTIVE EQUIPMENT

Nominal System (Line) Voltage^a (kV)	Insulation Class	AC Factory Test (kV)	Maximum Field Applied AC Test (kV)	Maximum Field Applied DC Test (kV)
1.2	1.2	10	6.0	8.5
2.4	2.5	15	9.0	12.7
4.8	5.0	19	11.4	16.1
8.3	8.7	26	15.6	22.1
14.4	15.0	34	20.4	28.8
18.0	18.0	40	24.0	33.9
25.0	25.0	50	30.0	42.4
34.5	35.0	70	42.0	59.4

^a Intermediate voltage ratings are placed in the next higher insulation class.

TABLE 20
RATED CONTROL VOLTAGES AND THEIR RANGES
FOR CIRCUIT BREAKERS

The maximum voltage is measured at the point of user connection to the circuit breaker (see Notes (9) (10)) with no operating current flowing, and the minimum voltage is measured with maximum operating current flowing.

Rated Control Voltages and their Ranges for Circuit Breakers					
Rated Control Voltage (8)	Direct Current Voltage Ranges (1)(2) Volts, DC		Opening Functions All Types	Rated Control Voltage (60 Hz)	Alternating Current (1)(2)(3)(5) Closing, Tripping, and Auxiliary Functions
	Closing and Auxiliary Functions				
	Indoor Circuit Breakers	Outdoor Circuit Breakers		Single Phase	SINGLE PHASE
24	---	---	14-28	120 240	104-127 (4) 208-254 (4)
48	38-56	36-56	28-56		
125	100-140	90-140	70-140	Polyphase	Polyphase
250	200-280	180-280	140-280		
---	---	---	---		180Y/104-
---	---	---	---	208Y/120	220Y/127
				240	208-254

Derived from Table 8, ANSI C37.06-2000, AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis – Preferred Ratings and Related Required Capabilities.

Rated Control Voltages and their Ranges for Circuit Breakers	
Solenoid-Operated Devices	
Rated Voltage	Closing Voltage Ranges for Power Supply
125 dc	90 – 115 or 105 – 130
250 dc	180 – 230 or 210 – 260
230 ac	190 – 230 or 210 - 260

Notes:

1. Electrically operated motors, contactors, solenoids, valves, and the like need not carry a nameplate voltage rating that corresponds to the control voltage rating shown in the table as long as these components perform the intended duty cycle (usually intermittent) in the voltage range specified.
2. Relays, motors, or other auxiliary equipment that function as a part of the control for a device shall be subject to the voltage limits imposed by this standard, whether mounted at the device or at a remote location.
3. Includes supply for pump or compressor motors. Note that rated voltages for motors and their operating ranges are covered by ANSI/NEA MG-1-1978.
4. Includes heater circuits.
5. Voltage ranges apply to all closing and auxiliary devices when cold. Breakers using standard auxiliary relays for control functions may not comply at lower extremes of voltage ranges when relay coils are hot, as after repeated or continuous operation.
6. Direct current control voltage sources, such as those derived from rectified alternating current, may contain sufficient inherent ripple to modify the operation of control devices to the extent that they may not function over the entire specified voltage ranges.
7. This table also applies for circuit breakers in gas-insulation substation installations.
8. For an outdoor circuit breaker, the point of user connection to the circuit breaker is the secondary terminal block point at which the wires from the circuit breaker operating mechanism components are connected to the user's control circuit wiring.
9. In cases where other operational ratings are a function of the specific control voltage applied, tests in C37.09 may refer to the "Rated Control Voltage." In these cases, tests shall be performed at the levels in this column.
10. For an indoor circuit breaker, the point of user connection to the circuit breaker is either the secondary disconnecting contact (where the control power is connected from the stationary housing to the removable circuit breaker), or the terminal block point in the housing nearest to the secondary disconnecting contact.
11. Some solenoid operating mechanisms are not capable of satisfactory performance over the range of voltage specified in the standard; moreover, two ranges of voltage may be required for such mechanisms to achieve an acceptable standard of performance.

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12. The preferred method of obtaining the double range of closing voltage is by use of tapped coils. Otherwise, it will be necessary to designate one of the two closing voltage ranges listed above as representing the condition existing at the device location due to battery or lead voltage drop or control power transformer regulation. Also, caution should be exercised to ensure that the maximum voltage of the range used is not exceeded.

END OF SECTION 260813

SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION OF SYSTEM

- A. Provide devices such as wall box dimmers, wall and ceiling mounted occupancy sensors, ambient light sensors, sensor power packs, etc., as shown on drawings.
- B. Openings shall be covered with devices and matching plates.
- C. Devices of same type shall be from same manufacturer.

1.2 REFERENCE STANDARDS

- A. UL 20 - General Use Snap Switches.
- B. UL 773A - Non-Industrial Photoelectric Switches for Lighting Control.
- C. UL 924 - Emergency Lighting and Power Equipment
- D. NEMA WD 7 - Occupancy Motion Sensors.
- E. California Building Energy Efficiency Standards
- F. California Title 20 Appliance Efficiency Database

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings shall include:
 - 1. Bill of material
 - 2. Schematic diagrams
 - 3. Suggested manufacturer layouts of all devices including overlays of product range.
- C. Samples: One for each type of device and wall plate specified, in each color specified upon request.
- D. Manufacturer's Installation Instructions:
 - 1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- E. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
- F. Closeout Submittals:
 - 1. Project Record Documents:
 - a. Record actual locations and type of devices.

2. Operation and Maintenance Data:
 - a. Include in manufacturers' packing label warnings and instruction manuals with labeling conditions.
 - b. Include source and current prices of replacement parts and supplies.

1.4 QUALITY ASSURANCE

- A. Obtain devices from one source and by single manufacturer.
- B. Regulatory Requirements:
 1. Comply with NFPA 70 for components and installation.
 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Maintain factory unopened packaging until ready for installation.

1.6 WARRANTY

- A. Refer to Division 01 and Section 260000 - General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of final acceptance.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers:
 1. Wall Box Dimmers: Acuity Brands Controls, Cooper Controls, Hubbell, Leviton, Lutron, Philips (Sunrise Series), Wattstopper
 2. Low Voltage Switches: Acuity Brands Controls, Cooper Controls, Hubbell, Leviton, Lutron, Philips, Wattstopper
 3. Sensors and Power Packs: Acuity Brands Controls, Cooper Controls, Hubbell, Leviton, Lutron, Philips, Wattstopper
 4. Exterior Occupancy Sensors: Acuity Brands Controls, Leviton, Wattstopper
 5. UL 924 Emergency Bypass/Control Device: Acuity Brands Controls, Hubbell, Leviton, Wattstopper, LVS
 6. Exterior Photocells: Cooper Controls, Hubbell, Intermatic, Leviton, Paragon, Tork
 7. Timeclocks: Intermatic, Paragon, Tork
 8. Self-Contained Automatic Timer Switches: Acuity Brands Controls, Cooper Controls, Hubbell, Leviton, Philips, Wattstopper

- B. It is the responsibility of Electrical Contractor to ensure devices submitted meet or exceed functional intent and design quality standards.

2.2 FABRICATION AND MANUFACTURE

- A. Devices shall be UL listed for loads and voltages as indicated in contract drawings and specifications.

2.3 WALL BOX DIMMERS

- A. Dimmers shall:
 - 1. Operate in ambient temperature range of 32°F to 104°F.
 - 2. Be linear slide or pushbutton preset or programmable dimmers with power-failure memory.
 - 3. Incorporate separate control of intensity and ON/OFF.
 - 4. Include voltage compensation circuitry that adjusts firing angle of dimmer to compensate light output for variations in AC line voltage. Dimmers in which firing angle is held constant with varying AC line voltage shall not be acceptable.
 - 5. Provide smooth and continuous IESNA Square Law Dimming Curve throughout entire dimming range.
 - 6. Incorporate filter network to minimize interference (RFI) with radio, audio, and video equipment.
 - 7. Incorporate air-gap switch to meet requirements of UL 20 for air-gap switches in incandescent dimmers.
- B. LED dimmers shall:
 - 1. Be approved for use with luminaire and driver.
 - 2. Provide smooth non-flicker dimming of controlled luminaires.
 - 3. Be 0-10V type, unless otherwise noted on drawings.
 - 4. Provide at least 10 steps for continuously dimmed luminaires.
 - 5. Refer to Section 265000 - Lighting for solid state dimming ballast/driver specification.

2.4 LOW-VOLTAGE SWITCHES

- A. Low voltage switches shall:
 - 1. Mount in a single or double gang box.
 - 2. Be capable of multi-way switching.

2.5 OCCUPANCY AND VACANCY SENSORS

- A. Sensors shall:
 - 1. Operate with all lamp and ballast combinations; including magnetic, hybrid, and solid-state ballasts/drivers.
 - 2. Operate with ultrasonic, microphonic, passive infrared or presence technologies as indicated on drawings.
 - 3. Have visible LED to indicate occupant detection.

4. Have adjustable time delay or remote relay with a maximum setting of 30 minutes and adjustable sensitivity.
5. Contain isolated relay with normally open, normally closed, and common outputs for use with HVAC system, data logging, controlled receptacles or other system control options where indicated in contract documents.
6. Be provided with ceiling, wall or wall switch style mounting as indicated on drawings.
7. Have daylight filter to ensure PIR sensor is insensitive to short-wavelength waves emitted by the sun.
8. Incorporate by-pass switch to enable lighting to be turned on if sensor fails.

B. Occupancy Sensor shall:

1. Provide automatic ON, automatic OFF operation where indicated on drawings.

C. Vacancy Sensor shall:

1. Provide manual ON, automatic OFF operation where indicated on drawings.

2.6 AMBIENT LIGHT SENSORS

A. Ambient light sensors shall:

1. Incorporate photoconductive cell to measure light levels between 1 and 1,000 footcandles.
2. Be adjustable with deadband feature to prevent cycling of lighting from minor changes in cloud cover.
3. Have adjustable time delay range from 3 to 5 minutes.
4. Not permit lighting systems to be turned on if enough daylight is present.
5. Incorporate by-pass switch to enable lighting to be turned on if sensor fails.

2.7 POWER PACKS

A. Sensor power packs shall:

1. Be self-contained transformer relay modules.
2. Have universal rated voltage inputs 120-277 VAC, 60 Hz.
3. Have normally closed dry contacts rated for switching 120-277 volts, 60 Hz. 20 amp loads. Provide 24VDC output capable of controlling low-voltage occupancy sensors.

2.8 UL 924 EMERGENCY BYPASS/CONTROL DEVICES

A. UL 924 listed bypass relays shall:

1. Be UL 924 listed and labeled for connection to both normal and emergency lighting power sources.
2. Have universal rated voltage inputs 120-277 VAC, 60 Hz.
3. Have normally closed dry contacts rated for switching 120-277 volts, 60 Hz. 20 amp loads.
4. Have integral manual test switch.
5. Have auxiliary isolated normally closed contact for connection to remote test switch, fire alarm system, or other external system capable of providing a normally closed dry contact closure.

6. Have status indication for presence of normal and emergency power sources and current operational mode (normal or emergency).
7. Utilize zero crossing circuitry to protect relay contacts from the damaging effects of inrush current generated by switching electronic ballast loads.
8. Be forced into the emergency mode upon loss of normal power sense and turn ON the emergency lighting.
9. Automatically switch emergency lighting ON/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.

B. Operational temperature range shall be -40°F to 140°F.

C. Device shall have universal mounting; surface, above suspended ceiling or recessed.

2.9 EXTERIOR PHOTOCELLS

A. Photocells shall:

1. Have universal rated voltage inputs 120-277 VAC, 60 Hz.
2. Be rated for up to 2,000 watts.
3. Have cadmium sulfide, 1" diameter cell.
4. Have SPST normally closed contacts.
5. Have a minimum delay of 3 minutes to prevent false switching.

B. ON/OFF adjustment shall be done by moving light selector with range from 2 to 50 footcandles.

C. Operational temperature range shall be -40°F to 140°F.

D. Enclosure shall be die cast zinc, gasketed for maximum weatherproofing.

E. Enclosure shall include positioning lug on top.

F. Mounting shall be for 1/2" conduit nipple.

2.10 TIMECLOCKS

A. Timeclocks shall:

1. Be multi-purpose, 7-day, 365-day advance single and skip a day, combination 2-channel electronic astronomical time clock with SPDT switching configuration.
2. Have universal rated voltage inputs 120-277 VAC, 60 Hz.
3. Be capable of programming in AM/PM or 24-hour format by jumper selection or digital setting, in one-minute resolution, using 2 buttons for basic settings.
4. Have 365-day and/or holiday selection capabilities, with 16 single date and 5 holiday selection options and user selectable daylight savings/standard time functions.
5. Have 72-hour memory backup with rechargeable battery and charger.
6. Have manual override, ON/OFF to the next scheduled event, using one button for each channel.

7. Have operational temperature range of -40°F to 150°F.
 8. Have a maximum allowed over-ride period no greater than 2 hours.
- B. Contacts shall be rated 10 amp resistive at 120/250 VAC, 7.5 amps inductive at 120/250 VAC, 5 amps inductive at 30 VDC and up to 1/2 hp at 250 VAC.
- C. Display shall be LCD type.
- D. Enclosure shall be rated for installation location.

2.11 SELF-CONTAINED AUTOMATIC TIMER SWITCHES

- A. Timer switches shall:
1. Have universal rated voltage inputs 120-277 VAC, 60 Hz.
 2. Be programmable to turn lights OFF after a preset time.
 3. Have a ground wire and ground strap for safety with a latching air gap relay switching mechanism.
 4. Use Zero Crossing Circuitry to increase the relay life, protect from the effects of inrush current.
 5. Be compatible with all electronic ballasts, motor loads, LEDs and LED drivers, compact fluorescent and inductive loads. Triac and other harmonic generating devices shall not be allowed.
 6. Have no minimum load requirement and shall be capable of controlling 0 to 800 watt incandescent, fluorescent @ 100/120 VAC, 50/60 Hz; 0 to 1200 watts fluorescent @ 230/277 VAC, 50/60 Hz; 1/6 hp @ 125 VAC. LED with internal or external driver @ 100/120VAC.
 7. Have the option for light flash warning at five minutes before the timer runs out and again when the countdown reaches one minute.
 8. Have the option for a beep warning that shall sound every five seconds once the time switch countdown reaches one minute.
 9. Have manual feature for timer reset where pressing the ON/OFF switch for more than 2 seconds resets the timer to the programmed time-out period.
 10. Have a feature that shows the timer's countdown.
 11. Have the calibration switch for setting time-out, time scroll, one second light flash, and beep warning shall be concealed to prevent tampering of adjustments and hardware.
 12. Have a maximum allowed over-ride period no greater than 2 hours.
 13. Be capable of operating as an ON/OFF switch.
 14. Utilize terminal style wiring.
 15. Have a 100% OFF override switch with no leakage current to the load.

2.12 FINISHES

- A. Color:
1. Wall box dimmers, low-voltage switches, occupancy sensors, ambient light sensors and device cover plates: as coordinated with architectural interior design.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install devices at heights scheduled, and as indicated on drawings.
- B. Install wall devices vertically on latch side of door within 6" of frame edge, unless otherwise noted.
- C. Install ceiling devices as shown on drawings and as recommended by device manufacturer.
- D. Ceiling mounted occupancy sensors shall be located minimum of 6 ft from supply air diffusers.
- E. Install devices plumb, level with finished surfaces and free from blemishes.
- F. Verify device locations prior to rough in.
- G. Control wiring shall be low voltage, Class II wiring, electrically isolated from power wiring by a Class II transformer.
- H. Provide separate neutral conductor for each dimmer.
- I. Wiring shall be in conduit.
- J. Electrical Contractor shall be responsible for final adjustment and testing of all devices.

3.2 TESTING

- A. Verify proper location and operation of all devices.
- B. Verify dimmers function without:
 - 1. Producing lamp flicker or audible noise.
 - 2. Interference of audio and visual equipment.
- C. Adjust occupancy sensors for a 15 minute time delay or as specified in the Building Sequence of Operations.
- D. Adjust occupancy sensor sensitivity such that movement outside range of coverage shall not trigger sensor.
- E. Adjust ambient light sensor to maintain illuminance level equal to light level from controlled lighting in the space when no daylight is present or as indicated per drawings. Demonstrate ambient light sensor(s) control lighting as specified.

END OF SECTION 260923

SECTION 262200 - LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Section includes dry type distribution and buck-boost transformers rated 600V and less, with capacities up to 300 kVA.

1.2 REFERENCE STANDARDS

- A. ANSI/NECA 1 – Standard Practices for Good Workmanship in Electrical Contracting
- B. IEEE C57.12.91 – Test Code for Dry Type Distribution and Power Transformers
- C. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum)
- D. NEMA ST 1 – Specialty Transformers (except General Purpose Type)
- E. NEMA ST 20 – Dry-Type Transformers for General Applications
- F. NFPA 70 – National Electrical Code
- G. UL 506 – Specialty Transformers
- H. UL 1561 – Dry-Type General Purpose and Power Transformers
- I. 10 CFR 431, Subpart K (a) (2) – Energy Conservation Standards and Their Effective Dates

1.3 SUBMITTALS

- A. Product Data:
 - 1. Include rated nameplate data, capacities, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.
- B. Shop Drawings:
 - 1. For each transformer size and type:
 - a. Physical dimensions, including bolting templates, weight, and center of gravity
 - b. Loads, method of field assembly, components, and location and size of each field connection
 - c. Wiring Diagrams: Power, signal, and control wiring
 - d. kVA rating
 - e. Primary taps
 - f. Insulation class and temperature rise
 - g. Efficiency values measured at 0, 25, 50, 75, and 100% load
 - h. Impedance value – X/R and %Z
 - i. Sound level
 - j. “K” factor listing, where applicable

- C. Submit 1/4" scale electrical room floor plans with transformer locations.
- D. Manufacturer's Installation Instructions:
 - 1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- E. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
- F. Output Settings Report: Record output voltages and tap settings.
- G. Closeout Submittals:
 - 1. Project Record Documents:
 - a. Record actual locations of transformers.
 - 2. Operation and Maintenance Data:
 - a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
 - b. Include manufacturer's Seismic Qualification Certification, Installation Seismic Qualification Certification, manufacturer's Ultra Quiet Transformers Sound Level Certification, where applicable, and Output Settings Report.

1.4 QUALITY ASSURANCE

- A. Obtain transformers from one source and by single manufacturer.
- B. Regulatory Requirements:
 - 1. Comply with NFPA 70 for components and installation.
 - 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.
- B. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.6 WARRANTY

- A. Refer to Division 01 and Section 260000 - General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of final acceptance.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Schneider Square D
- B. ABB-GE Industrial Solutions
- C. Eaton Cutler-Hammer
- D. Siemens

2.2 DISTRIBUTION TRANSFORMERS

A. Fabrication:

- 1. NEMA ST 20, UL 1561
- 2. Factory assembled and tested
- 3. Air-cooled, for 60 Hz service
- 4. Two winding dry type
- 5. Coils:
 - a. Continuous wound construction and impregnated with non-hydroscopic, thermosetting varnish.
 - b. Conductors: Continuous windings without splices, except for taps, and encapsulated wire resin compound to seal out moisture and air.
 - c. Materials: Copper
 - d. Separate primary and secondary
 - e. Internal Connections: Braised or pressure type
- 6. Cores: High-grade silicon steel, non-aging, with high magnetic permeability, low eddy current losses and low hysteresis. Magnetic flux densities below saturation point. Core laminations clamped with steel members, one leg per phase.
- 7. Rubber vibration absorbing mounts to isolate base of enclosure from core and coil assembly.
- 8. Transformer neutral visibly grounded to enclosures with flexible grounding conductor.

B. Enclosure:

- 1. NEMA 250
- 2. Type 3R, unless otherwise indicated to comply with environmental conditions at installed location.
- 3. Code-gauge steel panel over core and coil.
- 4. Ventilated (air-cooled): Louvered openings for convection cooling.
- 5. Cooling and terminal chamber access with both sides and rear obstructed.
- 6. Manufacturer's lifting eyes or brackets.
- 7. Finish: Manufacturer's standard gray enamel over prime coat after being degreased, cleaned, and phosphatized.

C. Ratings:

1. KVA Rating: 300 kVA maximum
2. Primary Voltage: 480V, 3-phase, 3 wires.
3. Secondary Voltage: as indicated on drawings.
4. Insulation Class and Winding Temperature Rise:
 - a. Transformers 15kVA and smaller: Class 185°C, with 115°C temperature rise above 40°C ambient temperature, capable of carrying 15% continuous overload without exceeding 150°C rise.
 - b. Transformers 25kVA – 112.5kVA: Class 220°C, with 115°C temperature rise above 40°C ambient temperature, capable of carrying 15% continuous overload without exceeding 150°C rise.
 - c. Transformers above 112.5kVA: Class 220°C, with 80°C temperature rise above 40°C ambient temperature, capable of carrying 30% continuous overload without exceeding 150°C.
5. Top of Enclosure Temperature: Maximum 35°C above 40°C ambient temperature at warmest point at full load.
6. K-Factor Rating: UL 1561, as indicated.

D. Primary Taps:

1. Transformers rated less than 3kVA: One 5% tap above normal full capacity.
2. Transformers rated 3kVA - 15kVA: One 5% above and one 5% below normal full capacity.
3. Transformers rated 15kVA and larger: Two 2.5% above and two 2.5% below normal full capacity, minimum of four taps.

E. Energy Efficiency:

1. Transformers rated 15kVA and larger, except K-rated, quiet type and ultra quiet type:
 - a. 10 CFR 431, Subpart K .196 (a) (2) compliant

F. Sound Levels:

1. NEMA ST 20 , maximum average sound levels as follows:
 - a. 45 dB for general-purpose transformer sizes less than 51kVA.
 - b. 50 dB for general-purpose transformer sizes 51-150kVA.
 - c. 55 dB for general-purpose transformer sizes 151-300kVA.

2.3 LUGS

- A. Manufacturer's primary and secondary bolted lugs: labeled for 75°C copper and aluminum conductors for ventilated enclosures and labeled for 90°C copper and aluminum conductors for non-ventilated enclosures.
- B. Connections at sides near bottom, accessible from front of cabinet.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions for compliance with enclosure and ambient temperature requirements for each transformer.
- B. Examine areas and surface to receive transformers for compliance with requirements, installation tolerances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. Verify space indicated for transformers' mounting meets code-required working clearances.
- D. Notify Architect/Engineer of any discrepancies prior to submittal of product data and shop drawings.
- E. Verify that ground connections are in place and requirements in Section 260526 - Grounding and Bonding for Electrical Systems have been met.
- F. Verify with manufacturer that "touch-up" paint kit is available for repainting.

3.2 INSTALLATION

- A. Install transformers in accordance with ANSI/NECA 1.
- B. Install level and plumb within 1/2 degree, and at least 6" from the adjacent wall or structure to ensure proper ventilation, in accordance with manufacturer's written instruction, and in compliance with recognized industry practices.
- C. Transformer mounting, seismic restraints, and vibration control:
 - 1. Mount transformers on floor.
 - 2. Floor mounting:
 - a. Secure to floor via isolation pads between floor brackets (per manufacturer recommendations) and transformer.
- D. Install engraved plastic nameplates under provisions of Section 260553 - Electrical Systems Identification. Attach nameplate to transformer using small, corrosion-resistant metal screws or rivets. Do not use contact adhesive.
 - 1. Indicate kVA rating, voltage/phase rating, taps, insulation class and temperature rise, impedance value, sound level, and K-factor listing.
- E. Install conduit per requirements in Section 260533 - Raceway and Boxes for Electrical Systems .
- F. Install transformer in dedicated electrical space per NFPA 70 and as shown on drawings. Coordinate with miscellaneous trades for equipment foreign to the electrical installation to be outside of dedicated electrical space.

3.3 CONNECTIONS

- A. Ground transformers according to Section 260526 - Grounding and Bonding for Electrical Systems.
- B. Connect wiring according to Section 260519 - Low-Voltage Electrical Power Conductors and Cables.

3.4 FIELD QUALITY CONTROL

- A. Inspect transformers for physical damage, proper alignment, anchorage, grounding, connections, and installation.
- B. Test transformers per requirements in Sections 260812 - Power Distribution Acceptance Tests and 260813 - Power Distribution Acceptance Test Tables .
- C. Interpret test results in writing and submit to Engineer.
- D. Output Settings Report: Prepare a written report recording output voltages and tap settings and submit to Engineer.

3.5 REPAINTING

- A. Remove paint splatters and other marks from surface of equipment.
- B. Touch-up chips, scratches, or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Owner.

3.6 ADJUSTING

- A. Record transformer secondary voltage at each unit for at least 48 h of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10% and not being lower than nameplate voltage minus 3% at maximum load conditions.
- B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5%, at secondary terminals.

3.7 CLEANING

- A. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.

END OF SECTION 262200

SECTION 262413 - SWITCHBOARDS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Section includes free-standing, dead-front type low-voltage distribution switchboards.

1.2 REFERENCE STANDARDS

- A. ANSI/IEEE C37.13 – Low-Voltage AC Power Circuit Breakers Used in Enclosures
- B. ANSI/NECA 400 – Recommended Practice for Installing and Maintaining Switchboards
- C. IEEE C62.41.1 Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
- D. IEEE C62.41.2 Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits
- E. NFPA 70 – National Electrical Code
- F. NEMA AB 1 – Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
- G. NEMA AB 3 – Molded-Case Circuit Breakers and Their Applications
- H. NEMA FU 1 – Low-Voltage Cartridge Fuses
- I. NEMA KS 1 – Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
- J. NEMA PB 2 – Dead-Front Distribution Switchboards
- K. NEMA PB 2.1 – General Instructions for Proper Handling, Installation and Maintenance of Dead-Front Distribution Switchboards Rated 600 Volts or Less
- L. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
- M. UL 98– Enclosed and Dead-Front Switches
- N. UL 486A-486B – Wire Connectors
- O. UL 489 – Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
- P. UL 869A – Reference Standard for Service Equipment
- Q. UL 891 – Dead-Front Switchboards
- R. UL 1053 – Ground-Fault Sensing and Relaying Equipment

S. UL 1066 – Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures

1.3 SUBMITTALS

A. Product Data: For each switchboard, components and accessories indicated:

1. Include data on features and components and complete description; submit catalog cut sheets showing voltage, size, rating and size of surge protective devices, switching and overcurrent protective devices.
2. Features, characteristics, factory settings and time-current curves of individual protective devices, auxiliary components and ground fault relaying.

B. Shop Drawings:

1. For each switchboard specified in this Section:
 - a. General Arrangement:
 - 1) Indicate front, plan, and side views of switchboards; access requirements (front, side, rear); overall dimensions and components list; shipping splits and weights.
 - 2) Front elevation indicating location of devices and instruments.
 - 3) Sections through switchboard showing space available for conduits.
 - b. Conduit entrance locations and requirements.
 - c. Nameplate legends.
 - d. Configuration, size and number of bus bars for each phase and current rating of buses.
 - e. Ground bus.
 - f. Neutral bus.
 - g. Short circuit ratings of switchboards and overcurrent protective devices, and bus withstand rating.
 - h. Instrument details; enclosure types and details.
 - i. Wiring diagrams: power, signal and control wiring.
 - j. Utility company's metering provisions with indication of approval by utility company.
 - k. Descriptive documentation of optional barriers specified for electrical insulation and isolation.
 - l. UL listing for series rating of installed devices.
2. Contractor to submit 1/4" scale floor plans with switchboard locations and required clearances and service space around equipment.

C. Manufacturer's Installation Instructions:

1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

D. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.

E. Complete review of this specification noting for each paragraph whether proposed equipment complies with project specifications or deviates. Justification must be given for each deviation.

F. Closeout Submittals:

1. Project Record Documents:
 - a. Record actual locations, configurations, and ratings of switchboard and major components on single-line diagrams and plan layouts.
2. Operation and Maintenance Data:
 - a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
 - b. Include manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 - c. Include spare parts data listing, source, and current prices of replacement parts and supplies.
 - d. Include Manufacturer Seismic Qualification Certification and Installation Seismic Qualification Certification.
 - e. Include time-current curves, including selectable ranges for each type of overcurrent protective device.

1.4 QUALITY ASSURANCE

- A. Obtain switchboards from one source and by single manufacturer.
- B. Regulatory Requirements:
 1. Comply with NFPA 70 for components and installation.
 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, fumes, water, corrosive substances, construction debris, and traffic. Provide temporary heaters in switchboards as required to prevent condensation.
- B. Deliver switchgear in shipping splits of length that can be moved in deliver path, as indicated. , individually wrapped for protection, and mounted on shipping skids. Mark crates, boxes, and cartons clearly to identify equipment. Show crate, box, or carton identification number on shipping invoices.
- C. Handle switchboards in accordance with NEMA PB 2.1 and ANSI/NECA 400. Use factory-installed lifting provisions. Handle carefully to avoid damage to switchboard internal components, enclosure, and finish.

1.6 WARRANTY

- A. Refer to Division 01 and Section 260000 - General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of final acceptance.

1.7 MAINTENANCE

- A. Extra Materials: Furnish extra materials described below that match product installed, are packaged with protective covering for storage, and are identified with labels describing contents.
 - 1. Potential Transformer Fuses: Equal to 10% of amount installed for each size and type, but no fewer than 2 of each size and type.
 - 2. Control-Power Fuses: Equal to 10% of amount installed for each size and type, but no fewer than 2 of each size and type.
 - 3. Fuses for Fused Switches and for Fused Circuit Breakers: Equal to 10% of amount installed for each size and type, but no fewer than 3 of each size and type.
 - 4. Indicating Lights: Furnish quantity equal to 10% of amount installed for each size and type, but no fewer than 2 of each size and type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Schneider Square D
- B. ABB-GE Industrial Solutions
- C. Eaton Cutler-Hammer
- D. Siemens

2.2 RATINGS

- A. Nominal system voltage: 480Y/277V.
- B. Main bus continuous amp: As indicated on the drawings or scheduled.
- C. Short circuit current rating: as indicated on drawings.
- D. Brace switchboard components to withstand mechanical forces for symmetrical fault current shown.

2.3 CONSTRUCTION

- A. NEMA PB 2, UL 891
- B. Free-standing, dead-front type; vertical sections bolted together; sides and rear covered with removable bolt-on covers; adequate ventilation within enclosure; supporting frame: steel channels rigidly fastened together, with same outside dimensions as the enclosure.
- C. Adequate strength and rigidity necessary to resist conditions of use to which it may be subjected and to support equipment, devices and appurtenances contained therein.

- D. Barriers shall be placed such that no uninsulated, ungrounded service busbar or service terminal is exposed to inadvertent contact by persons or maintenance equipment while servicing load terminations
- E. Incoming lug locations: Top, as applicable per drawings.
- F. Connection to the supply source by conduit and wiring.
- G. Environmental Limitations:
 - 1. Ambient temperatures: Not exceeding 40°C.
 - 2. Altitude: Not exceeding 2 km
 - 3. Temperature rise: Not to exceed 65°C over a 40°C ambient environment, with no derating required.
- H. Device Mounting and Type:
 - 1. Front accessible switchboard: Rear aligned for placement against the wall:
 - a. Main and tie device: Panel mounted.
 - b. Feeder devices: Panel mounted molded-case circuit breakers.
 - c. Devices: Front removable; load connections: Front accessible.
- I. Bus:
 - 1. Material: Copper with silver plating; copper: 98% conductivity. The bus bars shall have sufficient cross-sectional area to meet UL 891 temperature rise requirements through actual tests. The bus bars shall be standard density rated for 1000 amperes per square inch copper.
 - 2. Connections:
 - a. Bolted:
 - 1) Not fewer than 4 bolts for each 4" x 4" contact.
 - 2) Not fewer than 2 bolts for each 2" x 2" contact.
 - 3) Grade 5 bolts and conical spring-type washers.
 - 4) Clamp joints are not allowed.
 - 3. Sizing: Standard size, based on 65°C over 40°C.
 - 4. Main Phase Buses: Three phase, 4 wire; fully rated; uniform capacity for entire length of switchboard; ampacity as indicated on drawings; rated for the main protective device frame size or main incoming conductors.
 - 5. All feeder device line and load connection straps: Rated to carry current rating of device frame (not trip rating).
 - 6. Support for Buses: Mounted on high-impact, non-tracking insulated supports; joints in the vertical bus are not permitted.
 - 7. Bus arrangement: A-B-C (left to right, top to bottom, front to rear).
- J. Ground Bus: Insulated, extend length of switchboard.
 - 1. 1/4" x 2" minimum-size, hard-drawn copper of 98 percent conductivity, equipped with pressure connectors for feeder ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection.

- K. Neutral Bus: 100% of the ampacity of phase buses, as indicated on drawings, equipped with pressure connectors for outgoing circuit neutral cables. Bus extensions for busway feeder neutral bus are braced.
- L. Main incoming compartment.
- M. Hinged Front Doors: Allow access to metering and accessory compartments; concealed hinges; fastened by head bolts.
- N. Cable Supports: For each vertical section.
- O. Barriers: Between adjacent sections.
- P. Bus Connections: Extend from load side of devices into rear compartment for connections to outgoing cables.
- Q. All buswork shall have 3 cycles withstand rating.
- R. Future Provisions: Fully equip spaces for future devices with bussing, mounting brackets, supports, and appurtenances, insulated and braced for short circuit currents, with continuous current rating as indicated on drawings. Extension of phase, neutral, and ground buses from both ends.
- S. Adequate lifting means.
- T. Dimensions: 90" maximum height, excluding floor sills, lifting members and pull boxes. Length and depth indicated scaled on the drawing are maximum allowed.
- U. Line and Load Terminations: Compression type accessible from front only of switchboard, labeled for 75°C copper and aluminum conductors; suitable for number, size and trip ratings.
- V. Enclosure: Steel, NEMA 250, Type 1:
 - 1. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

2.4 SERVICE ENTRANCE

- A. UL 869A
- B. Switchboards labeled as suitable for use as service entrance equipment, with incoming line isolation barriers, and a removable neutral bond to switchboard ground for solidly grounded wye systems.
- C. Surge arrestors on all phases: per requirements in Section 26 4300 – Surge Protective Devices.

2.5 SHORT CIRCUIT CURRENT RATING

- A. Each switchboard with minimum short circuit current rating as indicated on drawings.
- B. Switchboards: Marked with their maximum short circuit current rating at supply voltage.
- C. Switchboards: Series rated switchboards are not acceptable.

2.6 SURGE PROTECTIVE DEVICES (SPD)

- A. By switchboard manufacturer.
- B. IEEE C62.41.1; integrally mounted, plug-in style, solid-state, parallel-connected, suppression and filtering modules
- C. Per requirements in Section 264300 - Surge Protective Devices (SPD)

2.7 OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker: NEMA AB 1, NEMA AB 3, UL 489; lockable handle; interrupting capacity to meet available fault current.
 - 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 225 A and below.
 - 2. Electronic (solid-state microprocessor based) trip unit circuit breakers: digital true RMS sensing trip units; interchangeable in the field within the frame size (field-replaceable rating plug to determine the breaker trip rating), field-adjustable settings and the following trip functions for circuit breaker frame sizes 250 A - 1200 A:
 - a. Instantaneous trip
 - b. Long- and short-time pickup levels
 - c. Long- and short-time time delay adjustments with I²t response
 - d. Ground-fault pickup level, time delay, and I²t response
 - 3. Listed for 100% of breaker's continuous ampere rating.
- B. Molded-Case Circuit Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.
 - 1. Position: ON and OFF, clearly marked on escutcheon; trip-to-test means on the escutcheon for manually tripping the breaker and exercising the mechanism and trip latch.
- C. Circuit Breaker Electronic Trip Units general characteristics:
 - 1. Circuit breakers, with solid-state microprocessor based trip units:
 - a. Unit shall consist of current sensors, solid-state trip device, and solid-state adjustable time/current curve shaping elements.
 - b. Trip units shall be removable to allow for field upgrades.
 - c. Trip units shall incorporate "True RMS Sensing."
 - 2. Solid-state elements shall provide functions as indicated above.
 - 3. Adjustments shall be made using non-removable, discrete steps.
 - 4. Sealable transparent cover shall be provided over adjustments.
 - 5. Adjustable long-time pickup (I_r) and delay shall be available in an adjustable rating plug that is UL listed as field-replaceable. Adjustable rating plug shall allow for five minimum long-time pickup settings from 0.4 to 1.0 times the sensor plug (I_n). Other adjustable rating plugs shall be available for more precise settings to match the application. Long-time delay settings shall be at least three bands.

6. Short-time pickup shall allow for five minimum settings from 1.5 to 10 times I_r . Short-time delay shall be at least three bands with I_{2t} ON and OFF.
 7. Instantaneous settings on the trip units shall be available in five minimum bands from 2 to 15 times I_n . The instantaneous settings shall also have an OFF setting when short-time pickup is provided.
 8. Trip units shall have the capability to electronically adjust the settings locally and remotely to fine increments below the switch settings. Fine increments for pickup adjustments are to be one ampere. Fine increments for delay adjustments are to be one second.
 9. Trip unit shall indicate:
 - a. Long-time fault
 - b. Short-time fault
 - c. Instantaneous fault
 - d. Ground fault, where provided
 10. Trip unit shall provide local trip indication and capability to indicate local and remote reason for trip, i.e., overload, short circuit or ground fault.
 11. Trip unit shall contain means to conduct circuit breaker test, or via separate test kit.
 12. Breaker shall be equipped with externally accessible test points to be used for field testing.
 13. Trip units shall be available to provide real time metering. Metering functions include current, voltage, power and frequency.
 14. Trip units shall be provided with the following standard features:
 - a. True RMS sensing
 - b. LI
 - c. LSI
 - d. LSIG/Ground-fault trip
 - e. Ground Fault Alarm (no trip), with external relay, where required
 - f. Adjustable rating plugs
 - g. LCD or LED – Long-time pickup
 - h. LCD or LED – Trip indication
 - i. Digital Ammeter
 - j. Communications
 - k. LCD dot matrix display
 - l. Advanced user interface
 - m. Protective relay functions
 - n. Neutral protection
 - o. Incremental fine tuning of settings
 - p. Selectable long-time delay bands
 - q. Power measurement
 - r. Maximum peak demand (measure of average power over a 15-minute period) continuously recorded over a one-year period
- D. Ground Fault protection equipment on breakers rated 1000A or more and where indicated:
Integrally mounted relay and trip unit, push-to-test feature and ground fault indicator:

1. Ground-fault protection with at least three adjustable short-time delay settings and three trip-time delay bands; adjustable current pickup with maximum setting of 1200 amps. Arrange to provide protection for the following:
 - a. Four-wire circuit or system
2. Trip units shall be capable of the following types of ground-fault protection: source ground return and modified differential. Ground fault sensing systems shall be changed in the field.
3. Neutral current transformers shall be provided for 4-wire system.
4. Ground-fault settings for circuit breaker sensor sizes 1200 A or below shall be in nine bands from 0.2 to 1.0 times I_n . The ground-fault settings for circuit breakers above 1200 A shall be in minimum three bands up to 1200 A.
5. Ground-Fault Relay: UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and 3-phase current transformer/sensor.

2.8 CONTROL POWER, COMPONENTS IDENTIFICATION, AND CONTROL WIRING

- A. Control Circuits: 120 V, supplied through secondary disconnecting devices from control-power transformer.
- 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 components mounted within assembly, such as relays, pushbuttons, switches, etc.: Suitably marked for identification, corresponding to appropriate designations on manufacturer's wiring diagrams.
- D. Control Wiring: Factory installed, with bundling, lacing, and protection included; flexible conductors for #8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units; insulated locking spade terminals for all control connections, except where saddle type terminals, integral to a device; current transformer secondary leads, connected to short circuit terminal blocks; terminal blocks with suitable numbering strips for group of control wires leaving switchboard, with wire markers at each end of control wiring.

2.9 ACCESSORY COMPONENTS AND FEATURES

- A. Furnish accessory set including tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- B. Furnish set of tools for manually charging circuit breaker stored energy device.
- C. Lockout Devices: Circuit breakers with integral, lockout/tagout devices.
- D. Absence of Voltage Tester (AVT) - provide absence of voltage tester to provide visible indication of the presence of voltage on the Load side of the main breaker.

2.10 CUSTOMER METERING

- A. Per requirements in Section 262713 - Electrical Metering.

PART 3 - EXECUTION

3.1 COORDINATION

- A. Instruct manufacturer about the location of incoming lugs, i.e., top or bottom feed based on incoming feeder entrance location.
- B. Coordinate installation of housekeeping concrete pad based on actual equipment supplied:
 - 1. Concrete: Per requirements in Division 03 – Concrete.
 - 2. Dimensions: Per requirements in Section 260529 - Hangers and Supports for Electrical Systems.
- C. Coordinate with miscellaneous trades for equipment foreign to the electrical installation to be outside of dedicated electrical space.
- D. Coordinate with busway system manufacturer factory installation of termination fittings.
- E. Coordinate utility company metering equipment requirements.
- F. Verify with manufacturer that “touch-up” paint kit is available for repainting.

3.2 EXAMINATION

- A. Examine areas and surface to receive switchboards for compliance with requirements, installation tolerances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Verify that space indicated for switchboard mounting meets code-required working clearances.
- C. Notify Architect/Engineer of any discrepancies prior to submittal of product data and shop drawings.

3.3 INSTALLATION

- A. Install switchboard in accordance with NEMA PB 2.1 and ANSI/NECA 400.
- B. Install engraved plastic nameplates under provisions of Section 260553 - Electrical Systems Identification for each switchboard, every instrument, overcurrent protective device and disconnect device. Attach nameplate to exterior of each switchboard using small corrosion-resistant metal screws and rivets. Do not use contact adhesive. Indicate switchboard manufacturer's name and drawing number, name, amperage, voltage, phase, number of wires, short circuit current rating (amp, RMS symmetrical and MVA 3-phase symmetrical) and momentary and fault-closing ratings (amp, RMS asymmetrical). For each overcurrent protective device and disconnect device, include circuit, load and area served, voltage/phase rating, and fuse size and type, when applicable.
- C. Provide framed, printed operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of switchboards.

- D. Install switchboards in dedicated electrical space per NFPA 70, and as indicated on drawings.
- E. Tighten electrical connectors and terminal according to equipment manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- F. Connect surge protective devices to switchboard bus per requirements in Section 264300 - Surge Protective Devices (SPD).
- G. Tighten electrical connectors and terminals according to equipment manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

3.4 CONNECTIONS

- A. Ground switchboards according to Section 260526 - Grounding and Bonding for Electrical Systems.
- B. Connect power and control wiring according to Section 260519 - Low-Voltage Electrical Power Conductors and Cables.

3.5 FIELD QUALITY CONTROL

- A. Inspect switchboards for physical damage, proper alignment, connections, anchorage, seismic restraints and grounding.
- B. Test continuity of each circuit.
- C. Test switchboards per requirements in Sections 260812 - Power Distribution Acceptance Tests and 26 0813 – Power Distribution Acceptance Test Tables.
- D. Interpret test results in writing and submit to Engineer.
- E. Test switch operators once after energizing.

3.6 REPAINTING

- A. Remove paint splatters and other marks from surface of equipment.
- B. Touch-up chips, scratches or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Owner.

3.7 ADJUSTING

- A. Set field-adjustable circuit breakers trip settings or change the trip settings to values indicated on drawings or recommended by the overcurrent protective device coordination study per Section 260573 - Power System Studies.
- B. Field adjustments or changing of trip setting and adjustment or replacement of equipment to comply with Section 260573 - Power System Studies; no additional cost to Owner.

INDOOR PRACTICE FACILITY
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3.8 CLEANING

- A. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.

3.9 DEMONSTRATION

- A. Provide training session by manufacturer for one workday at a job location, to train the Owner's personnel in the operation and maintenance of switchboards.

END OF SECTION 262413

SECTION 262416.13 - LIGHTING AND APPLIANCE PANELBOARDS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Section includes circuit breaker type lighting and appliance branch circuit panelboards as shown on drawings and as scheduled.

1.2 REFERENCE STANDARDS

- A. NECA 407 - Recommended Practice for Installing and Maintaining Panelboards
- B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
- C. NEMA AB 1 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
- D. NEMA PB 1 - Panelboards
- E. NEMA PB 1.1 - General Instructions for Proper Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or Less
- F. NFPA 70 - National Electrical Code
- G. UL 50 - Enclosures for Electrical Equipment
- H. UL 67 - Panelboards
- I. UL 486A-486B - Wire Connectors
- J. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
- K. UL 869A - Reference Standard for Service Equipment

1.3 SUBMITTALS

- A. Product Data:
 - 1. Submit catalog data showing specified features of standard products. Eliminate extraneous catalog data.
- B. Shop Drawings:
 - 1. Submit for review prior to manufacture. Include complete description, front view, dimensions, voltage, main bus ampacity, circuit breaker arrangement and sizes, short circuit current rating, and factory settings of individual protective devices.
 - 2. Submit 1/4" scale electrical room floor plans with panelboard locations.
- C. Partial Submittals:

1. Panelboards shall be submitted for review together. Partial submittals of panelboards are not acceptable and will be rejected.
- D. Manufacturer's Installation Instructions:
 1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- E. Test Reports:
 1. Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
- F. Closeout Submittals:
 1. Project Record Documents:
 - a. Record actual locations of panelboards and record actual circuiting arrangements.
 2. Operation and Maintenance Data:
 - a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
 - b. Include manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 - c. Include time-current curves and selectable ranges for each type of overcurrent protective device.
 - d. Include spare parts data listing, source, and current prices of replacement parts and supplies.
 - e. Include manufacturer's Seismic Qualification Certification and Installation Seismic Qualification Certification.

1.4 QUALITY ASSURANCE

- A. Obtain panelboards, overcurrent protective devices, components, and accessories from one source and by single manufacturer.
- B. Regulatory Requirements:
 1. Comply with NFPA 70.
 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.
- B. Comply with NEMA PB 1.1 and manufacturer's written instructions.

1.6 WARRANTY

- A. Refer to Division 01 and Section 260000 - General Electrical Requirements for general warranty requirements.

- B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of final acceptance.

1.7 MAINTENANCE

- A. Extra Materials:
 - 1. Furnish Owner with two keys per panelboard.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Schneider Square D
- B. ABB-GE Industrial Solutions
- C. Eaton Cutler Hammer
- D. Siemens

2.2 LIGHTING AND APPLIANCE BRANCH CIRCUIT PANELBOARDS

- A. NEMA PB 1, UL 67 [98]
- B. Fabrication:
 - 1. Factory assembled.
 - 2. door-in-door construction.
 - 3. Incoming feeder lugs: copper conductors.
 - 4. Multiple lugs to match number of conductors per phase.
 - 5. Sub-feed (double) lugs, or feed-through lugs where indicated.
 - 6. Filler plates.
 - 7. Wiring terminals for field installed conductors: Pressure wire connectors, except wire-binding screws for #10 AWG or smaller conductors.
- C. Panelboard Buses:
 - 1. Copper
 - 2. Ampere rating as scheduled
 - 3. Ground bus: uninsulated, bonded to panelboard cabinet
 - 4. Insulated neutral bus: 100% of phase bus rating
- D. Molded-Case Circuit Breakers:
 - 1. NEMA AB 1, UL 489
 - 2. Bolt-on type, labeled for 75°C copper and aluminum conductors
 - 3. Quick-make, quick-break, with thermal-magnetic trip.
 - 4. Common internal trip on multi-pole breakers. Handle-ties are not permitted.

5. Ampere rating as scheduled
6. Listed as Type SWD for lighting circuits
7. Listed as Type HACR for air conditioning equipment circuits
8. Bussing, device mounting hardware, and steel knockouts in dead front where "space" is indicated
9. Tandem circuit breakers are not acceptable
10. Ground fault equipment protection (GFEP), rated 30 mA trip, to provide equipment protection for branch circuits feeding electrical heat tracing, where indicated
11. Ground fault circuit interrupter (GFCI), rated at 4-6 mA trip for protection of personnel, where indicated

E. Cabinet

1. NEMA 250, UL 50
2. NEMA Type 1, Type 3R (outdoor locations) Type 4X, stainless steel, operating room suites, kitchen areas, enclosure.
3. Front (trim) surface mounted with door in front with concealed self-adjusting trim clamps, and complete with cylinder-type lock and catch.
4. Same height matching trim, where two cabinets are mounted adjacent to one another in finished areas.
5. All sections of panelboards have the same size, where oversize cabinets are required for one section of multi-section panelboard.
6. Boxes and fronts made of code-gauge galvanized steel.
7. Manufacturer's standard gray enamel finish over prime coat.

2.3 SHORT CIRCUIT CURRENT RATING

- A. Each panelboard with minimum short circuit current rating as indicated on drawings.
- B. Panelboards marked with their maximum short circuit current rating at supply voltage.
- C. Panelboards: Series-rated panelboards are not acceptable.

2.4 SURGE PROTECTIVE DEVICES (SPD)

- A. By panelboard manufacturer.

2.5 SPARE CONDUITS

- A. Spare conduits per requirements in Section 260533 - Raceway and Boxes for Electrical Systems.

PART 3 - EXECUTION

3.1 COORDINATION WITH MANUFACTURER

- A. Instruct manufacturer about the location of additional wiring gutter space when required (i.e., top, bottom, right, left, or combination).

- B. Instruct manufacturer about the location of main lugs or main circuit breaker (i.e., top or bottom feed based on incoming feeder entrance location).
- C. Instruct manufacturer to provide multiple lugs where conductors in parallel or sub-feed (double) lugs or feed-through lugs are indicated.
- D. Instruct manufacturer on the size of cross-connection cables for panelboards fed via sub-feed (double) lugs or feed-through lugs. Make cable size with ampacity equal to incoming feeder.
- E. Verify that “touch-up” paint kit is available for repainting.

3.2 EXAMINATION

- A. Verify that space indicated for panelboard mounting meets code-required working clearances and dedicated equipment space.
- B. Notify Architect/Engineer of any discrepancies prior to submittal of product data and shop drawings.

3.3 INSTALLATION

- A. Install panelboards in accordance with NECA 407 and NEMA PB 1.1.
- B. Install panelboards plumb and rigid without distortion of box, in accordance with manufacturer's written instructions, and in compliance with recognized industry practices.
- C. Panelboard mounting and seismic restraints:
 - 1. Install panelboard anchorage devices and seismic restraints based on design by an Engineer registered and licensed in the State of North Carolina, and to comply with Section 260548 - Vibration and Seismic Controls For Electrical Systems for seismic criteria.
 - 2. Fasten panelboards firmly to walls and structural surfaces, ensuring they are permanently and mechanically anchored.
 - 3. Anchor and fasten panelboards and their supports to building structural elements (wood, concrete, masonry, hollow walls and nonstructural building surfaces) by the methods described in Section 260529 - Hangers and Supports for Electrical Systems.
 - 4. Install two rows of steel slotted channel, with a minimum of 4 attachment points, for each panelboard section.
 - 5. When not located directly on wall, provide support frame of steel slotted channel anchored to floor and ceiling structure.
- D. Install top breaker handle a maximum of 6'-7" above finished floor or working platform with handle in its highest position.
- E. Tighten electrical connectors and terminals according to equipment manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

- F. Install as-built typewritten circuit directory in directory frame (to indicate installed circuit loads) mounted inside each panelboard door. Include description of connected loads, room number, room name, area, or item served for each branch circuit. Indicate motor names and horsepower as applicable. Cover circuit directory with colorless plastic. Coordinate with Owner and Architect to ensure that room numbers used in panel directory are final numbers assigned by Owner.
- G. Install engraved plastic nameplates under provisions of Section 260553 - Electrical Systems Identification. Attach nameplate to exterior of each panelboard using small metal screws or rivets. Do not use contact adhesive.
 - 1. Include panelboard name, amperage, voltage, phase, and number of wires.
- H. Label spare circuits as SPARE. Leave spare breakers in OFF position.
- I. Room numbers used shall be those used by Owner except as otherwise directed by Architect.
- J. Install panelboard in dedicated electrical space per NFPA 70 and as shown on drawings. Coordinate with miscellaneous trades for equipment foreign to the electrical installation to be outside of dedicated electrical space.
- K. Install filler plates in unused spaces.
- L. Install three 3/4" spare conduits stubbed into accessible ceiling space or space designated to be ceiling space in the future for all flush-mounted panelboards. Install conduits in accordance with requirements in Section 260533 - Raceway and Boxes for Electrical Systems .

3.4 CONNECTIONS

- A. Ground panelboards according to Section 260526 - Grounding and Bonding for Electrical Systems.
- B. Connect wiring according to Section 260519 - Low-Voltage Electrical Power Conductors and Cables.

3.5 FIELD QUALITY CONTROL

- A. Inspect for physical damage, proper alignment, anchorage, and grounding.
- B. Maintain proper phasing for multi-wire circuits.
- C. Test main circuit breakers in accordance with requirements in Sections 260812 - Power Distribution Acceptance Tests and 260813 - Power Distribution Acceptance Test Tables.
- D. Interpret test results in writing and submit to Engineer.
- E. Check phase-to-phase and phase-to-ground insulation resistance levels prior to energization of panelboards.
- F. Check panelboards for electrical continuity of circuits and for short-circuits prior to energization.

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3.6 REPAINTING

- A. Remove paint splatters or other marks from surface of panelboards.
- B. Touch-up chips, scratches, or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Owner.

3.7 ADJUSTING

- A. Adjust fronts, covers, hinges, and locks.

3.8 CLEANING

- A. Clean panelboard interiors and exteriors prior to final inspection. Remove paint splatters and other spots, dirt and debris.

END OF SECTION 262416.13

SECTION 262416.16 - DISTRIBUTION PANELBOARDS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Section includes circuit breaker type and fusible switch type power distribution panelboards as shown on drawings and as scheduled.

1.2 REFERENCE STANDARDS

- A. NECA 407 - Recommended Practice for Installing and Maintaining Panelboards
- B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
- C. NEMA AB 1 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
- D. NEMA FU 1 - Low-Voltage Cartridge Fuses
- E. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
- F. NEMA PB 1 - Panelboards
- G. NEMA PB 1.1 - General Instructions for Proper Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or Less
- H. NFPA 70 - National Electrical Code
- I. UL 50 - Enclosures for Electrical Equipment
- J. UL 67 - Panelboards
- K. UL 486A-486B - Wire Connectors
- L. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
- M. UL 512 - Fuseholders
- N. UL 869A - Reference Standard for Service Equipment

1.3 SUBMITTALS

- A. Product Data:
 - 1. Submit catalog data showing specified features of standard products. Eliminate extraneous catalog data.
- B. Shop Drawings:

1. Submit for review prior to manufacture. Include complete description, front view, dimensions, voltage, main bus ampacity, circuit breaker fusible switch arrangement and sizes, short circuit current rating, and factory settings of individual protective devices.
 2. Submit 1/4" scale electrical room floor plans with panelboard locations.
 3. Submit features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
- C. Partial Submittals:
1. Panelboards shall be submitted for review together. Partial submittals of panelboards are not acceptable and will be rejected.
- D. Manufacturer's Installation Instructions:
1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- E. Test Report:
1. Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
- F. Closeout Submittals:
1. Project Record Documents:
 - a. Record actual locations of panelboards and record actual circuiting arrangements.
 2. Operation and Maintenance Data:
 - a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
 - b. Include manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 - c. Include time-current curves and selectable ranges for each type of overcurrent protective device.
 - d. Include spare parts data listing, source, and current prices of replacement parts and supplies.
 - e. Include manufacturer's Seismic Qualification Certification and Installation Seismic Qualification Certification.

1.4 QUALITY ASSURANCE

- A. Obtain panelboards, overcurrent protective devices, components, and accessories from one source and by a single manufacturer.
- B. Regulatory Requirements:
1. Comply with NFPA 70.
 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
- C. Certifications:

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1. Furnish Engineer with manufacturer's Seismic Qualification Certification: Submit certification that panelboards, overcurrent protective devices, and components will remain internally intact to withstand seismic forces defined in Section 260548 - Vibration and Seismic Controls For Electrical Systems. Include the following:
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.
- B. Comply with NEMA PB 1.1 and manufacturer's written instructions.

1.6 WARRANTY

- A. Refer to Division 01 and Section 260000 - General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of final acceptance.

1.7 MAINTENANCE

- A. Extra Materials:
 1. Furnish Owner with two keys per panelboard.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Schneider Square D
- B. ABB-GE Industrial Solutions
- C. Eaton Cutler Hammer
- D. Siemens

2.2 POWER DISTRIBUTION PANELBOARDS

- A. NEMA PB 1, UL 67.
- B. Fabrication:
 1. Factory assembled
 2. Individualized breaker fusible switch dead-front cover door-in-door construction
 3. Incoming feeder lugs: copper conductors
 4. Multiple lugs to match number of conductors per phase

5. Sub-feed (double) lugs, or feed-through lugs where indicated
 6. Filler plates
 7. Wiring terminals for field installed conductors: Pressure wire connectors, except wire-binding screws for #10 AWG or smaller conductors.
 8. Barriers shall be placed such that no uninsulated, ungrounded service busbar or service terminal is exposed to inadvertent contact by persons or maintenance equipment while servicing load terminations.
- C. Panelboard Buses:
1. Copper
 2. Ampere rating as scheduled
 3. Ground bus: uninsulated, bonded to panelboard cabinet
 4. Insulated neutral bus where applicable: 100% of phase bus rating
- D. Molded-Case Circuit Breakers:
1. NEMA AB 1, UL 489
 2. Bolt-on or I-line type, labeled for 75°C copper and aluminum conductors
 3. Quick-make, quick-break, with thermal-magnetic trip.
 4. Equipped with individually insulated, braced, and protected connectors
 5. Common internal trip on multi-pole breakers. Handle-ties are not permitted.
 6. Ampere rating as scheduled
 7. Front face flush with each other
 8. Large, permanent, individual circuit numbers affixed to each breaker in uniform position
 9. Tripped indication clearly shown by breaker handle taking position between “ON” and “OFF.”
 10. Listed as Type HACR for air conditioning equipment circuits
 11. Bussing, device mounting hardware, and steel knockouts in dead front where “space” is indicated
 12. For 225A frame size and below: thermal-magnetic trip
 13. For 250A frame size and above: electronic trip units interchangeable in the field within the frame size and field-adjustable Long Time Pick Up and Delay, and Short Time Pick Up and Delay where shown on the drawings, and instantaneous current settings. Each adjustment shall have discrete settings and shall be independent of all other adjustments.
- E. Cabinet
1. NEMA 250, UL 50
 2. NEMA Type 1, Type 3R (outdoor locations) Type 4X, stainless steel, kitchen areas, _____ enclosure.
 3. Four-piece front (trim) surface mounted without door with breakers exposed.
 4. Same height matching trim, where two cabinets are mounted adjacent to one another in finished areas.
 5. All sections of panelboards have the same size, where oversize cabinets are required for one section of multi-section panelboard.

6. Boxes and fronts made of code-gauge galvanized steel
7. Manufacturer's standard gray enamel finish over prime coat.

2.3 SHORT CIRCUIT CURRENT RATING

- A. Each panelboard with minimum short circuit current rating as indicated on drawings.
- B. Panelboards marked with their maximum short circuit current rating at supply voltage.
- C. Panelboards: Series-rated panelboards are not acceptable.

PART 3 - EXECUTION

3.1 COORDINATION WITH MANUFACTURER

- A. Instruct manufacturer about the location of additional wiring gutter space when required, i.e. top, bottom, right, left, or combination.
- B. Instruct manufacturer about the location of main lugs or main circuit breaker (i.e., top or bottom feed based on incoming feeder entrance location).
- C. Instruct manufacturer to provide multiple lugs where conductors in parallel or sub-feed (double) lugs or feed-through lugs are indicated.
- D. Instruct manufacturer on the size of cross-connection cables for panelboards fed via sub-feed (double) lugs or feed-through lugs. Make cable size with ampacity equal to incoming feeder.
- E. Verify that "touch-up" paint kit is available for repainting.
- F. Coordinate painting of cabinets in finished areas with work performed under Division 09 - Finishes

3.2 EXAMINATION

- A. Verify that space indicated for panelboard mounting meets code-required working clearances and dedicated equipment space.
- B. Notify Architect/Engineer of any discrepancies prior to submittal of product data and shop drawings.

3.3 INSTALLATION

- A. Install panelboards in accordance with NECA 407 and NEMA PB 1.1.
- B. Install panelboards plumb and rigid without distortion of box, in accordance with manufacturer's written instructions, and in compliance with recognized industry practices.
- C. Panelboard mounting and seismic restraints:
 1. Install panelboard anchorage devices and seismic restraints based on design by an Engineer registered and licensed in the State of North Carolina, and to comply with Section 260548 - Vibration and Seismic Controls For Electrical Systems for seismic criteria.

2. Fasten panelboards firmly to walls and structural surfaces, ensuring they are permanently and mechanically anchored.
 3. Anchor and fasten panelboards and their supports to building structural elements (wood, concrete, masonry, hollow walls and nonstructural building surfaces) by the methods described in Section 260529 - Hangers and Supports for Electrical Systems.
 4. Install two rows of steel slotted channel, with a minimum of four attachment points, for each panelboard section.
 5. When not located directly on wall, provide support frame of steel slotted channel anchored to floor and ceiling structure.
- D. Install top breaker handle a maximum of 6'-7" above finished floor or working platform, with handle in its highest position.
- E. Tighten electrical connectors and terminals according to equipment manufacturer's published torque tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- F. Install as-built typewritten circuit directory in directory frame (to indicate installed circuit loads before completing load balancing) mounted inside each panelboard door. Include description of connected loads, room number, room name, area, or item served for each branch circuit. Indicate motor names and horsepower as applicable. Cover circuit directory with colorless plastic. Coordinate with Owner and Architect to ensure that room numbers used in panel directory are final numbers assigned by Owner.
- G. Install engraved plastic nameplates under provisions of Section 260553 - Electrical Systems Identification. Attach nameplate to exterior of each panelboard using small, corrosion-resistant metal screws or rivets. Do not use contact adhesive.
1. Indicate panelboard name, amperage, voltage, phase, and number of wires.
- H. Label spare circuits as SPARE. Leave spare breakers in OFF position.
- I. Room numbers used shall be those used by Owner except as otherwise directed by Architect.
- J. Install panelboard in dedicated electrical space per NFPA 70 and as shown on drawings. Coordinate with miscellaneous trades for equipment foreign to the electrical installation to be outside of dedicated electrical space.
- K. Install filler plates in unused spaces.

3.4 CONNECTIONS

- A. Ground panelboards according to Section 260526 - Grounding and Bonding for Electrical Systems.
- B. Connect wiring according to Section 260519 - Low-Voltage Electrical Power Conductors and Cables.

3.5 FIELD QUALITY CONTROL

- A. Inspect for physical damage, proper alignment, anchorage, and grounding.

- B. Test circuit breakers per requirements in Sections 260812 - Power Distribution Acceptance Tests and 26 0813 – Power Distribution Acceptance Test Tables.
- C. Interpret test results in writing and submit to Engineer.
- D. Check phase-to-phase and phase-to-ground insulation resistance levels prior to energizing panelboards.
- E. Check panelboards for electrical continuity of circuits and for short-circuits prior to energizing.

3.6 REPAINTING

- A. Remove paint splatters or other marks from surface of panelboards.
- B. Touch-up chips, scratches, or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint to Owner.

3.7 ADJUSTING

- A. Adjust fronts, covers, hinges, and locks.
- B. Circuit Breakers: Set field-adjustable trip settings or change the trip settings recommended by the overcurrent protective device coordination study per Section 260573 - Power System Studies.

3.8 CLEANING

- A. Clean panelboard interiors and exteriors prior to final inspection. Remove paint splatters and other spots, dirt and debris.

END OF SECTION 262416.16

SECTION 262713 - ELECTRICAL METERING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Electrical consumption and usage data for buildings connected to the ECU campus electrical distribution systems, as well as other selected buildings, is monitored by Square D ION, web-based campus enterprise metering system. This system is generally comprised of individual building meters and submeters, which are interconnect via the campus Ethernet to a central computer server and software. The metering system is presently configured to operate on Schneider "ION" software.
- B. Owner Metering:
 - 1. Provide electronic metering equipment for monitoring of electrical power.
- C. In all cases, meters must be interface to ECU central campus energy management system via building data network. Where noted, meter data shall be integrated with campus Schneider ION system for central data collection of energy use information. Coordinate with other contractors to ensure compatible communications protocols are provided to achieve these interfaces.
- D. Nonelectrical meters (e.g. water, natural gas, etc.) shall be provided and installed by the applicable division but integration into the ION system is the responsibility of Division 26.

1.2 REFERENCE STANDARDS

- A. ANSI C12.1 – Code for Electricity Metering
- B. ANSI C12.7 – Requirements For Watthour Meter Sockets
- C. NEMA C12.9 – Test Switches For Transformer-Rated Meters
- D. ANSI C12.10 – Watthour Meters
- E. ANSI C12.11 – Instrument Transformers for Revenue Metering, 10 kV BIL Through 350 kV BIL (0.6 kV NSV Through 69 kV NSV)
- F. ANSI C12.18 – Protocol Specification For ANSI Type 2 Optical Port
- G. ANSI C12.19 – Utility Industry End Device Data Tables
- H. ANSI C12.20 – Electricity Meters-0.2 and 0.5 Accuracy Classes
- I. ANSI C39.1 – Requirements, Electrical Analog Indicating Instruments
- J. IEEE C37.90.1 – Standard Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
- K. IEEE C57.13 – Standard Requirements for Instrument Transformers
- L. IEEE C62.11 – Metal-Oxide Surge Arresters for Alternating Current Power Circuits

- M. IEEE C62.41.1 – Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits
- N. IEEE C62.41.2 – Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits
- O. IEEE C62.45 – Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits
- P. NECA 1 – Standard Practices for Good Workmanship in Electrical Contracting
- Q. NECA 400 – Recommended Practice for Installing and Maintaining Switchboards
- R. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum)
- S. NEMA AB 1 – Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
- T. NEMA AB 3 – Molded-Case Circuit Breakers and Their Applications
- U. NEMA EI 21.1 – Instrument Transformers for Revenue Metering (110KV BIL and Less)
- V. NEMA KS 1 – Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
- W. NEMA LA 1 – Surge Arresters
- X. NEMA PB 2 – Dead-Front Distribution Switchboard
- Y. NFPA 70 – National Electrical Code
- Z. UL 50 – Standard for Enclosures for Electrical Equipment (1995)
- AA. UL 98 – Enclosed and Dead-Front Switches
- BB. UL 414 – Standard for Meter Sockets (1999)
- CC. UL 467 – Grounding and Bonding Equipment
- DD. UL 486A-486B – Wire Connectors
- EE. UL 489 – Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
- FF. UL 891 – Dead-Front Switchboards
 - 1. ASTM D1535 – Standard Practice for Specifying Color by the Munsell System

1.3 SUBMITTALS

- A. Product Data: For metering equipment, components and accessories indicated:
 - 1. Include data on features, components, and complete description; submit catalog cut sheets showing electrical characteristics and ratings.

2. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes. Describe operating sequences, both automatic and manual.
- B. Shop Drawings:
 1. Dimensioned plans and sections or elevation layouts.
 2. Wiring Diagrams: Power, signal, and control wiring. Identify terminals and wiring designations and color codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field installed wiring, and show circuit protection features.
- C. Manufacturer's Installation Instructions:
 1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- D. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
- E. Closeout Submittals:
 1. Project Record Documents:
 - a. Record actual locations and ratings of metering equipment on single-line diagrams and plan layouts.
 2. Operation and Maintenance Data:
 - a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
 - b. Include manufacturer's written instructions for testing.
 - c. Include spare parts data listing, source, and current prices of replacement parts and supplies.
 - d. Include manufacturer's Seismic Qualification Certification and Installation Seismic Qualification Certification.

1.4 QUALITY ASSURANCE

- A. Obtain metering equipment from one source and by single manufacturer.
- B. Regulatory Requirements:
 1. Comply with NFPA 70 for components and installation.
 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Receive, store, and handle modular meter center as specified in NECA 400. Use factory installed lifting provisions. Handle carefully to avoid damage to assembly internal components, enclosure, and finish.

1.6 WARRANTY

- A. Refer to Division 01 and Section 260000 - General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of final acceptance.

1.7 MAINTENANCE

- A. Extra Materials: Furnish extra materials described below that match product installed, are packaged with protective covering for storage, and are identified with labels describing contents.
 - 1. Potential Transformer Fuses: Equal to 10% of amount installed for each size and type, minimum of 2 of each size and type.
 - 2. Control-Power Fuses: Equal to 10% of amount installed for each size and type, minimum of 2 of each size and type.
 - 3. Fuses for Fused Switches: Equal to 10% of amount installed for each size and type, minimum of 3 of each size and type.

PART 2 - PRODUCTS

2.1 EQUIPMENT FOR OWNER ELECTRICAL METERING

- A. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
 - 1. Manufacturers:
 - a. Square D (Refer to Owner Preferred Brand Alternate)
 - b. General Electric
 - c. Siemens
 - d. Cutler-Hammer
 - e. Approved equal
 - 2. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
 - a. Phase Currents, Each Phase: +/-0.5%
 - b. Phase-to-Phase Voltages, Three Phase: +/-1%
 - c. Phase-to-Neutral Voltages, Three Phase: +/-1%
 - d. Megawatts: +/-2%
 - e. Megavars: +/-2%
 - f. Power Factor: +/-2%
 - g. Frequency: +/-0.5%
 - h. Megawatt Demand: +/-2%; demand interval programmable from 5 to 60 minutes

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- i. Accumulated Energy, Megawatt Hours: +/-2%. Accumulated values unaffected by power outages up to 72 hours
 - j. Maximum demand (measure of average power demand over a 15-minute period) continuously recorded over a one-year period.
 - k. Total Harmonic Distortion, Amperes
 - l. Total Harmonic Distortion, Volts
 - m. Individual Amperage Harmonics through the 63rd
 - n. Integral Communications Port
3. Mounting: Display and control unit flush or semiflush, mounted in instrument compartment door.

B. Instrumentation:

- 1. Manufacturers:
 - a. Square D
 - b. General Electric
 - c. Siemens
 - d. Cutler-Hammer
 - e. Approved equal
- 2. Instrument Transformers: NEMA EI 21.1, IEEE C57.13, and the following:
 - a. Potential Transformers: Secondary voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
 - 1) 600 V and below: external PTs not required; fused potential connection.
 - b. Current Transformers: Bar or Window type; ratios shall be as indicated with accuracy class and burden suitable for connected relays, meters, and instruments; shorting test blocks: 10 poles – 4 potential and 6 current, mounted with meter or in accessible location.
 - c. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kV.
 - d. 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.

C. Data Communications:

- 1. Means to transmit data to central control and monitoring system.
 - a. Digital communication port connection in IP compatible communication protocol to communicate with existing campus Schneider ION System via Ethernet.
 - b. Provide integration and programming to include all new meters into existing monitoring system.
 - c. Keypad and scrollable display for local reading of measured values.
 - d. Cat6 Connection to building data network for interfacing with ECU central campus Energy Management system.

PART 3 - EXECUTION

3.1 COORDINATION

- A. Mount meters in dedicated enclosures separate from switchboard and panelboard assemblies such that meter can be serviced without exposure to shock or arc flash hazards.
- B. Provide all work necessary to integrate meter data into existing campus Schneider ION system.
- C. Coordinate with miscellaneous trades for equipment foreign to electrical installation to be outside of dedicated electrical space.
- D. Verify with manufacturer that “touch-up” paint kit is available for repainting.
- E. Coordinate utility company metering equipment requirements.

3.2 EXAMINATION

- A. Examine areas and surface to receive modular meter center for compliance with requirements, installation tolerances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Verify that space indicated for modular meter center mounting meets code-required working clearances.
- C. Notify Architect/Engineer of any discrepancies prior to submittal of product data and shop drawings.

3.3 INSTALLATION

- A. Comply with installation requirements in NECA 1.
- B. Install engraved plastic nameplates under provisions of Section 260553 - Electrical Systems Identification for modular meter center, every instrument, overcurrent protective device, and disconnect device. Attach nameplate to exterior of modular meter center using small corrosion-resistant metal screws and rivets. Do not use contact adhesive. Indicate modular meter center manufacturer's name and drawing number, name, amperage, voltage, phase, number of wires, short circuit current rating (amp, RMS symmetrical and MVA three-phase symmetrical), and momentary and fault-closing ratings (amp, RMS asymmetrical). For each overcurrent protective device and disconnect device, include tenant name, load served, voltage/phase rating, and fuse size and type, when applicable.
- C. Tighten electrical connectors and terminal according to equipment manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

3.4 FIELD WIRING

- A. Install field wiring to complete the electricity metering installation.

3.5 CONNECTIONS

- A. Ground metering equipment according to Section 260526 - Grounding and Bonding for Electrical Systems.
- B. Connect power and control wiring according to Section 260519 - Low-Voltage Electrical Power Conductors and Cables.

3.6 FIELD QUALITY CONTROL

- A. Test continuity of each circuit.
- B. Test metering equipment per requirements in Sections 260812 - Power Distribution Acceptance Tests and 260813 - Power Distribution Acceptance Test Tables.
- C. Interpret test results in writing and submit to Engineer.
- D. Test Owner's electricity-metering installation for proper operation, accuracy, and usability of output data.
 - 1. Connect a load of known kilowatt rating, 1.5 hp minimum, to a circuit supplied by metered feeder.
 - 2. Turn off circuits supplied by metered feeder and secure them in off condition.
 - 3. Run test load continuously for 8 h, minimum, or longer to obtain a measurable meter indication. Use test load placement and setting that ensures continuous, safe operation.
 - 4. Check and record meter reading at end of test period and compare with actual electricity used based on test load rating, duration of test, and sample measurements of supply voltage at test load connection. Record test results.
 - 5. Repair or replace deficient or malfunctioning metering equipment, or correct test setup; then retest. Repeat for each meter in installation until proper operation of entire system is verified.
- E. Inspect modular meter center for physical damage, proper alignment, connections, anchorage, seismic restraints and grounding.
- F. Verify that correct multiplier is indicated on face of meter.
- G. Verify that current transformer secondary circuits are intact.
- H. Inspect indicating devices for proper operation.

3.7 REPAINTING

- A. Remove paint splatters and other marks from surface of equipment.
- B. Touch-up chips, scratches or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Owner.

3.8 ADJUSTING

- A. Adjustment and programming of metering equipment: By factory-authorized representative.

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- B. Compare meter display readings with readings taken with clamp on ammeter and handheld volt-meter.
- C. Make adjustments as necessary.

3.9 CLEANING

- A. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.

3.10 DEMONSTRATION

- A. Provide training session by manufacturer for up to 4 h at a job location, to train the Owner's personnel in the operation and maintenance of metering equipment.

END OF SECTION 262713

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Section includes general-use snap switches, wall-box dimmers, fan speed controls, receptacles, hazardous (classified) location receptacles, pendant cord-connector devices, cord and plug sets and device cover plates.

1.2 REFERENCE STANDARDS

- A. IEEE C62.41.2 – Characterization of Surges in Low-Voltage (1000V and less) AC Power Circuits
- B. IEEE C62.45 – Surge Testing for Equipment Connected to Low-Voltage (1000V and less) AC Power Circuits
- C. NECA 1 – Good Workmanship in Electrical Contracting
- D. NFPA 70 – National Electrical Code
- E. NFPA 99 –Health Care Facilities
- F. NEMA FB 11 – Plugs, Receptacles, and Connectors of the Pin and Sleeve Type for Hazardous Locations
- G. NEMA WD 1 – General Color Requirements for Wiring Devices
- H. NEMA WD 6 – Wiring Devices - Dimensional Requirements
- I. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum)
- J. UL 20 – General-Use Snap Switches
- K. UL 498 – Attachment Plugs and Receptacles
- L. UL 943 – Ground-Fault Circuit-Interruptioners
- M. UL 1203 – Safety Explosion-Proof and Dust-Ignition Proof Electrical Equipment for Use in Hazardous (Classified) Locations
- N. UL 1436 – Outlet Circuit Testers and Similar Indicating Devices
- O. UL 1449 – Transient Voltage Surge Suppressors
- P. UL 1472 – Solid-State Dimming Controls
- Q. UL 1917 – Solid-State Fan Speed Controls

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
- C. Samples: One for each type of device and wall plate specified, in each color specified.
- D. Manufacturer's Installation Instructions:
 - 1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- E. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
- F. Closeout Submittals:
 - 1. Project Record Documents:
 - a. Record actual locations and ratings of wiring devices.
 - 2. Operation and Maintenance Data:
 - a. Include in manufacturers' packing label warnings and instruction manuals with labeling conditions.
 - b. Include source and current prices of replacement parts and supplies.

1.4 QUALITY ASSURANCE

- A. Obtain wiring devices from one source and by single manufacturer.
- B. Regulatory Requirements:
 - 1. Comply with NFPA 70 for components and installation.
 - 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Maintain factory unopened packaging until ready for installation.

1.6 WARRANTY

- A. Refer to Division 01 and Section 260000 - General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of final acceptance.

1.7 MAINTENANCE

- A. Extra Materials: Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.
- B. Furnish 1 key for each keyed switch.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Cooper Wiring Devices; a division of Cooper Industries, Inc.
- B. Hubbell Incorporated; Wiring Device-Kellems
- C. Leviton Manufacturing Company, Inc.
- D. Pass & Seymour/Legrand; Wiring Devices & Accessories

2.2 GENERAL-USE SNAP SWITCHES

- A. Comply with NEMA WD 1 and UL 20.
- B. Switches: Heavy-duty (specification grade); back and side wired; flush or surface mounting; Body and Handle: thermoplastic with rocker handle; for connection to copper or copper-clad conductors:
 - 1. Ratings:
 - a. Voltage: 120-277V, AC
 - b. Current: 20 A
 - 2. Single pole
 - 3. Double pole
 - 4. Three-way
 - 5. Four-way
 - 6. Locator Light: Lighted handle type switch (single pole with red neon-lighted handle, illuminated when switch is "OFF.")
 - 7. Pilot Light: Indicator light switch (single pole with green neon-lighted handle, illuminated when switch is "ON.")
 - 8. Locking Type: Designed to prevent tampering and unauthorized switching.
 - 9. Key-Operated: Single pole, with factory-supplied key in lieu of switch handle.
 - 10. Single-Pole, Double-Throw, Momentary Contact, Center-Off: For use with mechanically held lighting contactors.
 - 11. Key-Operated, Single-Pole, Double-Throw, Momentary Contact, Center-Off: For use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.
 - 12. Weatherproof: Toggle switch

13. Dimmers are permitted to control lighting fixtures but not motorized loads or receptacles. Fan speed controls are listed for that application.
14. Special devices may be desirable to minimize buzzing at lights, radio frequency interference, or in the case of multiwire circuits with dimmers on multiple phases, and variation in brightness due to interaction through the grounded conductor.

2.3 WALL-BOX DIMMERS

- A. Comply with NEMA WD 1 and UL 1472.
- B. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.
 1. Power Rating: Match load shown on drawings watts minimum
 2. Body: Thermoplastic
 3. Control: Continuously adjustable slider; with single-pole or three-way switching.

2.4 RECEPTACLES

- A. Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
- B. Receptacles: 125 V, 20A, heavy-duty (specification grade); back and side wired; flush or surface mounted; straight blade; 2 pole, 3 wire grounding; thermoplastic body; duplex as indicated on drawings.
 1. Ground Fault Circuit Interrupter (GFCI):
 - a. Additional compliance with UL 943 Class A.
 - b. Leakage current trip level: 4 to 6 mA.
 - c. Trip time: .025 seconds nominal.
 - d. Feed- through type
 - e. Reverse line-load function to prevent GFCI from functioning if wired incorrectly.
 - f. Indicator Light: Lighted when device is tripped.
 2. Tamper Resistant (TR):
 - a. Requires insertion of object in both left and right contacts to energize.
 - b. 2- or 3-prong plug.
 3. Twist-locking:
 - a. NEMA WD 6 configuration As indicated on drawings.
 4. Switched: Upper half switched and lower half not switched.
 5. Special Purpose Receptacles: Specification grade, rated for voltage, amperage and NEMA configuration as noted on drawings.

2.5 DEVICE COVER PLATES

- A. Single and combination types to match corresponding wiring devices:
 1. Attachment: Metal screws with head color to match plate finish.
 2. Material for Finished Spaces: 0.035" thick, satin-finished stainless steel.
 3. Material for Unfinished Spaces: Galvanized steel.

4. Material for Damp Locations: Thermoplastic with while-in-use hinged cover, and listed and labeled for use in "wet locations".
- B. Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant , thermoplastic with weatherproof while-in-use hinged cover.
- C. Lockable Cover:
 1. Hinged steel cover with cylinder lock.
 2. Keyed master.
- D. Tamper Resistant (TR):
 1. Slide cover over receptacle.

2.6 FINISHES

- A. Color:
 1. Switch handles, receptacle faceplates, and device cover plates: WHITE, except as follows:
 - a. Switch handles and receptacle faceplates connected to Emergency or Standby Power System: Red; labeled "Emergency."

PART 3 - EXECUTION

3.1 COORDINATION

- A. Special Purpose Receptacles: Coordinate final selections of NEMA configuration (locking, straight, blade, etc.) with configuration of plug on utilization equipment.
- B. Receptacles for Owner-furnished equipment and equipment furnished under other divisions of specifications: Match plug configurations.
- C. Cord and Plug Sets: Match equipment requirements.
- D. Coordination with Other Trades:
 1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers guided by riding against outside of the boxes.
 2. 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.
 3. Install device boxes in brick or block walls so that the device cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.

3.2 EXAMINATION

- A. Verify location of wiring devices with architectural interior elevation drawings, prior to rough-in.
- B. Verify outlet boxes are installed at proper height.
- C. Verify wall openings are neatly cut and completely covered by wall plates.

- D. Verify wall openings for multiple devices in adjacent locations are aligned vertically and spaced horizontally in an even fashion, allowing for full faceplates to be installed with no overlap.
- E. Verify branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.

3.3 PREPARATION

- A. Clean debris from outlet boxes.

3.4 INSTALLATION

- A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise scheduled or indicated on drawings. Indicated dimensions are to center of device.
- B. Conductors:
 - 1. Do not strip insulation from conductors until just 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. Length of free conductors at outlets for devices shall meet provisions of NFPA 70 , Article 300, without pigtails.
 - 4. Do not place bare stranded conductors directly under device screws. Use crimp on fork terminals for device terminations.
- C. Device Installation:
 - 1. Replace all devices that have been in temporary use during construction or show signs of installation prior to completion of building finishing operations.
 - 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 last possible moment.
 - 4. Connect devices to branch circuits using pigtails that are not less than 6" in length.
 - 5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
 - 6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
 - 7. When conductors larger than #12 AWG are installed on 15A or 20A circuits, splice #12 AWG pigtails for device connections.
 - 8. Tighten unused terminal screws on the device.
 - 9. When mounting into metal boxes, remove fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.
 - 10. Install devices plumb, level with finished surfaces and free from blemishes.
 - 11. Install lighting switches vertically on latch side of door within 6" of frame edge.
 - 12. Install devices above counters, 2" to the bottom of device above countertop or backsplash. Install all devices at same height above any one counter or fixed cabinet.

13. Install special purpose receptacles and switches according to shop and rough-in drawings furnished by trade(s) producing such equipment. Verify locations prior to rough-in.
 14. Install weatherproof GFCI receptacles:
 - a. Within 25'-0" of roof-mounted mechanical equipment
 - b. Outdoors
 - c. As indicated on drawings
 15. Group adjacent switches under single, multigang wall plates.
 16. Connect wiring device grounding terminal to outlet box with bonding jumper and branch circuit equipment grounding conductor. Ground per requirements in Section 260526 - Grounding and Bonding for Electrical Systems.
- D. Installation Orientations:
1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.
 2. Install switches with handle operating vertically, with "ON" position up.
 3. Unless otherwise indicated or where space problem occurs, mount devices flush, with long dimension vertical.
- E. Device Cover Plates: 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.
- F. Wall-Box Dimmers:
1. Install dimmers within terms of their listing.
 2. Verify that dimmers used for fan speed control are listed for that application.
 3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.
- G. Arrangement of Devices:
1. Unless otherwise indicated or where space problem occurs, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

3.5 IDENTIFICATION

- A. Comply with Section 260553 - Electrical Systems Identification.
1. Switches and Receptacles: Use hot, stamped or engraved machine printing with black-filled lettering on face of cover plate, and durable wire markers or tags inside outlet boxes.
 - a. Receptacles: Label shall indicate receptacle voltage, phase, and amperage for receptacles other than 20A, 120 V, at top of cover plate, and panel and circuit number at bottom of cover plate.
 - b. Switches: Label shall indicate switch voltage, phase, and amperage at top of cover plate, and panel, circuit number and switch designation at bottom of cover plate.

2. Engrave cover plates on all Owner-furnished equipment and equipment furnished under other divisions of these specifications with panelboard, circuit number and "emergency" (where applicable) as specified in this section. This includes headwalls, gas columns and booms, patient consoles, medical rail systems, custom casework with electrical devices, etc.

3.6 FIELD QUALITY CONTROL

- A. Inspect wiring devices for defects.
- B. Operate wall switches with circuits energized and verify proper operation.
- C. Verify receptacle device is energized.
- D. Perform tests and prepare test reports:
 1. Test receptacle devices for proper polarity:
 - a. Test every receptacle with receptacle circuit tester. Tester shall test for open ground, reverse polarity, open hot, open neutral, hot and ground reversed, hot or neutral and hot open. Rewire receptacles with faults and retest.
 2. Test each GFCI receptacle device for proper operation:
 - a. Perform testing using an instrument specifically designed and manufactured for testing ground-fault circuit interrupters. Apply the test to the receptacle. "TEST" button operation will not be acceptable as a substitute for this test. Replace receptacles that do not shut off power with 5/1000 A within 1/40 second and retest.
 3. Test Instruments: Use instruments that comply with UL 1436.
 4. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.
- E. Tests for Convenience Receptacles:
 1. Line Voltage: Acceptable range is 105 V to 132 V.
 2. Percent Voltage Drop under 15A Load: A value of 5% or higher is not acceptable.
 3. Ground Impedance: Values of up to 2 ohms are acceptable.
 4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
 5. Using the test plug, verify that the device and its outlet box are securely mounted.
 6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.
- F. Operational Tests: Demonstrate the operation of each switch with the systems fully energized and operating. Each switch shall be demonstrated three times.
- G. Interpret test results in writing and submit to Engineer.

3.7 ADJUSTING

- A. Adjust devices and wall plates to be flush and level.

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3.8 CLEANING

- A. Remove excess plaster from interior of outlet boxes.
- B. Clean devices and cover plates after painting is complete. Replace stained or improperly painted devices and cover plates.

END OF SECTION 262726

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Section includes fusible and non-fusible disconnect switches and circuit breakers in individual enclosures.

1.2 REFERENCE STANDARDS

- A. ANSI/NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting
- B. NEMA AB 1 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breakers Enclosures
- C. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
- D. NFPA 70 - National Electrical Code
- E. UL 98 - Enclosed and Dead Front Switches
- F. UL 486A-486B - Wire Connectors
- G. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
- H. UL 869A - Reference Standard for Service Equipment

1.3 SUBMITTALS

- A. Product Data:
 - 1. Submit catalog cut sheet indicating voltage, amperage, HP ratings, enclosure type, and dimension, fuse clip features, terminal lugs and all accessories including interlock devices, short circuit current ampere rating and factory settings of individual protective devices.
- B. Manufacturer's Installation Instructions:
 - 1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- C. Test Reports:
 - 1. Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
- D. Closeout Submittals:
 - 1. Project Record Documents:
 - a. Record actual locations of disconnect switches and ratings of installed fuses.

- b. Record actual locations and continuous current ratings of enclosed circuit breakers.
- 2. Operation and Maintenance Data:
 - a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
 - b. Include spare parts data listing, source, and current prices of replacement parts and supplies.
 - c. Include Manufacturer's Seismic Qualification Certification and Installation Seismic Qualification Certification.

1.4 QUALITY ASSURANCE

- A. Obtain disconnect switches and enclosed circuit breakers from one source and by single manufacturer.
- B. Regulatory Requirements:
 - 1. Comply with NFPA 70 for components and installation.
 - 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.
- B. Comply with manufacturer's written instructions.

1.6 WARRANTY

- A. Refer to Division 01 and Section 260000 - General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of final acceptance.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Schneider Square D
- B. ABB-GE Industrial Solutions
- C. Eaton Cutler-Hammer
- D. Siemens

2.2 DISCONNECT SWITCHES

- A. NEMA KS 1, UL 98

- B. Load interrupter enclosed knife switch, heavy-duty type.
- C. Fusible or non-fusible type as indicated.
- D. Switch Interiors:
 - 1. Switch blades that are visible in “OFF” position when switch door is open.
 - 2. Plated current carrying parts.
 - 3. Removable arc suppressors to permit easy access to line side lugs.
- E. Switch Mechanism:
 - 1. Quick-make, quick-break, with visible blades and externally operable handle.
 - 2. Lockable only in “OFF” position and accept three industrial type, heavy-duty padlocks.
 - 3. Dual cover interlock to prevent unauthorized opening of switch door when handle is in “ON” position, and to prevent closing of switch mechanism with door open.
 - 4. Defeater mechanism to bypass interlock.
 - 5. Operating handle integral part of enclosure.
 - 6. Handle to physically indicate “ON” and “OFF” position.
- F. Ratings:
 - 1. Ampacity as indicated on drawings.
 - 2. Horsepower rated.
- G. Provide viewing window positioned over blades to allow visual verification of the ON-OFF status.

2.3 ENCLOSED CIRCUIT BREAKERS

- A. NEMA AB 1, UL 489.
- B. Enclosed molded-case circuit breakers:
 - 1. Tripped indication clearly shown on breaker handle taking position between “ON” and “OFF”.
 - 2. 225A frame size and below: thermal-magnetic trip.
 - 3. 250A frame size and above: electronic (solid-state microprocessor-based) trip units interchangeable in the field within the frame size and field-adjustable current settings. Each adjustment shall have discrete settings and shall be independent of other adjustments.
- C. Breaker Mechanism:
 - 1. Quick-make, quick-break.
- D. Ratings:
 - 1. Ampacity as indicated on drawings.
 - 2. Listed as Type HACR for air conditioning equipment circuits.
 - 3. Listed as Type SWD for lighting circuits.

2.4 LUGS

- A. Front removable lugs.
- B. Labeled for 75°C copper and aluminum conductors.
- C. Multiple lugs to match number of conductors per phase.
- D. Termination of field installed conductors: Pressure wire connectors, except wire-binding screws for #10 AWG or smaller conductors.

2.5 ACCESSORIES:

- A. Solid neutral assembly, where required.
- B. Equipment ground kit.

2.6 ENCLOSURES

- A. NEMA KS 1, NEMA AB 1, UL 98, UL 489, as applicable.
- B. NEMA Type 1, Type 3R (outdoor locations) _____ enclosure.
- C. Code-gauge galvanized steel.
- D. Manufacturer's standard gray enamel finish over prime coat.
- E. Surface-mounted. .

2.7 SERVICE ENTRANCE

- A. UL 869A
- B. Switches and circuit breakers identified for use as service entrance equipment are to be labeled for this application, provided with solid neutral assembly and equipment ground bar, and must include connection for bonding and grounding of neutral conductor.

2.8 SHORT CIRCUIT CURRENT RATING

- A. Each circuit breaker shall have minimum short circuit current rating as indicated on drawings.

PART 3 - EXECUTION

3.1 COORDINATION WITH MANUFACTURER

- A. Instruct manufacturer about the location of incoming lugs, i.e., top or bottom feed based on incoming feeder entrance location.
- B. Verify that "touch-up" paint kit is available for repainting.

3.2 EXAMINATION

- A. Examine areas and surface to receive disconnect switches and enclosed circuit breakers for compliance with requirements, installation tolerances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Verify that space indicated for disconnect switches and enclosed circuit breakers mounting meets code-required working clearances.
- C. Notify Architect/Engineer of any discrepancies prior to submittal of product data and shop drawings.

3.3 INSTALLATION

- A. Install disconnect switches and/or enclosed circuit breakers in accordance with ANSI/NECA 1.
- B. Install disconnect switches and/or enclosed circuit breakers level and plumb, in accordance with manufacturer's written instruction.
- C. Disconnect switches and enclosed circuit breakers mounting and seismic restraints:
 - 1. Fasten disconnect switches and enclosed circuit breakers firmly to walls and structural surfaces, ensuring they are permanently and mechanically anchored.
 - 2. Anchor and fasten disconnect switches and enclosed circuit breakers and their supports to building structural elements (wood, concrete, masonry, hollow walls and nonstructural building surfaces) by the methods described in Section 260529 - Hangers and Supports for Electrical Systems.
 - 3. Install two rows of steel slotted channel, with a minimum of four attachment points, for each disconnect switch and enclosed circuit breaker.
 - 4. When not located directly on wall, install support frame of steel slotted channel anchored to floor and ceiling structure.
- D. Do not support disconnect switches and/or enclosed circuit breakers by raceway.
- E. Install top disconnect switch and/or enclosed circuit breaker handle a minimum of 3'-6" and maximum of 6' 6" above finished floor.
- F. Tighten electrical connectors and terminals according to equipment manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- G. Install engraved plastic nameplates under provisions of Section 260553 - Electrical Systems Identification. Attach nameplate to exterior of each switch and/or enclosed circuit breaker using small corrosion-resistant metal screws or rivets. Do not use contact adhesive.
 - 1. Include switch and/or enclosed circuit breaker name, amperage, voltage, phase, and number of wires.
- H. Install fuses in fusible switches at job site per requirements in Section 262813 - Fuses.

3.4 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.

3.5 FIELD QUALITY CONTROL

- A. Inspect for physical damage, proper alignment connections, anchorage, and grounding.
- B. Correct malfunctioning units on-site and retest to demonstrate compliance. Remove and replace with new units and retest.
- C. Test disconnect switches and/or enclosed circuit breakers per requirements in Sections 260812 - Power Distribution Acceptance Tests and 26 0813 – Power Distribution Acceptance Test Tables.
- D. Interpret test results in writing and submit to Engineer.

3.6 REPAINTING

- A. Remove paint splatters and other marks from surface of equipment.
- B. Touch-up chips, scratches, or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Owner.

3.7 ADJUSTING

- A. Circuit Breakers: Set field-adjustable trip settings or change the trip settings recommended by the overcurrent protective device coordination study per Section 260573 - Power System Studies.

3.8 CLEANING

- A. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.

END OF SECTION 262816

SECTION 263213 - ENGINE GENERATORS

PART 1 - GENERAL

1.1 DESCRIPTION OF SYSTEM

- A. Section describes complete package generator set, unit-mounted radiator cooling system, , microprocessor based control and monitoring panel, battery and charger, Building Management System (BMS) communications module, remote annunciator, and custom walk-in weather protective sound attenuated enclosure .
- B. Package generator set rated for emergency.
- C. Engine fuel system:
 - 1. Sub-base fuel tank
- D. Engine generator serves a Fire Pump system. Provide generator system that meets requirements of NFPA 20, including the requirement to run and continue to produce rated nameplate power without shutdown or deratings for alarms and warnings or failed engine sensors, except for overspeed shutdown.
 - 1. This operating condition shall be active only when the fire pump controller has indicated a loss of normal power. Generator safeties shall remain in place when fire pump is manually started for testing.
- E. ECU utilized remote monitoring of generator status. Provide 4#14 conductors (two red, two black) from a junction box beside generator remote annunciator and generator controller. Wiring will be used by ECU's OFOI system to monitor system Run and Fault status.

1.2 REFERENCE STANDARDS

- A. NEMA MG 1 – Motors and Generators
- B. IEEE 446 – Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
- C. NFPA 37 - Standard for Installation and Use of Stationary Combustion Engines and Gas Turbines
- D. NFPA 110 – Standard for Emergency and Standby Power Systems
- E. UL 2200 – Stationary Engine Generator Assemblies
- F. IEC8528 Part 4 – Control Systems for Generator Sets
- G. UL 142 – Steel Aboveground Tanks for Flammable and Combustible Liquids
- H. UL 2085 – Protected Aboveground Tanks for Flammable and Combustible Liquids

1.3 SUBMITTALS

- A. Shop Drawings

1. Submit for engineering review and approval prior to production release. Include the following for engine-generator:
 - a. Outline drawings of equipment showing weights
 - b. Overall dimensions including bolting template and earthquake restraints
 - c. Right hand, left hand, end, and top views of proposed assembly
 - d. Battery, battery rack, battery charger, and wiring diagrams
 - e. Vibration isolation bases, mounts, and hangers
 - f. Exhaust silencer and flexible fittings
 - g. Stub ups for fuel
 - h. Power and control wiring entrance locations
 - i. Main circuit breaker size, location, and required clearance
 - j. Lug sizes and locations
 - k. Engine-generator control panel drawings showing devices to be provided, with each device referenced to material list with complete description for device.
 - l. Weather protective enclosure installation drawings, structural calculations, lighting fixture catalog cut, conduit, and wiring.
 - m. Enclosure sound performance data
 - n. Muffler characteristics
 - o. Calculations for starting based on step loads outlined in Paragraph 2.2, B.5.
 - p. Factory certified prototype test report indicating fuel efficiency and emission levels
2. Information on engine characteristics:
 - a. Make, type, and number of cylinders
 - b. Brake horsepower (bhp) available
 - c. Jacket water heat rejection
 - d. Cooling pump characteristics
 - e. Exhaust flow rate and temperature at 25, 50, 75, and 100% rated load
 - f. Ventilation requirements
 - g. Combustion air requirements
 - h. Fuel consumption rates at 25, 50, 75, and 100% rated load
 - i. Liquid refill capacities
 - j. Exhaust backpressure limitation
 - k. Type and manufacturer of governor
 - l. Alternator size to limit voltage dip to 10%
3. Information on generator characteristics:
 - a. Make and type
 - b. Type of construction and overspeed capabilities
 - c. Temperature rise
 - d. Regulation characteristics
 - e. Ventilation requirements
 - f. Type of winding insulation

- g. KW power factor
 - h. Type of exciter and voltage regulator
- 4. Manufacturer seismic qualifications: Submit certification that , engine-generator set, batteries, battery rack, accessories, and components will withstand seismic forces defined in Section 260548 - Vibration and Seismic Controls For Electrical Systems.
- B. Interconnection detail drawing showing control and power connections in complete standby system. Control connections between components are to be labeled with identical nomenclature. Coordinate with generator manufacturer.
- C. Accessories including fuel lines, flexible exhaust couplings, exhaust flange, and other exhaust system components.
- D. Complete review of this specification, noting for each paragraph whether or not proposed equipment complies with project specifications, or deviates in some fashion. Justification must be provided for each deviation.
- E. Complete test specification detailing testing procedure to be used to verify performance of equipment provided.
- F. Recommended spare parts lists.
- G. Test Reports:
 - 1. Submit certified factory tests report on engine-generator delivery. Alarms, sensors, and meters must be tested and certified.
 - 2. Submit, upon completion of installation and testing of engine-generator sets, certified test reports from load tests for each engine-generator.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Handle equipment in accordance with manufacturer's written instructions. One copy of instructions is to be included with equipment at time of shipment. Maintain factory bracing, packaging, and wrapping.

1.5 OPERATION AND MAINTENANCE MANUALS

- A. Refer to Section 017700 - Closeout Procedures and herein below.
- B. Submit Operation and Maintenance (O&M) manuals to Engineer for review 60 days prior to acceptance of unit.
- C. Installation, maintenance, and operating instruction manuals shall include the following:
 - 1. 100% accurate system "as-installed" drawings, interconnect diagrams, schematic diagrams, wiring diagrams, individual sub-system component manuals, operation procedures, system description with theory of operation, maintenance schedules and procedures, original programmed settings and parameters, and other information necessary for the Owner to maintain, operate, test, and troubleshoot system.

2. The O&M manual shall contain step-by-step instructions for startup and shutdown. The first page shall contain name, address, and phone number of local representative to be called for service or parts. Follow with complete parts lists by actual ordering catalog numbers. O&M manual also shall contain four copies each of test record forms and service record forms for Owner use. Forms shall show proper interval for testing, servicing, and replacing of components, lubrication, filters, antifreeze, etc., including recommended specifications and fluid levels for lubricants.
3. Recommended spare parts list (with pricing) for 2 yrs of operation.
- D. O&M manuals shall not solely rely on sub-component manuals. Thorough consolidation of operating and maintenance information shall be available in system overview guide. Include major components of system in overview.
- E. Turn final reviewed manuals over to Owner prior to conducting training of Owner personnel.
- F. Seal single copy of service record forms, recommended operation and service practices for unit in plastic and wall mount in weather-protective enclosure.

1.6 WARRANTY

- A. The emergency generator, transfer switches and associated equipment shall be warranted by the manufacturer for a period of five (5) years, from the date of final inspection and acceptance. The warranty shall be included in the contract document. The warranty shall include all parts, labor (including travel), expenses and equipment necessary to perform replacement and/or repairs.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Acceptable Manufacturers:
 1. Engine Generator Set - Caterpillar, Cummins, Kohler
 2. Exhaust Silencer – Maxim, Nelson, or approved equal
 3. Isolation equipment
 4. Battery charger – Sens, La Marche, Charles Industries

2.2 RATINGS AND PERFORMANCE

- A. Engine Generator Set
 1. Generator kW Output: As shown on drawings
 2. Altitude 500 feet above sea level in ambient temperature of 90°F.
 3. Stable frequency regulation
- B. Alternator
 1. As shown on drawings kVA, .8 Power Factor
 2. 480 V, 3 Ph, 60 Hz, 4 Wire Y
 3. Stable voltage regulation 0-full load less than or equal to $\pm .5\%$.

C. Transient Performance

1. Engine
 - a. Start and load in 10 seconds per NFPA 110
 - b. Accept 100% block load per NFPA 110
2. Frequency regulation $\pm 5\%$ no load to full load. $\pm .5\%$ steady state.
3. Alternator
 - a. AC waveform output contains $<5\%$ total harmonic distortion (THD) at full linear load when measured from line to neutral with $<3\%$ in any single harmonic, and no third-order harmonics or their multiples.
 - b. Telephone influence factor < 40
 - c. Telephone harmonic factor < 3

D. Factory Prototype Test Certified

1. Harmonic Distortion Levels
 - a. Demonstrate
2. Airflow Restriction tests
 - a. Demonstrate controlled shutdown after overheating
3. Unit tested with enclosure
 - a. UL 2200 listed
4. 30 Degree Water Spray Unit Rain Test
 - a. Demonstrate no water leakage into electrical boxes
5. Air Filter Test
 - a. Demonstrate engine contains engine backfire explosion

E. Factory Production Test Certified

1. Alternator Impedance to Ground
2. Dielectric Testing
 - a. At 1000 V and 2 times rated voltage
3. Maximum kW Rating
4. Engine Response Time
5. Alternator Construction Testing
 - a. Impedance Balance Tested
6. Alternator Insulation Testing
 - a. Surge Tested

2.3 FABRICATION AND MANUFACTURER

A. Engine:

1. Type: Inline or vee
2. Four-stroke cycle diesel compression ignition at 1800 RPM consistent with engine durability.
3. Aspiration: Natural

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4. air cooled
5. Fuel Type: No. 2 domestic diesel fuel oil.
6. Engine accessories:
 - a. Fuel filter
 - b. Lube oil filter
 - c. Intake air filter
 - d. Lube oil cooler
 - 1) Suitable for operation of generator set at full rated load in ambient temperature specified.
 - e. Fuel transfer pump
 - f. Fuel priming pump
 - 1) Engine driven positive displacement, mechanical, full pressure
 - g. Gear driven water pump
 - h. Electronic direct fuel injection or have suitable emission control equipment
 - i. Electric speed sensing governor capable of isochronous regulation.
 - j. Safety-shut-offs for:
 - 1) High water temperature
 - 2) Low oil pressure
 - 3) Overspeed
 - 4) Overcranking
7. EPA Certified Tier 2

B. Cooling System:

1. Engine skid mounted, engine-driven radiator with blower type fan, sized to maintain safe operation at 122°F ambient temperature.
2. Provide radiator with:
 - a. Motor-driven fan with voltage same as generator
 - b. Motor Starter
 - c. Initiating contacts to actuate on generator startup
 - d. Connect to generator distribution system
 - e. Core guard
 - f. Fan guard
 - g. Mounting hardware
 - h. Direct adapter flange. Ductwork with flexible connection between radiator and exhaust plenum to be provided by Division 23. Coordinate with Division 23.
 - i. Flexible pipe connections at engine and radiator.
 - j. Supply power for fans and pumps on remote radiators from a tap at generator output terminals or ahead of first load circuit overcurrent protective device.
 - k. Heat exchangers
3. Block Heater
 - a. Water Jacket Heater: Circulating

- b. Maintain engine jacket water to 110°F in ambient temperature of 30°F
 - c. Heater to be equipped with thermostatic switch.
 - d. Single phase 208 V
 - e. Provide two heaters, 4500 W each minimum.
- 4. Fill engine cooling system with solution of 50/50 mix ethylene glycol at initial fill.
 - 5. Ductwork with flexible connection between radiator and exhaust dampers to be provided by others. Refer to Section 23 3113 – Facility Fuel Oil Piping.

C. Exhaust System:

- 1. Furnish critical type exhaust silencer:
 - a. Sized according to manufacturer's recommendations
 - b. Mount so weight is not supported by engine
 - c. Flexible exhaust fitting
 - d. Installation inside drop over enclosure
 - e. Refer to Section 23 2113 – Hydronic Piping
- 2. Condensate Traps
 - a. Drain plug at low point of muffler
- 3. Thermal Expansion
 - a. Stainless steel exhaust flex to accommodate thermal growth and vibration isolation
- 4. Exhaust Blankets
 - a. 1" high temperature fiberglass cloth wrap
 - b. Coordinate with weather protective enclosure.
- 5. Thimble
 - a. Pipe and wall of compatible construction
- 6. Acceptable Back Pressure
 - a. Size silencer and exhaust pipe so exhaust back pressure does not exceed maximum limitations specified by generator set manufacturer.
- 7. Exhaust clearing area

D. Starting System

- 1. Provide DC electric starting system with positive engagement drive. Provide DC voltage recommended by manufacturer.
- 2. Provide fully automatic start-stop controls.
- 3. Provide cycle cranking to open and lock out start circuit after 3 attempts to start failed engine start.
- 4. Batteries
 - a. Provide sealed lead-acid storage battery set:
 - 1) Heavy duty diesel starting type
 - 2) Voltage compatible with starting system voltage
 - 3) Capacity to provide for 1-1/2 minutes total cranking time at 0°F without recharging. In accordance with NFPA Level 1.
 - b. Provide vinyl coated steel battery rack.

- c. Provide starting battery heater:
 - 1) Heater plate under battery
 - 2) Heater type blanket around battery case
 - 3) Thermal switch - heater control relay
 - 4) 120 VAC input
 - d. Battery cables and clamps
 - 5. Battery Charger
 - a. Four Rate Battery Charger
 - 1) Constant current, constant voltage, high rate taper, and float equalized.
 - b. Dual Rate Battery Charger
 - 1) Constant current, and float equalized
 - c. Charger Accessories:
 - 1) Overload protection
 - 2) $\pm 1\%$ line and load regulation
 - 3) Electronic current limit output 105%
 - 4) DC ammeter and voltmeter digital meter with $\pm 2\%$ volt accuracy, $\pm 5\%$ amp accuracy.
 - 5) UL 1236 listed and meets NFPA 110 requirements
 - 6) Output protection
 - 7) Temperature compensation
 - 8) Enclosed in NEMA 1 aluminum or stainless steel enclosure
 - 9) Form C contacts for the following alarms
 - a) AC fail
 - b) Low battery volts
 - c) High battery volts
 - d) Charger fail
 - e) Battery fault
 - 6. AC input voltage: 208 V
 - 7. When installed on the engine generator set, mount on vibration isolators.
- E. Speed Control
- 1. Electronic: Isochronous
- F. Alternator:
- 1. Maximum temperature rise 275°F at 104°F ambient
 - 2. Synchronous type
 - 3. Self ventilated
 - 4. Drip-proof construction
 - 5. Directly connected to engine flywheel housing with a flex coupling
 - 6. Capable of sustaining 300% overcurrent for 10 seconds under a 3 Ph symmetrical short circuit

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7. 120 V Anti-Condensation heater
8. Subtransient Reactance limited to 12%
9. Insulation
 - a. Complies with NEMA (MG1-33.4)
 - b. Class H Insulation Systems
 - 1) UL 1449 recognized
 - 2) Vacuum impregnated with epoxy varnish
 - 3) Fungus resistant
10. Permanent magnet brushless excitation (PMG).
 - a. PMG shall derive excitation current from pilot exciter mounted on the rotor shaft. It is to be able to sustain 300% of rated current for ten seconds during a fault condition.
11. Rotor
 - a. 4 pole
 - b. Winding
 - 1) Wet layer wound
 - c. Varnish process
 - 1) Epoxy based material applied to each layer of magnet wire
 - d. Coil supports
 - 1) Driven through flexible coupling to ensure permanent alignment.
 - e. End winding spacing
 - f. Amortisseur windings
 - g. Bearings
 - 1) Regreasable
 - 2) Double
12. Stator
 - a. 3 Ph winding
 - b. Laminations
 - c. Cooling air passages and fan
 - 1) Provide space heater to keep alternator free of moisture. Space heater to be 1500 W, 120 VAC, 1 Ph.
 - d. Welded laminations to prevent cutting of wires
 - e. Skewed stack to minimize slot ripple on output voltage and produce smooth voltage waveform.
 - f. Pitch – Skewed design to optimize efficiency and minimize total harmonic distortion.
 - g. Varnish process
 - 1) 2 dips and bakes using Class A impregnating varnish
13. Alternator Components
 - a. Output Circuit Breaker(s)
 - 1) 1 100% insulated case rated circuit breaker

- 2) Adjustable long time, long time delay, short time, and short time delay curve shaping elements
- 3) Shunt Trip for integration with load bank controls
- 4) Solid state trip fixed mounted insulated case generator mounted circuit breaker
- 5) NEC required access in front of breaker

G. Controls:

1. NFPA 110 listed
2. Micro-processor based solid state controls to automatically start, protect and monitor engine-generator set with panel illuminating lighting and digital display.
3. Control panel includes:
 - a. Solid state trip main circuit breaker
 - b. Motor starting switch
 - c. Electrically operated fuel control
 - d. Relay to disconnect battery charger during cranking
 - e. Switching lamps and meters to be oil tight and dust tight. All active components to be installed within a NEMA 3R enclosure. There shall be no exposed components with door open operating 750 V.
 - f. Protective relays to open main circuit breaker and shut down and lockout engine on abnormal conditions including:
 - 1) Overspeed
 - 2) Operation of Remote Stop
 - 3) Overcrank alarm only when generator serves a fire pump
 - 4) Low lube oil pressure alarm only when generator serves a fire pump
 - 5) High Engine Temp alarm only when generator serves a fire pump
 - 6) Low coolant level
 - 7) Fail to crank
 - 8) Dead battery
 - g. Monitoring items shall include but is not limited to the following items and control:
 - 1) Coolant temperature
 - 2) Oil pressure
 - 3) Battery voltage
 - 4) RPM
 - a) Voltmeter, 3-1/2" dual type, 0.5% accuracy with selector switch
 - b) Ammeter, 3-1/2" dual type, .05% accuracy with selector switch
 - 5) Frequency meter, 55-65 Hz ± 0.125 Hz.
 - 6) Running Time Meter (hours and 1/10 hours)
 - 7) AC power metering to be 0.5% accuracy and include frequency, phase, selector switch with real time power metering including, kW, kVA, kVAR, kWh, PF, % of rated load.
 - h. Control Items:

- 1) Voltage level adjustment rheostat
 - 2) Overspeed level adjustment
 - 3) Overvoltage level adjustment
 - 4) Undervoltage level adjustment
 - 5) Overfrequency level adjustment
 - 6) Underfrequency level adjustment
 - 7) Position function switch(es) marked AUTO, MANUAL RUN, OFF/RESET and STOP
 - 8) 4 NO and 4 NC dry contacts for local and remote alarms, wired to terminal strips.
 - 9) Emergency off mushroom button
 - 10) Automatic remote start capability. Engine cranking system to permit minimum 4 cranking attempts of 10 seconds (adjustable) duration with rest of periods of 10 seconds (adjustable).
 - a) Overcrack lockout shall occur after 4 cranking attempts.
- i. In accordance with NFPA 110, Level 1, control panel shall furnish battery-powered individual visual alarm indicator functions at battery voltage and visual and audible pre-alarm:
- 1) Overcrank
 - 2) Low water temperature
 - 3) High engine temperature pre-alarm
 - 4) High engine temperature
 - 5) Low lube oil pressure pre-alarm
 - 6) Low lube oil pressure
 - 7) Overspeed
 - 8) Low fuel main tank
 - 9) Low coolant level
 - 10) EPS supplying load
 - 11) Control switch not in automatic position
 - 12) High battery voltage
 - 13) Low cranking voltage
 - 14) Low voltage in battery
 - 15) Battery charger ac failure
 - 16) Lamp test
 - 17) Contacts for local and remote common alarm
 - 18) Low starting air pressure
 - 19) Low starting hydraulic pressure
- j. Engine shut down, with audible alarm:
- 1) Low oil pressure
 - 2) High engine temperature
 - 3) Overcrank
 - 4) Overspeed

- k. Status report:
 - 1) Engine running
 - 2) Circuit breaker open
 - 3) Circuit breaker closed
- 4. Visual alarm resettable only after fault condition has been corrected.
- 5. Audible alarm shall include silencing circuit, which, after activation, will permit annunciation of subsequent failures.
- 6. Control Panel mounting:
 - a. Mounted on engine generator set in NEMA 1 enclosure on shock isolators
 - b. Wall mounted in NEMA 1 enclosure
 - c. Free standing in NEMA 1 enclosure
- 7. Provide remote annunciator panel
 - a. Compliant with NFPA Level 1 requirements.
- H. Isolate engine generator set from building structure and from connecting services.
 - 1. Separately derived grounding system. Connect generator ground as shown on drawings to grounding electrode system.
- I. Termination Bars and Connections:
 - 1. Silver- or tin-plated copper bus bars for terminating cables.
 - 2. Standard NEMA standard bolt hole spacing, for 3 Ph and neutral, within generator connection box with gasketed bolt on cover.
 - 3. Engine-generator set control interfaces to other system components to be made on a permanently labeled terminal block assembly. Provide labels describing connection points.
 - 4. Connections to engine-generator set: Flexible or isolation type connections. Include electrical, fuel, exhaust, and ventilation connections.
- J. Equipment Bases:
 - 1. Mount complete unit on a structural steel sub-base, rectangular in shape, with sufficient rigidity to maintain alignment of generator set. Provide perimeter beams with minimum depth equal to 1/10 of longest dimension of base, except beam depth need not exceed 14" provided that deflection and misalignment are kept within acceptable limits as determined by manufacturer. Engine-generator set to be statically and dynamically balanced at factory. Peak-to-peak amplitude of vibration velocity in horizontal, vertical, and axial direction shall not exceed 0.65" per second at main structural components.
 - 2. Engine-generator set weight distribution is to be considered to provide uniform deflections.
 - 3. Bases shall provide equipment alignment and assure uniform weight distribution. Provide side brackets on bases to contain isolating mounts and reduce total installed heights of equipment.
- K. Vibration Isolators:
 - 1. Prevent equipment vibrations from being transmitted to enclosure.
 - 2. Required between the structural steel sub-base and concrete housekeeping pad.

3. Steel or cast iron top and bottom housings incorporating 1 or more steel springs with built-in leveling bolts and built-in resilient chocks to control oscillation and withstand lateral forces in all directions.

L. Outdoor Weather Protective Drop-Over Enclosure:

1. Rated NEMA 3R
2. Attenuation:
 - a. Provide engine-generator set with sound-attenuated enclosure. Enclosure will reduce sound level of engine-generator set while operating at full rated load and ventilation running to maximum of 85 dBA at 3 ft or 77 dBA at 21 ft from engine-generator set in free-field environment.
3. Overall Size:
 - a. Drawings show generator footprint, which is maximum allowed for available space.
 - b. Air intake requirements are to be taken into consideration and shall not prevent enclosure from operating within space limitations indicated above.
4. Construction:
 - a. Construction to be aluminum.
 - b. Package listed to UL 2200
 - c. Lockable doors
 - d. Minimum 100A accessory distribution panel to power items listed in Paragraph 2.3.L.a.
 - e. Interior lights
 - f. Remote mounted emergency stop button
 - g. Lifting lugs
 - h. Refer to Paragraph 2.3.N for fuel system.
5. Ventilation:
 - a. Intake: Complete with gravity damper, hood with silencer, flex connections, and 1/2" x 1/2", 16 ga galvanized bird screen to protect against ice and snow.
 - b. Discharge: Complete with gravity-type damper with discharge duct, hood with silencer, flex connector, and 1" x 1/2", 16 ga galvanized bird screen.
6. Paint:
 - a. Clean surfaces to SSPC-SP1, seal seams, prime with industrial phenolic primer to 1.5 mils D.F.T. Top coat exterior with Clovacoat epoxy enamel to 2.0 mils D.F.T.
7. Power Coat Paint. Selections to include white, beige, ASA61 gray, and manufacturer factory standard. Architect to select.

M. Fuel System

1. Sub-base Fuel Tank and Appurtenances
 - a. Capacity: as required to provide 72 hours run-time at 100% of generator rated output.
 - b. Rating: UL 142 Listed
 - c. Double Wall Construction
 - d. Flex fuel lines (NFPA 110 construction)
 - e. Epoxy lined to prevent corrosion

- f. Tank Exterior: Chemically treated, primed, and painted in factory standard.
- g. Tank Accessories
 - 1) Overfill prevention valve on tank fill inlet
 - 2) Visual dial type fuel level gauge
 - 3) Manual gauge port with stick gauge
 - 4) Fuel supply and return ports
 - 5) Atmospheric vent port and mushroom type UL-listed flame arrester vent to be installed onto vent pipe by others
 - 6) Containment tank emergency vent port and pressure relief cap.
 - 7) Primary tank emergency vent port and pressure relief cap.
 - 8) Digital tank monitor/overfill control panel with pilot warning lights, audible alarm, output contactors, and press to silence/test/reset feature equal to Pneumercator TMS 2000. Provide with analog output option for use by Building Automation System. (Mounted near tank indoors.)
 - 9) Overfill panel with pilot warning light, audible alarm and press to silence/test/reset feature (mounted near tank indoors). Panel shall interface to digital tank monitor.
 - 10) Fill spill box
 - 11) Leak detection
 - a) Leak detection is meant to detect leaks within the interstitial space between the double walls of the tank assembly. Detection must actuate audible and visible alarms.
 - 12) Required internal piping and wiring
 - 13) Decals and signs required by code and authority having jurisdiction.

N. Service Platform

- 1. Provide aluminum service platform for access to all exterior service openings of outdoor generator. Service platform must be wide enough to allow doors to open fully, but in no case shall be less than 42" wide.

O. Generator Remote Start Control Wire Monitoring

- 1. Provide audible and visual notification of generator remote start circuit at generator control panel and remote annunciator. Fault shall automatically start generator. Install at generator and each automatic transfer switch.

2.4 PRIORITY LOAD ADDING AND LOAD SHEDDING

A. Load adding and load shedding:

- 1. Priority load adding and load shedding are to be provided by automatic opening and closing distribution circuit breakers in standby switchgear.
- 2. Upon signal from ATS to start engine, feeder circuit breakers for Priority #1 loads shall remain closed, but feeder circuit breakers for Priority #2 loads, Priority #3 loads, Priority #4 loads, and Priority #5 loads are to be opened.
- 3. Provide opening of feeder circuit breakers within no more than 6 seconds and before automatic transfer switch will be connected to engine-generator.

4. Load adding to be done on load priority basis. Next priority loads to be added based on ascending sequential priority.
5. Load adding of priority loads to be achieved by closing feeder circuit breakers for corresponding priorities.
6. Load shedding shall be done on a last-on, first-off basis.
7. Load shedding of priority loads to be achieved by opening standby switchgear feeder circuit breakers for corresponding priorities, upon signal from Building Control System (BCS) to standby switchgear.
8. Load shedding is not performed for priority #1 loads.

2.5 INTERFACE WITH BUILDING MANAGEMENT SYSTEM (BMS)

A. Interface shall be as follows:

1. Control panel shall incorporate communication module with digital communication port connection to building control system (BMS) via Ethernet communication.
2. Communications shall be for the following:

TYPE	CONDITION/DESCRIPTION	RANGE/UNITS
LDI 1	Low lube oil pressure prealarm	
LDI 2	Low water temperature	
LDI 3	High engine temperature prealarm	
LDI 4	Battery charger AC failure	
LDI 5	Spare	
LDI 6	Control switch not in automatic position	
LDI 7	High battery voltage	
LDI 8	Low coolant level	
LDI 9	Low cranking voltage	
LDI 10	Low voltage in battery	
LDI 11	EPS supplying loads	
LDI 12	Generator circuit breaker ground fault	
LDI 13	Low lube oil pressure	
LDI 14	High engine temperature	
LDI 15	Overcrank	
LDI 16	Overspeed	
LDI 17	Remote emergency manual stop switch	
LDI 18	Overcurrent (circuit breaker trip and lockout)	
LDI 19	Reverse power relay trip	
LDI 20		

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TYPE	CONDITION/DESCRIPTION	RANGE/UNITS
LDI 21	Engine running	
LDI 22	Generator running	
LDI 23	Generator circuit breaker open	
LDI 24	Generator circuit breaker closed	
LDI 25	Generator circuit breaker failed to close	
LDI 26	Spare	
LDI 27	Control voltage failure	
LDI 28	Auto start	
LDI 29	Battery charger failure	
LDI 30	Spare	
LDI 31	Spare	
LDI 32	Spare	
LDI 33	Sub-base fuel storage leak	
LDI 34	Spare	
LDI 35	Spare	
LDI 36	Spare	
LDI 37	Spare	
LDI 38	Spare	
LDI 39	Spare	
LDI 40	Spare	
LDI 41	Spare	
LDI 42	Load shed activated Priority #2	
LDI 43	Load shed activated Priority #3	
LDI 44	Load shed activated Priority #4	
LDI 45	Load shed activated Priority #5	
LDI 46	Load shed activated Priority #6 (spare)	
LDI 47	Load shed activated Priority #7 (spare)	
LDI 48	Load shed activated Priority #8 (spare)	
LDI 49	Load demand activated Priority #2	
LDI 50	Load demand activated Priority #3	
LDI 51	Load demand activated Priority #4	
LDI 52	Load demand activated Priority #5	
LDI 53	Load demand activated Priority #6 (spare)	

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TYPE	CONDITION/DESCRIPTION	RANGE/UNITS
LDI 54	Load demand activated Priority #7 (spare)	
LDI 55	Load demand activated Priority #8 (spare)	
LDI 56	Air damper closed	
LDI 57	System test mode (lamp test)	
LDI 58	Spare	
LDI 59	Spare	
LDI 60	Spare	
LDI 61	Spare	
LAI 1	Generator phase A-B voltage	Volts
LAI 2	Generator phase B-C voltage	Volts
LAI 3	Generator phase C-A voltage	Volts
LAI 4	Generator phase A current	Amperes
LAI 5	Generator phase B current	Amperes
LAI 6	Generator phase C current	Amperes
LAI 7	Total real power	KW
LAI 8	Total apparent power	KVA
LAI 9	Total reactive power	KVAR
LAI 10	Generator power factor	
LAI 11	Generator phase A frequency	Hertz
LAI 12	Generator phase B frequency	Hertz
LAI 13	Generator phase C frequency	Hertz
LAI 14	Battery voltage	Volts
LAI 15	Engine oil pressure	KPA
LAI 16	Engine speed	RPM
LAI 17	Engine water temperature	Degrees Centigrade
LAI 18	Engine running time	Hours
LAI 19	Spare	
LAI 20	Spare	
LAI 21	Spare	
LDO 1	Remote fault reset	
LDO 2	Remote start initiative	
LDO 3	Cool down override control	

TYPE	CONDITION/DESCRIPTION	RANGE/UNITS
LDO 4	Phase select	
LDO 5	Load adding and load shedding	

Notes:

LDI - LAN: Digital Input from control panel communication module to BMS via Ethernet communication.

LAI - LAN: Analog Input from control panel communication module to BMS via Ethernet communication.

LDO - LAN: Digital Output from BMS to communication module via Ethernet communication.

LAN – Local Area Network

3. Provide all additional information as required for a complete and operable system.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install engine-generator set and associated equipment as indicated. Coordinate final location of equipment with General Contractor. Final location of equipment to be reviewed with Engineer prior to installation.
- B. Install equipment in accordance with manufacturers recommendations. Provide equipment protection during and subsequent to installation.

3.2 ACCEPTANCE TESTS

- A. Perform Acceptance Testing in accordance with Section 260812 - Power Distribution Acceptance Tests and Section 260813 - Power Distribution Acceptance Test Tables.

3.3 LOAD TEST

- A. Conduct load testing of engine-generator set, under direct supervision of factory-authorized representatives of manufacturers of engine-generator set and auto-transfer switch.
- B. Provide external load bank control power for the load bank to avoid control drop-out during 100% block load.
- C. Generator start-up and load bank testing to be coordinated with project commissioning to advance project schedule and save costs.
- D. Installation is NFPA 110, Level 2.
- E. Testing to include cold start, 25, 50, 75, and 100% step loads (slow addition of load to confirm operation), 50% and 100% block loads (instantaneous load percentages), and 4 hour testing at rated nameplate.
 1. Loading shall be by use of contractor rented portable load banks.

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- F. Provide certified results of testing, including frequency and voltage regulation at 25, 50, 75, and 100% of rated load, fuel consumption, exhaust temperature, and exhaust emissions at the above load ratings, actual measured values for pickup and drop out relays for ATS, measured values for time delay relays.
- G. Engine-generator set test results are to be certified to comply with specification parameters or necessary corrective actions implemented and tests repeated until compliance is certified at no additional cost to Owner.
- H. At conclusion of testing, service engine-generator set including replacing air, oil and fuel filters, changing lubrication oil, checking and refilling batteries, adjusting fan belts for proper tightness, and refilling of cooling system as required.
- I. Provide fuel for load testing of engine-generator set. Fuel tank shall be full when building is turned over to Owner at final acceptance.

END OF SECTION 263213

SECTION 263250 - DOCKING STATION

PART 1 - GENERAL

1.1 REFERENCE

- A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.2 DESCRIPTION OF SYSTEM

- A. Section describes premanufactured cable termination cabinet used for load bank or portable generator connections. This docking station shall be designed as a dual-purpose portable generator and load bank docking station

1.3 REFERENCE STANDARDS

- A. ANSI/NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting
- B. NEMA AB 1 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breakers Enclosures
- C. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
- D. IEEE 446 – Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
- E. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
- F. NFPA 70 – National Electrical Code (NEC)
- G. UL 50 – Enclosures for Electrical Equipment, Non-environmental Considerations
- H. UL 1008 – Transfer Switch Equipment
- I. NFPA 99 – Essential Electrical System for Health Care Facilities
- J. NFPA 110 – Standard for Emergency and Standby Power Systems

1.4 SUBMITTALS

- A. Shop Drawings
 - 1. Submit for engineering review and approval prior to production release. Include the following for docking station:
 - a. General Arrangement:
 - 1) Indicate front, plan, and side views; access requirements (front, side, rear); overall dimensions and components list; shipping splits and weights.
 - 2) Front elevation indicating location of devices and instruments.
 - 3) Sections through docking station showing space available for conduits.

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- b. Conduit entrance locations and requirements.
 - c. Nameplate legends.
 - d. Configuration, size and number of bus bars for each phase and current rating of buses.
 - e. Ground bus.
 - f. Neutral bus.
 - g. Short circuit ratings of docking station and overcurrent protective devices, and bus withstand rating
 - h. Wiring diagrams: power, signal and control wiring
 - i. Circuit breaker size, location, and required clearance
 - j. Lug sizes and locations
 - k. Docking Station control panel drawings showing devices to be provided, with each device referenced to material list with complete description for device.
 - l. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
- B. Manufacturer's installation instructions:
 1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- C. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
- D. Complete review of this specification, noting for each paragraph whether proposed equipment complies with project specifications, or deviates in some fashion. Justification must be provided for each deviation.
- E. Recommended spare parts lists.
- F. Closeout Submittals:
 1. Refer to Division 1 - Closeout Procedures and herein below.
 2. Project Record Documents:
 - a. Record actual locations, configurations, and ratings of switchboard and major components on single-line diagrams and plan layouts.
 3. Operation and Maintenance Data:
 - a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
 - b. Include manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 - c. Include spare parts data listing, source, catalog number, and current prices of replacement parts and supplies.
 - d. Include Manufacturer Seismic Qualification Certification and Installation Seismic Qualification Certification.
 - e. Include time-current curves, including selectable ranges for each type of overcurrent protective device.

- f. 100% accurate system “as-installed” drawings, interconnect diagrams, schematic diagrams, wiring diagrams, individual sub-system component manuals, and other information necessary for the Owner to maintain, operate, test, and troubleshoot system.
- g. The O&M manual shall contain step-by-step instructions for hookup and disconnecting load bank and portable generator. The first page shall contain name, address, and phone number of a local representative to be called for service or parts.
- h. O&M manual also shall contain four copies each of test record form and service record form for Owner use. Forms shall show proper interval for testing, servicing, and replacing of components.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements:

- 1. Comply with NFPA 70 for components and installation.
- 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

B. Certifications:

- 1. Furnish Engineer with Manufacturer Seismic Qualification Certification: Submit certification that switchboards, accessories, and components will remain physically intact to withstand seismic forces defined in Section 26 0548 – Vibration and Seismic Controls for Electrical Systems. Include the following:
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
- 2. Furnish Engineer with Installation Seismic Qualification Certification: Submit certification that switchboards, accessories, and components will remain in place without separation of any parts when subjected to the seismic forces defined in Section 26 0548 – Vibration and Seismic Controls for Electrical Systems and will be fully operational after the seismic event. Include the following:
- 3. Furnish Engineer with Installation Seismic Qualification Certification: Submit certification that switchboards, accessories, and components will remain in place without separation of any parts when subjected to the seismic forces defined in Section 26 0548 – Vibration and Seismic Controls for Electrical Systems. Include the following:
 - a. Detailed description of equipment supports and seismic restraints on which the certification is based and their installation requirements.
 - b. Certification shall bear the seal and signature of an Engineer registered and licensed in the State of South Carolina.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, fumes, water, corrosive substances, construction debris, and traffic. Provide temporary heaters in docking stations as required to prevent condensation

- B. Handle equipment in accordance with manufacturer's written instructions. One copy of instructions is to be included with equipment at time of shipment. Maintain factory bracing, packaging, and wrapping.
- C. Comply with NEMA PB 1.1 and manufacturer's written instructions.

1.7 WARRANTY

- A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1 yr. warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- 1. ESL Power Systems Inc.
- 2. Trystar
- 3. ASCO
- 4. Gus Berthold Electric Co.
- 5. Powertron Corporation
- 6. Approved equal

2.2 RATINGS AND PERFORMANCE

- A. Docking Station
 - 1. Nominal system voltage: 480V As indicated on the drawings or scheduled
 - 2. Bus Ampacity: As indicated on the drawings or scheduled
 - 3. Short circuit current rating: as indicated on drawings.

2.3 FABRICATION

- A. Dual-Purpose Docking Station and Temporary Generator Docking Station
 - 1. Entire package must be listed to UL 1008 Standards. UL listing of individual components is not acceptable.
 - 2. Enclosure:
 - a. NEMA 3R enclosure
 - 1) Pad-lockable front door shall include a hinged or affixed access plate at the bottom for entry of cables from portable generator and portable load bank.
 - 2) NEMA 3R integrity shall be maintained while cabling is connected during use.
 - 3) Front and sides shall be accessible through removable panels.
 - 4) Top, sides, and bottom shall be accessible for permanent cabling.
 - 5) Drip hood or sloped top.

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- b. Finishes:
 - 1) Paint after fabrication. Powder coated ANSI 61 Gray or manufacturer equivalent Gray
- c. Pad Mount
- 3. Buses.
 - a. Material: copper.
 - b. Equipment ground bus: bonded to box.
 - c. Ground bus: 50% of phase size.
 - d. Neutral bus: 100% of phase bus rating.
 - e. Rounded edges on bus.
- 4. Connectors:
 - a. Shall include protective flip lids to prevent accidental contact
 - b. Hardwired
 - 1) Hardwired connections shall be compression lug, broad range set-screw type, located behind a barrier. Phase Rotation Monitoring Device to have adjustable delay times and reset response with automatic detection of line faults or incorrect phase sequencing.
 - c. Camlok style
 - 1) Inlet connections shall be male connections, outlet connections shall be female connectors.
 - 2) Shall be camlok style mounted on gland plate. Camlok shall be color coded according to system voltage:
 - d. Generator Connections:
 - 1) A phase – Match color of phase conductors (Black / Brown)
 - 2) B phase – Match color of phase conductors (Red / Orange)
 - 3) C phase – Match color of phase conductors (Blue / Yellow)
 - 4) N Neutral – White
 - 5) G Ground – Green
 - e. Load Bank Connections:
 - 1) A phase – Match color of phase conductors (Black / Brown)
 - 2) B phase – Match color of phase conductors (Red / Orange)
 - 3) C phase – Match color of phase conductors (Blue / Yellow)
 - 4) G Ground – Green
- 5. Provide phase rotation monitor kit, assembled as part of factory installation.
- 6. Provide two-wire auto generator start wire terminal as part of factory installation.
- 7. Configuration
 - a. Kirk Key Interlock System: As Indicated on the drawings or scheduled
 - b. Integral manual transfer switch
 - c. Circuit breaker disconnects.
 - 1) 120V shunt trip
 - 2) UL 489 Listed

3) Shall be removable for service and maintenance

B. Accessories:

- a. Battery charger receptacle 5-20R
- b. Block heater receptacle L5-30R
- c. Cable protection locking plate
- d. SCADA terminal port
- e. Listed monitoring device
- f. Strip heater and unit thermostat
- g. Custom listed receptacle
- h. Surge protection device
- i. Load shed receptacle
- j. Utility light/alarm

PART 3 - EXECUTION

3.1 COORDINATION

- A. Instruct manufacturer about the location of incoming camlock plugs, i.e., bottom or side feed.
- B. Instruct manufacturer to provide multiple lugs where conductors in parallel or sub-feed (double) lugs or feed-through lugs are indicated.
- C. Coordinate installation of housekeeping concrete pad based on actual equipment supplied:
 - 1. Concrete: Per requirements in Division 03 – Concrete.
 - 2. Dimensions: Per requirements in Section 26 0529 – Hangers and Supports for Electrical Systems.
- D. Verify with manufacturer that “touch-up” paint kit is available for repainting.

3.2 EXAMINATION

- A. Examine areas and surface to receive docking station for compliance with requirements, installation tolerances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Verify that space indicated for docking station mounting installation provides code-required working clearances. Contractor shall be responsible for coordinating with site and civil prior to placement on site.
- C. Notify Architect/Engineer of any discrepancies prior to submittal of product data and shop drawings.

3.3 INSTALLATION

- A. Install equipment as indicated. Coordinate final location of equipment with General Contractor. Final location of equipment to be reviewed with Engineer prior to installation.

- B. Mounting and seismic restraints:
 - 1. Dual-Purpose Docking Station shall be pad mounted . Install anchor bolts to elevations required for proper attachment. Refer to manufacturer installation requirements.
 - 2. Install anchorage devices and seismic restraints based on design by an Engineer registered and licensed in the State of South Carolina, and to comply with Section 26 0548 – Vibration and Seismic Controls for Electrical Systems for seismic criteria.
 - 3. Fasten surface mount equipment firmly to walls and structural surfaces, ensuring they are permanently and mechanically anchored.
 - 4. Anchor and fasten panelboards and their supports to building structural elements (wood, concrete, masonry, hollow walls and nonstructural building surfaces) by the methods described in Section 26 0529 – Hangers and Supports for Electrical Systems.
 - 5. Install two rows of steel slotted channel, with a minimum of four attachment points where required for surface mount equipment.
- C. Tighten electrical connectors and terminal according to equipment manufacturer’s published torque-tightening values. Where manufacturer’s torque values are not indicated, use those specified in UL 486A-486B.
- D. Install engraved plastic nameplates under provisions of Section 26 0553 – Electrical Systems Identification. Attach nameplate to exterior of the docking station using small corrosion-resistant metal screws and rivets. Do not use contact adhesive.
 - 1. Indicate docking station manufacturer’s name, docking station name, amperage, voltage, phase, number of wires, short circuit current rating (amp, RMS symmetrical and KVA 3-phase symmetrical) and momentary and fault-closing ratings (amp, RMS asymmetrical).
- E. Provide framed, printed operating instructions for docking station, including control and key interlocking sequences and emergency procedures. Place in a lockable weatherproof enclosure mounted on the exterior of the enclosure. Mount on front of docking station.

3.4 CONNECTIONS

- A. Ground docking station according to Section 26 0526 – Grounding and Bonding for Electrical Systems and grounding diagram.
- B. Connect wiring according to Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables

3.5 ADJUSTING

- A. Set field-adjustable circuit breakers trip settings or change the trip settings to values indicated on drawings or recommended by the overcurrent protective device coordination study per Section 26 0573 – Power System Studies.

3.6 FIELD QUALITY CONTROL

- A. Inspect for physical damage, proper alignment, connections, anchorage, seismic restraints, and grounding.
- B. Test continuity of each circuit.

- C. Test as a system for compliance with NFPA 101 and a Level 1 system. Required to ensure proper operation during generator testing.
- D. Test circuit breakers per requirements in Sections 26 0812 – Power Distribution Acceptance Tests and 26 0813 – Power Distribution Acceptance Test Tables.
- E. Provide factory commissioning by manufacturer factory authorized technician
- F. Perform Acceptance Testing in accordance with Section 26 0812 - Power Distribution Acceptance Tests and Section 26 0813 – Power Distribution Acceptance Test Tables.
- G. Provide on-site training for Owner upon startup, training shall be provided by a factory authorized technician. Training shall be done onsite during startup. Training shall include education and demonstration on how to connect the docking station to portable generator and load bank.

3.7 CLEANING

- A. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.

END OF SECTION 263250

SECTION 263623 - AUTOMATIC TRANSFER SWITCHES

PART 1 - GENERAL

1.1 DESCRIPTION OF SYSTEM

- A. Provide automatic transfer switch, 3 phase, 60 Hz, 4 pole, with switched neutral for voltage and current as indicated on drawings.

1.2 REFERENCE STANDARDS

- A. NEMA ICS 10 Part 1 Industrial Control and Systems Part 1: Electromechanical AC Transfer Switch Equipment
- B. UL 1008 Automatic Transfer Switches

1.3 SUBMITTALS

- A. Submit shop Drawings for equipment provided under this Section.

1.4 QUALITY ASSURANCE

- A. Obtain automatic transfer switches from one source and by single manufacturer.
- B. Regulatory Requirements:
 - 1. Comply with NFPA 70 for components and installation.
 - 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
- C. Factory Test
 - 1. Test system in accordance at the factory in accordance with Section 260812 - Power Distribution Acceptance Tests and Demonstration of Transfer Functions.
 - 2. Provide factory test report.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, fumes, water, corrosive substances, construction debris, and traffic. Provide temporary heaters in switchgear as required to prevent condensation.
- B. Deliver in shipping splits of length that can be moved in delivery path, as indicated, individually wrapped for protection, and mounted on shipping skids. Mark crates, boxes, and cartons clearly to identify equipment. Show crate, box, or carton identification number on shipping invoices.
- C. Use factory-installed lifting provisions. Handle carefully to avoid damage to internal components, enclosure, and finish.

1.6 WARRANTY

- A. Refer to Division 01 and Section 260000 - General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 5 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of final acceptance.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Acceptable Manufacturers:
 - 1. Asco by Schneider Electric
 - 2. Cummins
 - 3. Russelectric by Siemens
 - 4. Caterpillar

2.2 AUTO-TRANSFER SWITCH

- A. Auto-transfer switch:
 - 1. Mechanically held, electrically operated type
 - 2. Interlocked to ensure only 2 possible positions, normal and emergency.
 - 3. Rated for continuous duty in unventilated sheet metal enclosure
 - 4. Suitable for all classes of loads at maximum rated voltages
 - 5. Withstand rating that meets or exceeds withstand rating of transfer switch feeder breakers.
 - 6. Shall be closed transition type as specified on drawings.
- B. Provide main contacts with silver alloy wiping action type protected by arcing contacts.
- C. Provide switch components accessible from front of enclosure.
- D. Provide 3 cycle short circuit rating to guarantee contact opening and no damage when transfer switch is served by fused switches
- E. Provide switch with the following items:
 - 1. Adjustable 1 to 3 second time delay to override momentary voltage dips and outages.
 - 2. Time delay on transfer to emergency. Adjustable from 1 to 300 seconds (factory set at 3 seconds).
 - 3. Time delay on retransfer to normal. Adjustable from 2 seconds to 30 minutes.
 - 4. Full phase protection consisting of 2 phase relays and one close differential relay. Phase relays shall be set to 70% drop out, 90% pick up, and differential relays set for 92 to 95% pick-up and 83 to 85% drop-out.
 - 5. Pushbutton reset to normal.
 - 6. Pushbutton to bypass time delay on retransfer to normal.

7. Pilot light to indicate normal position.
 8. Pilot light to indicate emergency position.
 9. Auxiliary contact to close when normal power fails.
 10. Auxiliary contact to open when normal power fails.
 11. Auxiliary contact on same shaft as main contacts (closed on normal).
 12. Auxiliary contact on same shaft as main contacts (closed on emergency).
 13. Pushbutton, or selector switch, or graphical display input to provide "Test," "Auto," "OFF", and "Engine Start."
 14. Contacts to start engine-generator when normal power fails.
 15. Time delay engine start, adjustable from 0 to 5 seconds.
 16. Adjustable time delay on retransfer to normal source with 5 minute unloaded running time of standby plant:
 - a. Minimum delay 2 minutes
 - b. Maximum delay 25 minutes
 - c. Built in circuitry to nullify time delay if emergency source fails and power is available at normal source.
 17. Relay to prevent transfer to emergency until voltage and frequency of generating plant have reached 90% of rated value.
 18. Provide bi-direction in-phase monitor or dual motor operator with programmed neutral to allow voltage decay in motor and transformer circuits.
- F. Bypass/isolation switch:
1. Dual-source enclosed.
 2. Isolate transfer switch and de-energize for maintenance, testing or repair.
 3. Dual-source operation - bypass either to normal or emergency source directly to load at discretion of operator.
 4. Break-before-make operation of contacts.
 5. Operation - fully mechanical, designed to provide quick-make-quick-break of contacts and only allow switch to be fully closed or fully open with no mid position possible.
 6. Operation - possible regardless of the position or condition of the automatic transfer switch.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install equipment in accordance with manufacturer's recommendations.
- B. Provide equipment protection during and subsequent to installation.
- C. Provide wiring between transfer switch and elevator controller. Final connections at elevator controller by Elevator Contractor.
- D. Connect transfer switches that are part of fire pump controllers.

3.2 OPERATION

- A. Parallel “start engine-generator” contacts of automatic transfer switches, such that failure of normal source at any switch shall start engine.
- B. Transfer of one switch from normal to emergency shall not preclude any other switch from transferring.
- C. Engine generator cool down cycle shall not start until all transfer switches have timed out back to normal source.

3.3 ACCEPTANCE TESTING

- A. Perform acceptance testing in accordance with Section 260812 - Power Distribution Acceptance Tests.
- B. Adjust or replace equipment as needed to comply with manufacturer's specifications and resubmit corrected test reports.

END OF SECTION 263623

SECTION 264113 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Section includes lightning protection systems consisting of air terminals, roof conductors, bonding conductors, down conductors, fastener connections, and grounding.

1.2 REFERENCE STANDARDS

- A. ANSI/NEMA GR 1 - Grounding Rod Electrodes and Ground Rod Electrode Couplings
- B. NFPA 70 - National Electrical Code
- C. NFPA 780 - Standard for the Installation of Lightning Protection Systems
- D. UL 467 – Grounding and Bonding Equipment
- E. UL 96 - Lightning Protection Components
- F. UL 96A - Installation Requirements for Lightning Protection Systems

1.3 SUBMITTALS

- A. Product Data:
 - 1. Submit manufacturer's descriptive and technical literature and catalog cuts.
- B. Shop Drawings:
 - 1. Submit installation shop drawings for the overall lightning protection system. Include physical layout of the equipment, mounting details, and relationship to other parts of the work.
 - 2. Submit detail drawings for each major component.
 - 3. Submit location, size, and material of grounding electrodes, and connection type.
 - 4. Submit roof adhesive data for air terminals mounted on single-ply roofing.
- C. Certification, signed by Contractor, that roof adhesive for air terminals is approved by manufacturers of both the terminal assembly and the single-ply roofing material.
- D. Copy of Owner's UL Master Label Certificate.
- E. Manufacturer's Installation Instructions:
 - 1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation.
- F. Closeout Submittals:
 - 1. Project record documents:
 - a. Record active location of lightning protection system components.

2. Operation and maintenance data:
 - a. Provide Owner complete Inspection Guide and forms for conducting all inspections and testing of the lightning protection system as noted in teh Annex to NFPA 780, Inspection and Maintenance of Lightning Protection Systems.
 - b. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventative maintenance instructions.

1.4 QUALITY ASSURANCE

- A. Qualifications:
 1. Lightning protection system materials:
 - a. Consists of standard products by a manufacturer regularly engaged in production of lightning protection systems.
 - b. UL Listed
 2. Lightning protection system installer: UL Listed.
- B. Regulatory Requirements:
 1. Lightning protection system: Comply with NFPA 780, UL 96, and UL 96A.
- C. Certifications:
 1. Furnish Owner with UL Master Label Certificate upon completion of installation providing proof that the lightning protection system is in compliance with UL 96 and UL 96A standards.

1.5 SEQUENCING

- A. Coordinate installation of lightning protection with installation of other building systems and components, including supporting structures and building materials, metal bodies requiring bonding to lightning protection components, exterior and interior building finishes, and building roofing.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Thompson Lightning Protection Company
- B. Harger Lightning Protection, Inc.
- C. Heary Brothers Lightning Protection Company, Inc.
- D. National Lightning Protection Corporation
- E. Erico International Corporation
- F. Approved Equal

2.2 LIGHTNING PROTECTION SYSTEM COMPONENTS

- A. NFPA 780, UL 96.
- B. Materials: Air terminals, main and cross-run roof conductors, bonding and down conductors, conductor fasteners, air terminal supports, chimney bands, clips, and connections: Class II:
 - 1. Air terminals: Solid type with a safety tip, at least 24" in height, above the object to be protected when spaced at intervals exceeding 20 ft but not more than 25 ft with mounting base.
- C. ANSI/NEMA GR 1 Grounding Electrodes: 3/4" x 10 ft long copper-clad steel ground rod.
- D. Concrete-Encased Electrodes: As shown on drawings.
- E. Ground Ring Electrode: As shown on drawings.
- F. Ground Connectors: Conform to UL 96
 - 1. Bronze of the clamp type and bronze clamp accessories.
 - 2. Provide in accordance with the requirements in Section 260526 - Grounding and Bonding for Electrical Systems.
- G. Galvanic Compatibility of Materials:
 - 1. Air terminals, conductors, fasteners, and connectors shall be galvanically compatible with surfaces they are mounted to.
 - 2. Copper materials in all locations except where the use of aluminum materials is necessary for galvanic compatibility.
 - 3. Aluminum materials on copper roofs are not acceptable.
 - 4. Aluminum materials where mounted on aluminum roofing, siding, or other aluminum surfaces.
- H. Bimetallic fittings when joining metals that are not galvanically compatible.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install lightning protection to comply with UL 96A, NFPA 70, and NFPA 780. Conform to the most stringent requirement in NFPA 780.
- B. Bond exterior metals including flashing, roof drains, vent stacks, fans, water pipes, metal raceways, enclosures, frames, and other non-current carrying metal parts of electrical and mechanical equipment on roof to lightning protection system.
- C. Bond lower end of exhaust ducts, vent stacks, etc., passing through roof.
- D. Run bonding jumpers continuously horizontally or down from point of bond to point of connection to main conductor.

- E. Make down conductors electrically continuous, with direct paths from air terminals to ground connections. Avoid sharp bends and narrow loops. Protect down conductors, where necessary, to prevent physical damage or displacement to the conductor. Use PVC Schedule 40 conduits. Provide conduits in accordance with requirements in Section 260533 - Raceway and Boxes for Electrical Systems .
 - 1. For structural steel construction, utilize steel columns (bond top and bottom) in lieu of down lead conductors – every other column and not to exceed an average of 60 foot spacing.
- F. Conceal system conductors, down conductors, interior conductors, and conductors within normal view of exterior locations at grade.
- G. Notify Architect at least 48 H before concealing lightning protection system components.
- H. Below-grade or concealed cable connections: Use approved exothermic-welded connections for all conductor splices and connections between conductors and other components.
- I. Exposed cable connections: Use approved mechanical connections.
- J. Air terminals mounted on single-ply roofing: Use adhesive recommended by manufacturer of air terminals and approved by manufacturer of roofing material. Comply with adhesive manufacturer's installation instructions. For roofing work, refer to Division 07 - Thermal and Moisture Protection.
- K. Attach each down conductor to the grounding electrode by exothermic welding.
- L. Provide grounding electrodes with top 2 ft below finished grade.
- M. Ramps and covered passageways shall be protected by the lightning protection system.
- N. For construction utilizing post tensioning systems to secure precast concrete sections, do not use the post tension rods as down conductors. Bond tension rods to the lightning protection and grounding system – follow recommendations of the post tension rod manufacturer.

3.2 CORROSION PROTECTION

- A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the present of moisture, unless moisture is permanently excluded from the junction of such materials.
- B. Use conductors with suitable protective coatings where conditions would cause deterioration or corrosion of conductors.

3.3 FIELD QUALITY CONTROL

- A. Apply for inspection by Underwriters Laboratories, Inc. (UL) to obtain UL Master Label Certificate.

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AIM # 1752

- B. Verify that lightning protection surge arrestor devices are installed on all incoming power and communications lines, in order to obtain UL Master label Certificate.

END OF SECTION 264113

SECTION 264300 - SURGE PROTECTIVE DEVICES (SPD)

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Provide Type 1 Surge Protective Devices (SPD) for the protection of AC electrical circuits formerly known as Transient Voltage Surge Suppression (TVSS) System. Provide high energy surge current diversion and be suitable for application in Type 1 environments.
- B. Modes of Protection:
 - 1. Line to Ground, Line to Neutral, and Neutral to Ground for services with a neutral
 - 2. For Services without a neutral, Line to Line and Line to Ground
- C. Provide common and normal modes of protection.

1.2 REFERENCE STANDARDS

- A. ANSI/UL 1449 Surge Protective Devices Fourth Edition
- B. IEEE C62.41.1 – Recommended Practice on Surge Voltages in Low Voltage AC Power Circuits FIPS PUB 94
- C. IEEE C62.11 – Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (> 1 kV)
- D. IEEE C62.41.1 Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
- E. IEEE C62.41.2 Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits
- F. IEEE C62.45 IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and less) AC Power Circuits
- G. IEEE C62.62 IEEE Standard Test Specifications for Surge Protective Devices (SPDs) for Use on the Load Side of the Service Equipment in Low Voltage (1000V and less) AC Power Circuits
- H. National Electrical Code – Article 242
- I. NEMA LA 1 – Surge Arresters
- J. National Fire Protection Association – NFPA 20, 70, 75, and 780
- K. UL 96A Installation Requirements for Lightning Protection Systems

1.3 SUBMITTALS

- A. Submit Shop Drawings for equipment provided under this Section.

- B. Submit shop drawings and product information for approval and final documentation in quantities listed according to Conditions of the Contract. Identify customer name, customer location, and customer order number.
- C. Submit ANSI/UL 1449 Listing documentation to indicate the following:
 - 1. Short Circuit Current Rating (SCCR)
 - 2. Voltage Protection Ratings (VPRs) for all modes
 - 3. Maximum Continuous Operating Voltage rating (MCOV)
 - 4. Nominal Discharge Current rating (I-n)
 - 5. Type 1 device
 - 6. VPR, MCOV, I-n, and Type 1 information is posted at www.UL.com under Certifications; search using UL Category Code: VZCA. SCCRs are posted in manufacturer's published documentation.
 - 7. UL data and visual inspection takes precedence over manufacturer's published documentation.
- D. Provide shop drawings including manufacturer installation instruction manual and line drawings detailing dimensions and weight of enclosure, internal wiring diagram illustrating all modes of protection in each type of SPD required, wiring diagram showing field connections, and manufacturer's recommended wire and breaker sizes (if required).
- E. Upon request, modules using encapsulation shall be presented without encapsulation for visual inspection, proprietary technology included. MOV type and quantity shall reflect kA ratings on cutsheets, verification of diagnostic monitoring, thermal and overcurrent protection, etc.

PART 2 - PRODUCTS

2.1 MATERIAL

- A. Acceptable manufacturers:
 - 1. Internally-mounted unit by the power distribution equipment manufacturer.
 - 2. Erico

2.2 PERFORMANCE CHARACTERISTICS

- A. SPD shall bear the UL Mark and shall be Listed to Third Edition of ANSI/UL 1449. "Manufactured in accordance with" is not equivalent to UL Listing and does not meet intent of specification.
- B. Post SPD and performance parameters at www.UL.com under Category Code: VZCA. Products or parameter without posting at UL.com are not approved.
- C. Minimum surge current capacity for Service Entrance units based on 8 x 20 microsecond current waveform:
 - 1. 200,000 A between each phase for line-to-line mode
 - 2. 200,000 A each phase for line-to-ground mode
 - 3. 200,000 A each phase for line-to-neutral mode

4. 200,000 A for neutral-to-ground mode
- D. Minimum surge current capacity for panelboard units based on 8 x 20 microsecond current waveform:
 1. 80,000 A between each phase for line-to-line mode
 2. 80,000 A each phase for line-to-ground mode
 3. 80,000 A each phase for line-to-neutral mode
 4. 80,000 A for neutral-to-ground mode
- E. Sequential Surge Current Survivability:
 1. 1,000 sequential category surges without failure.
- F. Current Rating:
 1. Rated for continuous current and AIC rating of equipment protected.
 2. Mark SPD Short-Circuit Current Rating on the SPD label.

2.3 OPERATING CONDITIONS

- A. Temperature range: -40°F to 122°F
- B. Relative humidity range: 0 to 95%, non-condensing
- C. Audible noise level: < 40 dBA at 5 ft
- D. SPD Surface Temperature: less than 131°F

2.4 FABRICATION

- A. SPD Modules:
 1. UL Labeled as Type 1 (verifiable at www.UL.com), intended for use without need for external or supplemental overcurrent controls. Protect suppression component of every mode, including N-G, by internal overcurrent and thermal overtemperature controls. SPDs relying on external or supplementary installed safety disconnects do not meet intent of specification.
 2. UL Labeled with 20kA I-nominal (I-n) (verifiable at UL.com) for compliance to UL 96A Lightning Protection Master label and NFPA 780
 3. Suppression components: Heavy-duty MOVs, selenium cells, or combination of both.
 4. Provide surge current diversion paths for all modes of protection: L-N, L-G, N-G in WYE systems, and L-L, L-G in DELTA systems.
 5. Provide service entrance SPD audible diagnostic monitoring by way of audible alarm.
 6. Provide service entrance SPD with 1 set of NO/NC dry contacts for alarm conditions.
 7. Provide visual LED diagnostics including a minimum of 1 green LED indicator per phase, and 1 red service LED. Include an audible alarm with on/off silence function and diagnostic test function (excluding branch).
 8. If a dedicated breaker for the SPD is not provided in the switchgear, switchboard, or panelboard include an integral UL Recognized disconnect switch. Dedicated breaker to serve as a means of disconnect for distribution SPDs.

9. Meet or exceed the following criteria:

- a. ANSI/UL 1449 Listed Voltage Protection Ratings (VPRs) for 6kV 3000A testing as follows:

VOLTAGE	L-N	
	L-G	L-L
	N-G	
208Y/120V	≤800V	≤1200V
480Y/277V	≤1200V	≤2000V

10. ANSI/UL 1449 Listed Maximum Continuous Operating Voltage (MCOV) (verifiable at UL.com):

System Voltage	Allowable System Voltage Fluctuation (%)	MCOV
208Y/120	15%	150V
480Y/277	15%	350V

11. Provide serviceable, replaceable modules (excluding Branch).
12. Provide warranty for a period of 10 yrs, incorporating unlimited replacements of suppressor parts if they are destroyed by transients during the warranty period.

B. Service Entrance:

1. Install 1 primary suppressor external to the service entrance in accordance with manufacturer instructions.
2. Install SPD on line or load side.
3. Bond SPD ground to service entrance ground.

C. Distribution Panelboards:

1. Install 1 suppressor external to each designated distribution panelboard.
2. Install surge suppression device in accordance with manufacturer instructions.

D. SPD Low-Impedance Interconnect Cable:

1. Provide low-impedance cable specifically listed for SPD installations.
2. Low impedance approximately 25% of conventional pipe and wire for improved clamping voltage.

PART 3 - EXECUTION

3.1 APPLICATION OF SPD

- A. Provide UL approved disconnect switch at Service Entrance or Transfer Switch as a means of service disconnect if a breaker sized per manufacturer's recommendations is not available.
- B. Provide independent means of servicing disconnect at Distribution, MCC, and Branch such that the protected panel remains energized. A 30A breaker (or larger based on manufacturer's recommendations) may serve this function.

- C. Provide SPD for each panel associated with the Emergency branch(es) of power.

3.2 INSTALLATION

- A. Install per manufacturer's recommended practices.
- B. Provide short and straight conductors not exceeding 3 ft in length. Manufacturer-approved cables may be used that allow conductor length to extend beyond 3 ft in length without affecting capability of unit.
- C. Input conductors twisted together to reduce inductance.
- D. Avoid 90-degree bends in cable.

3.3 QUALITY ASSURANCE

- A. Factory test system before shipment. Include quality control check, "Hi-Pot" tests at 2 times rated voltage plus 1,000 V, ground leakage tests, and calibration.
- B. Manufacturer Qualifications: Engage a firm with at least 5 yrs experience in manufacturing surge protective devices.
- C. Manufacturer of equipment shall have produced similar electrical equipment for a minimum period of 5 yrs. When requested by Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with requirement.
- D. Provide SPD compliant with the Restriction of Hazardous Substances (RoHS) Directive 2002/95/EC.

3.4 FIELD QUALITY CONTROL

- A. Inspections before SPD startup:
 - 1. Visual Inspection:
 - a. Verify installation per drawings.
 - b. Verify phase, neutral, and ground conductors are properly sized and configured.
 - 2. Mechanical Inspection:
 - a. Check connections for tightness.
 - b. Check terminal screws, nuts and/or connectors for tightness.
 - 3. Electrical Inspection:
 - a. Confirm input voltage.
 - b. Confirm phase, neutral and ground connections are proper.

3.5 WARRANTY

- A. Provide 10 yr manufacturer warranty.

END OF SECTION 264300

SECTION 265000 - LIGHTING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Provide complete and fully operational lighting system per Contract Drawings and Specifications.
- B. Luminaires shall be provided complete with necessary accessories for proper installation.
- C. Catalog numbers shown in luminaire schedule are basic luminaire types. Additional features, accessories and options specified, scheduled or necessary for proper installation shall be included.
- D. Specifications and drawings convey the features and functions of luminaires only and do not show every item or detail necessary for the work.
- E. Work includes final aiming and focusing of luminaires under direction of the Architect/Engineer.

1.2 REFERENCE STANDARDS

- A. NECA/IESNA 500 - Standard for Installing Indoor Commercial Lighting Systems (ANSI)
- B. NECA/IESNA 501 - Standard for Installing Exterior Lighting Systems (ANSI)
- C. NECA/IESNA 502 - Standard for Installing Industrial Lighting Systems (ANSI)
- D. NEMA LE 4 - Recessed Luminaires, Ceiling Compatibility
- E. UL 676 – Underwater Luminaires and Submersible Junction Boxes
- F. UL 773 - Plug-in Photocontrols for use with area lighting
- G. UL 924 - Emergency Lighting and Power Equipment
- H. UL 1574 – Track Lighting
- I. UL 1598 – Luminaires
- J. UL 1838 – Low Voltage Landscape Lighting Systems
- K. UL 2108 – Low Voltage Lighting Systems
- L. UL 2388 – Flexible Lighting Products
- M. UL 2562 – Pendant Cable
- N. UL 8750 – LED Light Sources for use in Lighting Products
- O. ANSI C78.377 – Chromaticity

- P. IESNA LM-79 – Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products
- Q. IESNA LM-80 - Approved Method: Testing Lumen Maintenance of LED Light Sources
- R. IESNA TM21-11 - Projecting Long Term Lumen Maintenance of LED Light Sources including Addendum A

1.3 QUALITY ASSURANCE

- A. Luminaire and accessory components shall be constructed of materials appropriate for their use. Luminaires intended for use in marine environments shall be constructed of materials resistant to corrosion.
- B. Luminaires, drivers, other components shall meet the requirements of all applicable State and Municipal codes and energy codes.
- C. Provide luminaires listed and labeled by UL or other testing lab acceptable to local jurisdiction for their indicated use and installation conditions.
- D. Contractor shall coordinate installation of lighting systems with all trades.
 - 1. Manufacturers listed in the luminaire schedule shall be assumed capable of supplying listed luminaires. Any such exceptions shall immediately be brought to the attention of Architect, Engineer, or Lighting Designer.
 - 2. Multiple Name Specification:
 - a. When multiple manufacturers are listed, Electrical Contractor shall choose which of the listed products are to be provided.
 - b. Products of the same type shall be of same manufacturer.
 - 3. Contractor shall coordinate and verify compatibility of luminaires with lighting control system
 - a. Control protocol indicated for luminaires matches protocol of lighting control system specified. Contractor shall coordinate and verify compatibility of all dimming luminaires with control system to ensure that dimming is flicker free, continuous dimming through the dimming range noted on the luminaire schedule.
- E. Substitution requests:
 - 1. Will be evaluated prior to Bid.
 - 2. Shall follow procedures set forth in this Section under paragraph 1.7 and in Section 012500 - Substitution Procedures .
 - 3. Shall be made not less than 10 days prior to bid date.
 - 4. Shall include the following information indicating that the proposed substitution is of similar construction quality and assembly, lumen output and distribution, color temperature, color consistency, and controllability:
 - a. Specified and proposed manufacturer's product data sheet, noting options and features.
 - b. Provide dimensioned drawing of luminaire.
 - c. Provide photometric data in form of an electronic IES file on USB or via email.

5. Provide table-top working samples and/or mockup of specified luminaire and proposed alternate.
6. Electrical Contractor shall be responsible for all costs incurred by substitution request sample and/or mockup production and review.
7. Equipment delivery lead time shall not be held as a valid reason for requesting luminaire substitution unless luminaire lead time from specified manufacturer is in excess of 14 weeks. It shall be sole responsibility of Electrical Contractor to determine necessary equipment lead times, deliver submittals for review in a timely fashion, and place orders accordingly to ensure timely delivery.
8. When requesting a substitution, Electrical Contractor shall provide unit and extended pricing for specified luminaire, unit and extended pricing for proposed alternate, and unit and extended delta savings to Owner to be realized by accepting proposed alternate. If requested, provide unit pricing for each luminaire type specified to provide a baseline comparison for substitution request.
9. Electrical Contractor shall guarantee pricing on all luminaire types for which a substitution request has been granted. This price guarantee shall be per unit and shall be maintained through the end of construction, regardless of quantity purchased.
10. For all luminaire types using an LED light source, provide independently tested, IESNA LM-79 compliant photometry testing data and IESNA LM-80 Lumen Maintenance data.

1.4 WARRANTY

- A. Exit Signs Utilizing LED Technology: Provide manufacturer's warranty for a period of not less than five years from the date of substantial completion including parts and labor for full replacement of defective product.
- B. LED Luminaires: Provide Manufacturer's warranty for a period of not less than five years from the date of final acceptance or the specified warranty period greater than five years for repair or replacement of defective electrical parts, including light source and driver.
- C. Luminaires without integral LED sources: Provide manufacturer's warranty for a period of not less than one year from the date of final acceptance including parts and labor for full replacement of defective product.

1.5 SUBMITTALS

- A. Electronic submittal format shall be limited to the greater of 500 pages or 30 MB to ensure that all pages load correctly. Bookmarks by luminaire type are required for ease of navigation. Submittals exceeding these limits should be broken in a logical fashion into multiple volumes for separate review. Measures to reduce file size should not compromise legibility or any other factors affecting ease of review.
- B. Upon award of Contract, submit complete list of lighting products to be furnished, with manufacturer and catalog designations, including current unit cost. Unit price shall be for equipment only and not include installation or miscellaneous electrical costs.

- C. Upon award of Contract, submit complete list of lighting products to be furnished, with manufacturer and catalog designations, including currently quoted lead times for product delivery. Should Electrical Contractor anticipate delivery schedule of any specified product may adversely impact construction schedule, they shall bring it to the attention of Owner/Architect /Lighting Designer at this time.
- D. In addition to complying with requirements of Section 260000 - General Electrical Requirements, submittals shall include the following:
 - 1. Manufacturer's product data
 - 2. Installation instructions
 - 3. Maintenance data
 - 4. Parts list for each luminaire accessory
 - 5. Photometric Data: photometric data for luminaire, including optical performance as follows:
 - a. Coefficients of utilization
 - b. Luminance table
 - c. Candela distribution data
 - d. Zonal lumens
 - e. Area and roadway luminaires shall include Isocandela Charts, IES Roadway Distribution Classification and IES BUG (Backlight – Uplight – Glare) ratings.
 - 6. Driver schedule indicating manufacturer, type, and catalog number for each luminaire
 - 7. Driver cut sheet for each driver used, referencing luminaire type(s)
 - 8. Product color/finish
 - a. Where specific finish or color is not specified and options exist, submit color or finish samples to Architect/Engineer/Lighting Designer for selection.
- E. Shop Drawings for equipment provided under this Section shall include the following:
 - 1. Overall submittal drawings indicating luminaire size, mounting (including ceiling type), light source, shielding, and voltage attributes, as well as manufacturer's product data, installation instructions, maintenance data, and parts list for each luminaire.
 - 2. Catalog cutsheets lacking sufficient detail will not be accepted.
 - 3. Detailed drawings of linear pendant mounted and suspended luminaires including dimensions, support spacing, suspension type, power feed type and locations, driver locations, wiring and controls configuration, luminaire joint locations and end plates. Provide canopy details that indicate coordination with the ceiling system provided.
 - 4. Detailed drawings for each cove and linear wall system configuration including dimensions, power feed locations, driver locations, luminaire joint locations, extension plates for end and corner sections and end plates.
 - a. LED strip luminaires mounted in architectural coves, provide dimensioned drawings and sections and include accessory cut sheets as specified. Within coves, all luminaires are to be mounted end to end with no more than 12” unlit split evenly between ends
 - 5. Detailed drawings for LED systems including LED color, color consistency, rated life, warranty, and scale plans with luminaire layout, number, type and location for drivers, and a complete bill of materials.

6. Detailed drawings for continuous recessed or continuous surface mounted luminaires including dimensions, power feed locations, driver locations/quantity, luminaire joint locations, extension plates for end and corner sections and end plates as applicable.
 7. Detailed drawings for custom LED handrail systems including dimensions, power feed locations, driver locations/quantity, luminaire joint locations as applicable.
 8. Submit documentation that indicates specified products have been tested, or will be tested, for compatibility with the lighting controls being procured and will perform as specified. Control devices or system shall be able to control luminaires with flicker free, continuous dimming, in range specified. Electrical Contractor, luminaire manufacturer and lighting control manufacturer shall be financially responsible for any incompatibilities.
 9. Detailed drawings for nonstandard/custom luminaires indicating dimensions, weights, method of field assembly, components, features, and accessories. Details shall be scaled to a legible size.
 10. Detailed drawings for fiber optic systems including scaled plans with cable layout number and type of fiber bundles, illuminator quantity and location, and a complete bill of materials.
 11. Drawings for site lighting shall include pole data with wind loading, complete dimensions and finish, pertinent physical characteristics and accessories including mounting details, driver type and location and any specified control options.
 12. Photometric Data: Where indicated on luminaire schedule and Contract Drawings, supply complete photometric data for luminaire, including optical performance rendered by independent testing laboratory developed according to methods of the Illuminating Engineering Society of North America as follows:
 - a. Coefficients of utilization
 - b. Luminance table with data presented numerically, showing maximum luminaire luminance at shielding angles. Readings should be taken both crosswise and lengthwise in case of linear luminaire or luminaire with an asymmetric distribution.
 - c. Candela distribution data, presented graphically and numerically, in 5° increments (5°, 10°, 15°, etc.). Data developed for up and down quadrants normal, parallel, and at 11-1/2°, 45°, 67-1/2° to source if light output is asymmetric.
 - d. Zonal lumens stated numerically in 10° increments (5°, 15°, etc.) as above.
 13. No variation from the general arrangement and details indicated on drawings shall be made on shop drawings unless required by actual conditions. All variations shall be marked on drawings submitted for approval.
- F. Provide luminaires with factory or field finish as directed by Architect/Engineer/Lighting Designer. Verify final finish requirements before releasing luminaires for fabrication.
- G. Where specific finish or color is not specified and options exist, submit color or finish samples to Architect for selection. Luminaires not having color or finish acceptable to Architect shall be replaced at no additional cost.

1.6 SAMPLES

- A. Upon return of submittals, and prior to release for manufacturing, Contractor shall furnish one working sample of each luminaire for which sample requirement is noted in Luminaire Schedule.

1. All requested samples shall be furnished as specified on luminaire schedule including: light output, correlated color temperature, distribution, lens type and finish EXCEPT sample shall be wired with minimum 6-ft cord and plug for energization at 120V.
- B. Shipping: Samples shall be complete with specified LED module(s), cord and plug, ready for hanging, energizing, and examining, and shall be shipped, prepaid by Contractor, to Architect/Engineer/Lighting Designer or as otherwise advised.
- C. Samples may not be returned, nor included in quantities listed for project.
- D. Sample must be actual working unit.
- E. All custom luminaires require a submission of material finish samples, component approval and a complete operating prototype luminaire. Prototype to be submitted prior to commencement of final luminaire fabrication and shall include specified LED modules. Modifications may be required as a result of prototype review. These modifications and others that do not materially affect the cost of the luminaire shall be incorporated at no additional cost to Owner.

1.7 LUMINAIRE MOCK-UPS

- A. Upon return of submittals, and prior to release for manufacturing, Contractor shall provide mock-up on site (or at another agreed upon location) in actual architectural conditions for review by Architect/Engineer/Lighting Designer and Owner.
- B. Provide type and quantity of luminaires as requested by Architect/Engineer/Lighting Designer.
- C. Mock-up shall include working luminaires and control devices proposed, and fastening devices.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Luminaires:
 1. As shown on Luminaire Schedule
- B. LED Drivers:
 1. Shall be manufacturer recommended compatible driver.
 2. All LED drivers shall be dimming type standard unless otherwise noted. Refer to construction documents for control per application.
 3. Manufacturers must be compatible with lighting control system(s) provided and control luminaires to specified minimum output per Luminaire Schedule and controls intent documents.
- C. Emergency LED Battery Pack:
 1. Bodine, Dual-Lite, Iota or as specified in the Luminaire Schedule
- D. Low Voltage Transformers:
 1. Q-Tran or as specified in the Luminaire Schedule
- E. LED Modules:

1. Philips Lumileds, Xicato, Cree, GE, Nichia, Osram Sylvania, Bridgelux, Citizen or as specified in the Luminaire Schedule

2.2 FABRICATION AND MANUFACTURER

A. Luminaires:

1. Construction

- a. Luminaires shall bear label indicating circuit voltage. Labels shall not be visible from normal viewing angles.
- b. Luminaires shall be constructed with joints made by means of welded, brazed, screwed, or bolted construction methods.
- c. Housings shall be so constructed that all electrical components are accessible and replaceable without removing luminaires from their mountings.
- d. Surface temperatures of luminaires with integral drivers shall not exceed 90°C in 30°C ambient.
- e. Luminaires recessed in ceilings utilized as air handling plenums shall be certified as suitable for the purpose and conform to NEC Article 300.
- f. Miter cuts shall be accurate, joints shall be flush and without burrs.
- g. Troffers with doors shall have spring-loaded door cam latches unless otherwise noted for special environments and applications.
- h. Luminaires shall be free of light leaks and designed to provide sufficient ventilation of source to provide the photometric performance documented. Low voltage transformers and drivers shall be vented per manufacturer's specifications.
- i. Provide inscription for exit and stairway signs to conform to applicable codes. Provide battery back-up as specified.
- j. Verify types of ceiling construction with General Contractor prior to releasing luminaires for fabrication and delivery and provide luminaires adapted to ceiling construction used.
- k. Coordinate recessed luminaire mounting appurtenances, flanges and trims with construction of ceiling in which luminaire is to be recessed. Provide correct luminaire mounting assembly.
- l. Luminaire frames shall be manufactured of non-ferrous metal or be painted after fabrication.

2. LED Luminaires are considered a lighting system with dependent components that must be evaluated as a complete system. Each LED luminaire includes a light emitting source, provisions for heat transfer, electrical control, optical control, mechanical support and protection, as well as aesthetic design elements. All LED luminaires shall:

- a. Be NRTL 3rd party tested to applicable UL standards. Where remote drivers are specified, all drivers shall also have UL listing or equivalent and comply with code requirements.
- b. Be tested to IESNA LM-79-19 testing using absolute photometry criteria.
- c. Be reported greater or equal to 70% lumen maintenance at 50,000 hours of operation.
- d. Be rapid cycle stress tested.
- e. Have integral LED modules with a minimum operating temperature of -20°C.

- f. Have modules that are capable of being easily replaced upon failure with a manufacturer provided replacement module without voiding the UL listing of the luminaire.
 - g. Have driver housings easily accessible for ease of maintenance.
 - h. Have a maximum operating temperature at LED junction to not exceed 90°C over the expected operating range of the luminaire.
 - i. Be RoHS compliant, lead and mercury free.
 - j. Have an LED operating frequency of + or – 120 Hz.
 - k. Must meet the appropriate Federal Communications Commission (FCC) requirements for FCC 47 CFR 15 (consumer use) and/or FCC 47 CFR Part 18 (industrial use)
 - l. Be Class A Sound rated.
 - m. Be supplied with power supply that complies with IEEE C62.41-1991.
 - n. Operate at 120 or 277 volts, $\pm 10\%$.
 - o. Have reverse polarity protected at all hardwired connections and have high voltage protection in the event connections are reversed or shorted during the installation process.
3. Lenses, Reflectors and Diffusers
- a. All lenses or louvers shall be removable but held so that normal motion will not cause them to drop out.
 - b. All glass used in luminaires shall be made from thermal shock resistant borosilicate glass.
 - c. Optical lenses shall be free from spherical and chromatic aberrations.
 - d. Acrylic lenses shall be 100% virgin acrylic material.
 - e. Diffuser materials shall be UV stabilized in applications exposed to sunlight.
 - f. Troffer lenses shall be 0.125" thick, unless otherwise noted.
 - g. Alzak reflectors and louvers shall be low iridescent equivalent to Coil Anodizers. All Alzak parabolic cones shall be guaranteed against discoloration for a minimum of ten years.
 - h. Reflector cones shall not have visible source flashing in the cone.
4. Optics and Adjustments
- a. Adjustable Angle Luminaire: Luminaires with adjustment beam angle shall contain reliable angle locking devices.
5. Finishes
- a. Provide luminaires with finish as shown in the luminaire schedule. Verify final finish requirements before releasing luminaires for fabrication.
 - b. Painted luminaires shall be painted after fabrication or "post painted".
 - c. Ferrous parts and supports shall be rust proofed after fabrication.
 - d. For weatherproof or vaportight installations, painted finishes of luminaires and accessories shall be weather resistant using proper primers or galvanized and bonderized epoxy, so that entire assembly is completely corrosion resistant for service intended and rated for an outdoor life expectancy of not less than 20 years.
6. Wiring

- a. Luminaires shall be completely wired at the factory and as required by code.
 - b. Internal wiring shall contain no splices.
 - c. Connections shall be made with insulated “wire nut” type mechanical connectors except that driver connections shall comply with NEC Article 410.
 - d. Luminaires shall be provided with flexible conduit, pigtails, and equipment for external connections.
 - e. Recessed luminaires installed in inaccessible ceilings shall be UL listed for through wiring with the junction box accessible from the luminaire opening.
 - f. Cords shall be fitted with proper strain reliefs and watertight entries where required by application.
7. Ceiling Coordination
- a. Verify type of ceiling construction prior to releasing luminaires for fabrication and delivery.
 - b. Provide mounting appurtenance, flanges, sloped ceiling adaptors where required.
 - c. Provide mounting assembly, clips or other mechanical mounting lugs as required for support of luminaires.
8. Track-Lighting Systems:
- a. A lighting track system is defined as a manufactured assembly designed to support and energize luminaires that are capable of being readily repositioned on the track. Its length may be altered by addition or subtraction of sections of track. Lighting track may be either flexible or rigid depending on the specific application.
 - b. Provide lighting track types as specified in Luminaire Schedule, in lengths as indicated on lighting plans.
 - c. Lighting track system includes current carrying conductors which may convey either line voltages (120V or 277V) or low voltages (12V or 24V). Characteristics of lighting track that conveys line voltages are different than a lighting track system that conveys low voltages and as such are governed by different requirements. Therefore, they are considered individually in these Specifications.
 - 1) Line voltage (120V or 277V) Lighting Track systems:
 - a) Provide components, including track, fittings, and luminaires from the same manufacturer as recommended by manufacturer for the intended use. All components shall be UL Listed and comply with the National Electric Code Standards for Lighting Track.
 - b) Maintain continuity of conductors through feeds, splice fittings and boxes. Relative positions of live and neutral conductors must always be maintained along continuous run so that track fittings connect into the track in a consistent manner.
 - c) Support lighting track at intervals recommended by the track manufacturer.
 - d) One or two circuit Lighting Track shall be supplied with separate neutral busbars and have the ability to have each circuit separately dimmed as required when using standard voltage and low voltage luminaires with either magnetic or electronic transformers.

- e) Lighting Track shall have the ability to be dimmed or switched in selected sections in addition to dimming or switching an entire track configuration or track run.
 - f) One and two circuit 120 volt Lighting Track shall be rated at 120/250 volt, 60 Hz, 2,400 watts maximum each circuit. Neutral busbar(s) shall be oversized and comparable to #10 AWG 30 amp wire to reduce the possibility of overheating due to non-linear loads and harmonics.
 - g) One and two circuit 277 volt Lighting Track shall be rated at 277 volt, 50/60 Hz, 5,540 watts maximum each circuit. Neutral busbar(s) shall be oversized and comparable to #10 AWG 30 amp wire to reduce the possibility of overheating due to non-linear loads and harmonics.
 - h) A separate grounding busbar shall be integral in all track lengths.
 - i) 277 volt Track fittings shall be identified by a red rotor and a 277 volt label.
- 2) Low voltage (12V or 24V) Lighting Track systems:
- a) Provide components, including track conductors, remote mounted transformers, fittings, and luminaires from the same manufacturer as recommended by the manufacturer for the intended use. Components shall be UL Listed as applicable for low voltage use.
 - b) Maintain continuity of conductors through feeds, splice fittings and boxes. Relative positions of conductors must always be maintained along continuous run so that track fittings connect into track in a consistent manner.
 - c) Support lighting track at intervals recommended by track manufacturer.
 - d) One and two circuit low voltage Lighting Track shall be supplied with three conductors and have the ability to have each circuit separately switched with either magnetic or electronic transformers provided by the track manufacturer. Two circuit low voltage Lighting Track can only be dimmed if both circuits are fed from the same transformer and as a result, separate circuit dimming shall not be attempted or permitted.
 - e) All transformers shall be supplied with both primary and secondary voltage over-current protection devices that shall remain readily accessible for maintenance and testing purposes.
 - f) Lighting Track shall have the ability to be dimmed or switched in selected sections in addition to dimming or switching an entire track configuration or track run. Separate, single circuit transformers are required for each independently controlled circuit with the use of electrically isolated couplers.
 - g) Conductors used in low voltage Lighting Track shall be, at minimum, equivalent to #10 AWG 30 amp wire or heavier and be capable of carrying a 300 watt load (at 12 volts) up to 32 ft from transformer feed within range of luminaire voltage tolerance. At 24 volts, conductors shall be capable of supplying a 600 watt load up to 60 ft from transformer feed within range of luminaire voltage tolerance.
 - h) If taut strung cable conductors are used as low voltage Lighting Track system, they shall have a Kevlar core to prevent strain on outer current carrying conductors.
 - i) Only insulated type taut strung cable conductors shall be used in order to comply with local electrical codes governing installation.

9. FIBER OPTIC LUMINAIRES

- a. General Constructions and Materials: Illuminators and fibers shall be of one manufacturer to ensure compatibility.
- b. Illuminators: Shall meet all conditions previously listed for LED luminaires.
- c. Where fans are used for cooling, they shall be low noise and quiet running.
- d. Illuminators shall have ultraviolet and infrared absorbing filters to prevent degradation of fiber.
- e. Provide suitable thermal cut out protection.
- f. All fibers shall be cut and installed per manufacturers specifications.

10. Outdoor Lighting Systems:

- a. Provide luminaires, mounting arms, brackets, poles, hand-hole covers, base components, and all other accessories for a complete assembly. Manufacturers shall be responsible for proper fitting of elements and structural integrity of unit
- b. Provide poles as shown on luminaire schedule.
 - 1) Poles shall have hand-holes.
 - 2) Fusing for each luminaire head shall be located in hand-hole near base of pole.
 - 3) Pole base anchor bolts shall be galvanized.
- c. Exterior Luminaires:
 - 1) Shall operate at a minimum ambient temperature of 0°F.
 - 2) Shall be fully gasketed, with UL wet location label.
 - 3) Shall have approved wire mesh screens for ventilation openings.
 - 4) Anodized aluminum reflectors shall have minimum of 0.00079" anodizing thickness.
- d. Pole/Luminaire combination shall have EPA rating that will withstand site wind conditions.
- e. All castings and extrusions shall be given minimum one coat of baked-on clear lacquer, unless painted finish is specified.
- f. Aluminum surfaces shall receive a duronodic or polyester powder paint finish.
- g. Cast-in Luminaire housings installed directly in concrete shall be fabricated of hot dip galvanized steel or cast aluminum or composite.
- h. Where cast aluminum housings are used, give two coats of asphaltum paint prior to installation.
- i. Provide 1/8" thick x 2" diameter solid neoprene grommets at each point light luminaire surfaces are mounted to concrete structure.

2.3 LED SOURCES

A. Static white LED sources shall be:

- 1. Minimum CRI of 85 unless otherwise noted on Luminaire Schedule
- 2. Less than 5% flicker
- 3. Within 0.004 on the CIE 1976 diagram for color spatial uniformity
- 4. Within 0.007 on the CIE 1976 diagram for color maintenance over the rated lifetime of the source

5. Binned within a 3-step MacAdam ellipse minimum, or as indicated in Luminaire Schedule
6. Color temperature as noted on Luminaire Schedule
7. Have a published life rating based on the point at which LED sources reach L70 lumen maintenance and tested in accordance with IES LM80-08 Approved Method: Testing Lumen Maintenance of LED light sources and IES TM-21-11: Projecting Long Term Lumen Maintenance of LED Light Sources
8. L70 rated life shall be a minimum of 50,000 hours.
9. LED modules, unless otherwise noted, shall be provided by light fixtures manufacturer and integral to luminaire.
10. Screw-base LED replacement lamps, where required and listed on the luminaire schedule, shall meet dimming, output, CCT and CRI as specified. 25,000 hours is acceptable L70 rated life for these products.

2.4 DRIVERS

- A. Drivers for use in cold or freezer rooms, parking structures, loading docks, and outdoors shall be low temperature type.
 1. Driver shall have lowest temperature rating available in standard manufacture for its type.
- B. Drivers shall be located in luminaire they serve, unless otherwise noted.
- C. LED Drivers and Power Supplies shall:
 1. Operate system LEDs within the current limit specification of the LED manufacturer.
 2. Be supplied with over-temperature protection circuitry.
 3. Be programmable via manufacturer-provided means to allow for LED replacement modules to be “tuned” to match the output of remaining adjacent modules in the event that some time has passed and there has been lumen depreciation.
 4. Be within a NEMA enclosure.
 5. Be equipped with knockouts to accommodate standard conduit sizes
 6. Have a Power Factor to be = or > than 0.9
 7. Dimmable LED drivers must be compatible with dimming system(s) provided and control luminaires per luminaire schedule and controls documentation.
 8. ETL certified, CBM and UL Listed, high power factor, and meet or exceed NEMA and ANSI Standards.
 9. Class A sound rated
 10. Equipped with resetting thermal sensitive device.
 11. For operation at 60 Hz and voltage as scheduled.
 12. Meet or exceed all ANSI or NEMA standards
 13. Capable of operating LEDs with less than 5% flicker
 14. Be DMX compatible in Color changing LED luminaires.
- D. Emergency LED Drivers shall:
 1. Be UL 924 listed
 2. Operate LED luminaire at 10W minimum output for 90 minutes with efficacy equal to or greater than the normal power efficacy.

3. Have high temperature nickel-cadmium battery. Field replaceable
4. Have solid state charging
5. Battery to be recharged within 24 h

2.5 LOW VOLTAGE TRANSFORMERS

- A. Transformers and power supplies shall be:
 1. Sized to compensate for voltage drop over indicated distances
 2. Locally fused
- B. Transformers shall have line voltage switch within reach.
- C. Provide adequate ventilation to meet code and manufacturers requirements.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Marking:
 1. Voltage identification: Luminaires designed for voltages other than 110-125 volt circuits shall be clearly marked with rated voltage.
 2. Markings must be clear and shall be located to be readily visible to service personnel but invisible from normal viewing angles when luminaires are in place.
- B. Installation of Luminaires:
 1. Housing, glassware, reflectors and refractors shall be clean and free of chips, cracks and scratches.
 2. Install decorative luminaires, reflector cones, baffles, aperture plates, lenses, trims, and decorative elements of recessed luminaires after completion of ceiling tile, plastering, painting, and general cleanup is completed. Where luminaire location or construction does not permit sequential installation, all reflectors, lenses, flanges and other visible surfaces shall be carefully protected.
 3. Light leaks between ceiling trim of recessed luminaires and ceiling are not allowed.
 4. Locations
 - a. Install luminaires at locations and heights as indicated.
 - b. Do not scale electrical drawings for locations of luminaires.
 - c. Architectural reflected ceiling plans show locations of luminaires.
 - d. Where noted on the drawings, the exact location of luminaires shall be confirmed (in the field) with the Architect/Engineer prior to installation.
 - e. Where luminaires are to be concealed, or surface mounted in highly visible public spaces, a small sampling of luminaires shall be installed, adjusted and aimed for Architect/Engineer's review approval, prior to installing remaining luminaire of same type.
 - f. Mount all luminaires so as to maintain full range of motion.
 - g. Install luminaires plumb, square, and level with ceilings and walls.

- h. Coordinate stem, rod, chain, or aircraft cable hanger lengths with job conditions. Provide extra length of adjustable supports where diffusers are mounted directly above light fixtures to facilitate air balancing efforts.
 - i. Industrial type luminaires in unfinished areas, which are near obstructions such as ducts and pipes, shall be:
 - 1) Suspended so that bottom of luminaire is no higher than bottom of obstruction
 - 2) Located at height of lowest luminaire
 - 3) Minimum height: 8'-0"
 - 4) Shall not be located until locations of obstructions are determined.
 - 5) Where a minimum height of 8'-0" is unachievable, wall mounted luminaires shall be utilized.
- 5. Support
 - a. Support surface mount luminaires from building structure.
 - b. Metal decking shall not be pierced for luminaire support.
 - c. Provide luminaires and/or luminaire outlet boxes with hangers to support luminaire weight.
 - d. Troffers shall be held in place by support clips.
 - e. Provide plaster frames for recessed luminaires in plaster ceilings.
 - f. Rigid metallic pipe stems shall be utilized for the support of pendant mounted luminaires, unless otherwise noted.
 - g. Stem hangers shall be equipped with aligner box covers or canopies so that stems hang vertically, irrespective of the angle of the surface they are mounted from.
 - h. Wherever a luminaire or its hanger canopy is attached to a surface mounted outlet box, a finishing ring shall conceal the outlet box.
 - i. Yokes, brackets and supplementary supporting members needed to mount luminaires to suitable ceiling members shall be furnished and installed by Contractor. Verify mounting hardware required prior to installation.
 - j. Recessed luminaires shall be supported with 12 ga wire hangers, 2 per luminaire, at diagonally opposite corners.
 - k. Troffers and luminaires over 55 lbs, such as 4x4 ft shall be supported with 12 ga wire hangers, 4 per luminaire, 2 at 45 degree diagonals, and two perpendicular to structure. Wire hangers and attachment to structure shall be capable of supporting 4 times luminaires weight.
 - l. In areas with seismic requirements, suspended or pendant mounted luminaires shall be able to swing 45 degrees in any direction without hitting an obstruction. In the event hitting an obstruction is unavoidable, guy wires will be used to secure the luminaire in place.
 - m. Surface luminaires installed in grid ceilings shall be supported by independent support clips and 12 ga wire.
 - n. Exit signs installed in grid ceilings shall be supported by electrical box hanger and additional 12 ga wire installed from box to structure.
 - o. Support surface mounted luminaires greater than 2 ft in length at a minimum of each additional 2 ft, or as recommended by manufacturer.

- p. Brace suspended luminaires installed near ducts or other constructions with solid pendants or threaded rods.
 - q. Rigidly align continuous rows of luminaires.
 - r. Luminaire types with remote mounted driver shall have:
 - 1) Proper support for driver weight.
 - 2) Mounting distance from remote driver to luminaire per manufacturer's recommendations.
- 6. Mounting and Enclosures
 - a. Install flush mounted luminaires to eliminate light leakage.
 - b. For luminaires mounted adjacent to insulation, provide barrier to prevent insulation from coming in contact with luminaire, unless luminaire is approved for installation in contact with such insulation.
 - c. Provide approved fire rated enclosures around luminaires in fire rated ceilings.
- 7. Conduit and Wiring
 - a. Wire for connections to modules and auxiliaries shall be suitable for temperature, current, and voltage conditions.
 - b. Recessed luminaires shall have final connections made with flexible metal conduit, not in excess of 72", with THHN conductors and green wire ground conductor.
 - c. Conduit shall be hidden from normal view in all possible cases. In public areas where surface mounted conduit must be used, Contractor shall install conduit as unobtrusively as possible. Contractor shall obtain field approval by the Architect for all exposed conduit runs prior to rough in.
- 8. In-Grade Luminaires:
 - a. Where installed in tree grates, furnish burial light lens and louver to tree grate manufacturer for coordination of opening.
 - b. Provide adequate drainage system per manufacturer's recommendations.
- C. Installation of Outdoor Pole Bases
 - 1. Contractor shall provide bases for luminaires.
 - 2. Pole base details shall be provided by the project structural engineer.
 - 3. Provide handhole for electrical connection within 4'-0" of pole base.
 - 4. Contractor shall:
 - a. Rough-in conduits
 - b. Coordinate spacing, base dimensions, heights, orientation of bases, etc. as necessary.
 - 5. Where square or rectangular poles or luminaire heads are used, Contractor shall verify orientation with Architect/Engineer/Lighting Designer.
- D. Pole Installation:
 - 1. Install luminaires, poles, hardware, etc., for complete system.
 - 2. Use web fabric slings (not chain or cable) to raise and set poles.
- E. Grounding:
 - 1. Ground luminaires and metal poles according to Division 26 Section "Grounding and Bonding for Electrical Systems".

2. Poles:
 - a. Install 10 ft driven ground rod at each pole.
3. Nonmetallic Poles:
 - a. Ground metallic components of lighting unit and foundations. Connect luminaires to grounding system with #10 AWG conductor.

3.2 SUBSTANTIAL COMPLETION

A. Quality Control:

1. At Date of Substantial Completion, replace LED modules/LED luminaires which are not operating properly.
2. Protection wrapping on lensed or louvered luminaires shall be removed before installation of furniture, but after finish work is complete.
3. Deliver spare equipment to Owner's representative.

B. Tests:

1. Give advance notice of dates and times for field tests.
2. Provide instruments to make and record test results.
3. Verify normal operation of each luminaire after luminaires have been installed and circuits have been energized.
4. Verify operation of luminaires with lighting control system and daylight harvesting systems. Any dimmed fixtures shall exhibit no signs of flickering.
5. Replace or repair malfunctioning luminaires and components, then retest. Repeat procedure until all units operate properly.
6. Report results of tests.

C. Adjusting and Cleaning:

1. Clean luminaires of handling marks, dust and dirt.
2. Cleaning and touch-up work shall be performed in accordance with luminaire manufacturer's recommendations.
3. Damaged luminaires or components shall be replaced with new.
4. Keep luminaires clean and protected for remainder of construction period.
5. Verify orientation of directional luminaires prior to installation.
 - a. This includes wall washers, cove lighting, floodlights, exterior area lights and adjustable accent luminaires. Contractor shall provide electrician's services to aim, adjust, and focus luminaires, as required, at direction of Architect/Engineer. These electricians shall be available at times designated by Architect/Engineer and shall be provided at no extra charge to Owner over base bid. Contractor shall provide equipment for luminaires' focus including ladders and mechanical lifting systems.
6. Program preset dimming system lighting levels.
7. Program ambient light sensors integral to luminaires for appropriate illumination levels as indicated in control narrative or in lighting control specifications.
8. Program occupancy sensors integral luminaires for appropriate time delay as indicated in control narrative or in lighting control specifications.

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9. Exterior poles, bollards, bases and other exterior luminaires shall be painted to match factory color where finish has been damaged.
10. No light leaks shall be permitted at ceiling line from any visible part or joint.

D. Training

1. Contractor shall provide Owner with 1 complete hardcopy and (1) digital copy of Operations and Maintenance manuals.
 - a. All "Approved as Noted" comments shall be corrected/picked-up in this record manual set.
 - b. Each manual shall contain specific information pertaining to the equipment installed. Each manual shall contain at a minimum:
 - 1) Detailed as built shop drawings for all lighting equipment installed.
 - 2) Manufacturer's product cut sheets for all equipment installed keyed by type as to as built drawings.
 - 3) Manufacturer's complete installation instructions for all equipment installed keyed by type to as built drawings.
 - 4) Equipment maintenance requirements and schedules.
 - 5) Equipment manufacturer contacts.
 - 6) Equipment manufacturer warranties.
 - a) Luminaires
 - b) Drivers
 - c) LED modules
2. Contractor shall provide qualified personnel onsite to provide a minimum of one day of training to Owner's representatives.
3. This training shall cover:
 - a. Luminaire use and maintenance
 - b. Architectural lighting system use and maintenance

END OF SECTION 265000

SECTION 265668 - ATHLETIC LIGHTING

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 lighting for fields used for one or more multi-directional aerial sports such as soccer, lacrosse, and football.
- B. Portions of this specification are specific to exterior lighting, such as pole and base requirements. Only criteria which could be applicable to interior lighting shall apply for interior applications.

1.3 REFERENCES

- A. Illumination Engineering Society Recommended Practice for Sports and Recreational Area Lighting, current edition. (IES RP-6-15)

1.4 DEFINITIONS

- A. Illuminance: The metric most commonly used to evaluate lighting systems. It is the density of luminous flux, or flow of light, reaching a surface divided by the area of that surface.
 - 1. Horizontal Illuminance: Measurement in foot-candles, on a horizontal surface, 36 inches above ground unless otherwise indicated.
 - 2. Target Illuminance: Average maintained illuminance level, calculated by multiplying initial illuminance by LLF.
 - 3. Vertical Illuminance: Measurement in foot-candles, in multiple directions on a vertical surface, at an elevation coinciding with plane height of horizontal measurements.
- B. Light Trespass: Light spill into areas and properties outside the playing areas, which is either annoying or unwanted.
- C. Lamp lumen depreciation (LLD): the decrease in lamp output as the lamp ages.
- D. Light loss factor (LLF): the product of all factors that contribute to light loss in the system.
- E. Luminaire: all components of a light-producing assembly to include the housing, source, heat sink, optics, accessories, and any integrated electronics required to condition the supplied power.
- F. Coefficient of Variation (CV): the statistical weighted average of all relevant illuminances.
- G. Uniformity gradient (UG): the rate of change of illuminance on the playing field, expressed as a ratio between the illuminances of adjacent measuring points on a uniform grid.

- H. Uniformity Ratio: (E_{max}/E_{min}) A ratio of the highest to lowest calculated or measured illumination value at a given surface.
- I. Primary playing area: an area including the playing field and extending 15 feet beyond the boundaries of the playing field in all directions.

1.5 ELECTRICAL DESIGN REQUIREMENTS

- A. Provide complete turnkey design and installation of electrical systems to support sports lighting system.
- B. Successful bidder to provide electrical design drawings (wire, conduit, breakers, contactors, etc.) detailing all electrical components between the multi-wire branch circuits indicated for each pole assembly and individual components within the athletic light assembly.
- C. Application is an indoor practice facility within an engineered metal building. Provide supports for fixtures, coordinate all attachments with building structure.
- D. Turnkey installation includes:
 - 1. Balance load between phases.
 - 2. Include required overcurrent protective devices for each luminaire and individual lighting control for each sports field or venue.

1.6 LIGHTING SYSTEM DESIGN REQUIREMENTS

- A. The maintained illuminance level shall be calculated using the published lumen output of the luminaire with a combined light loss factor (to account for lamp lumen depreciation at 50,000 hours and projected luminaire dirt depreciation) of not greater than 0.90.
- B. Glare and spill light control:
 - 1. Glare control may be achieved by internal and/or external hardware. Glare shall be minimized from the lamp and the reflector when standing in front of the lighting assembly beyond the property line and when standing 90-degrees perpendicular to the lighting assembly beyond the property line.
 - 2. Minimize spill light for each playing area on adjacent and nearby areas. Prevent light trespass on properties near Project as defined by the Town of Chapel Hill, NC. Calculate the horizontal and vertical illuminance due to spill light for points at the playing area boundary (fence) and 20-ft beyond.
- C. Illumination Calculations: Computer-analyzed point method complying with IESNA RP-6-15 to optimize selection, location, and aiming of luminaires.
 - 1. Grid Pattern Dimensions: For playing areas of each sport and areas of concern for spill-light control, correlate and reference calculated parameters to the grid areas. Each grid point represents the center of the grid area defined by the length and width of the grid spacing.
 - 2. Luminaire Mounting Height: Comply with IESNA RP-6-15, with consideration given to minimize spill light and glare.
 - 3. Luminaire Placement: Luminaire shall be outside the glare zones defined by IES RP-6-15.

1.7 LIGHTING SYSTEM PERFORMANCE REQUIREMENTS

- A. Facility Type: Collegiate
 - 1. Class II – Maximum CV = 0.21, Maximum Uniformity Ratio = 2.5 except where more stringent criteria is outlined in these or other construction documents
 - 2. Moderate to Fast speed of play as viewed by spectators
- B. Illumination Criteria:
 - 1. All criteria shall meet or exceed criteria of IES RP-6-15 for the given sport, class, and speed of play except where more stringent criteria are given herein. Such criteria may include:
 - a. Minimum average target illuminance level at 3-ft above the surface of play
 - b. CV, UG, and Uniformity Ratios
- C. Illumination Criteria: Practice field for Soccer or Football (indoor/outdoor)
 - 1. Minimum Average Target Illumination: 75 FC
 - 2. Uniformity Ratio: ??? 2.0
- D. The lighting design is to be based on counts, setbacks, and mounting heights consistent with IES RP-6-15.
- E. Lighting Control shall be automated by astronomic timeclock with manual override capability providing the following functions, integrated into a single control station, with multiple sub-control stations as required:
 - 1. Control Station: Key-operated master switch, manual push-button controls, and system status indicator lights.
 - 2. Soccer, lacrosse, football, field-hockey, and track in-field light levels: 2 levels at 100% and 50% of specified illumination
- F. Lighting Control shall incorporate web-based functionality to allow control by University Staff from cell phones, either via App or through web-based portal.

1.8 SUBMITTALS

- A. Alternate suppliers must submit the following information 14 days prior to bid for consideration:
 - 1. Photometric design layout for specified light level showing point by point “maintained” foot-candle levels for each field meeting requirements of these specifications.
 - 2. Photometric IES Files for fixtures being offered.
 - 3. Letter on light system manufacturer’s letterhead guaranteeing light levels will be met.
 - 4. Letter on light system manufacturer’s letterhead guaranteeing control system meets specification.
 - 5. Letter on light system manufacturer’s letterhead guaranteeing warranty and financial reserves.
 - 6. Letter on light system manufacturer’s letterhead guaranteeing energy consumption will not increase over time.

7. Descriptive literature on all proposed lighting equipment.
 8. Exceptions: Statement of exceptions and discrepancies to bid specifications if any.
- B. Product Data: For each type of lighting product indicated. Include the following:
1. Luminaires: Housing materials and construction, electronics, output and energy use data.
 2. Source data certified by NVLAP or NRTL; comply with IES LM-79.
 3. Projected lumen maintenance at 50,000 hours based on IES LM-80 and TM-21 standards.
 4. Control equipment
 5. Warranty details: provide sample warranty document without dates to demonstrate compliance with warranty requirements included in this section. Product data and shop drawings will not be approved without warranty details.
- C. Shop Drawings:
1. Mounting Details:
 - a. Site-specific details for supporting fixtures from structure provided.
 2. Electrical system design:
 - a. Wiring requirements, including required conductors and cables and wiring methods.
 - b. Total connected and estimated peak-demand electrical load, in kilowatts, of lighting system.
 - c. Capacity of service and feeders required to supply lighting system.
 3. Lighting calculations: Computer-derived lighting plan showing the point-by-point horizontal maintained illuminance levels on a 30 x 30-ft square grid with criteria as follows:
 - a. Grid shall be oriented such that one of the calculation points is offset fifteen feet in each direction from a point at the midpoint of the playing field.
 - b. Manufacturer's determination of LLF used in design calculations.
 - c. Uniformity ratio (EMAX:EMIN) of each playing area.
 - d. CV of each playing area.
 - e. Maximum UG of each playing area.
 - f. Point calculations of horizontal and vertical illuminance in areas of concern for spill light.
 4. Additional lighting system criteria: The following information may be provided in drawing or tabular format:
 - a. Number of luminaires used at each location.
 - b. Mounting height.
 - c. Energy consumption of the lighting system in kW.
 - d. Luminaire lumens (delivered) used in the calculations.
 - e. Light aiming point plan: The contractor shall submit an aiming plan indicating the horizontal degree setting and the vertical degree setting of each fixture on each of the pole assemblies.

5. Following designer review and approval, but before installation commences, complete submittal (shop drawings, product data, etc) must be submitted to the State Construction Office for review and approval. Submitted shop drawings must be stamped by a PE licensed in the state of North Carolina.

1.9 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. Drivers: Equal to 1% of amount installed for each size indicated, but no fewer than 2 units.
 2. Fuses: Equal to 2% of amount installed for each size indicated, but no fewer than 5 units.

1.10 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: emergency, operation, and maintenance manuals for sports lighting system components.
- B. Successful bidder to perform final light tests with Owner and make any adjustments necessary to meet specifications. A typed photometric report of actual light levels on each field must then be submitted prior to final payment being released.

1.11 QUALITY ASSURANCE

- A. All materials furnished under this Contract shall be new, free from defects of any kind, of the quality and design hereinafter specified, and shall conform to the standards of Underwriter's Laboratories Inc.
- B. The Sports Lighting Supplier shall be dedicated to sports lighting with in-house engineering, sales and support personnel. Supplier shall maintain inventory and personnel who are qualified to supervise the installation, to be responsible that the system is installed as submitted, to conduct system start up, instruct the Owners representatives in the proper operation of the system and provide service throughout the warranty period.
- C. Installer Qualifications:
 1. Trained and authorized by the manufacturer for installation of units required for this Project.
 2. Installer shall have been in business at least five consecutive years under the same name and shall have installed, under that name, at least ten sports lighting systems similar to this project.
 3. Installer shall be fully experienced in the installation of the lighting systems as herein specified, and shall furnish with the bid an itemized list of the installations of this type. The list shall include the name of the project, date of completion, the amount of the contract, the name, and telephone number of the person to contact for reference.

- D. The ability of any bidder to obtain plans and provide a performance bond shall not be regarded as the sole qualification of such bidder's competency and responsibility to meet the requirements and obligations of the contract. Before using the bid of a subcontractor as part of his bid, the General Contractor shall satisfy himself that the proposed subcontractor can satisfy all of the requirements expressed above. The Owner reserves the right to reject any bid if the evidence submitted by, or investigation of, such bidder fails to satisfy the Owner that the bidder and/or any subcontractor he proposes can properly qualify to carry out the obligation of any part of the contract, and to complete the work contemplated therein.

1.12 WARRANTY

- A. Lighting Manufacturer must maintain specifically funded financial reserves to assure fulfillment of the warranty for the full term. Warranty must cover the cost for labor, shipping expenses, lifts (or other equipment rentals) and material for repairs.
- B. Lighting Manufacturer must repair or replace any part of the sports lighting luminaires, wiring, alignment products, and structural components that proves to be defective for a period of 10 years from the date of final acceptance.
- C. Warranty must guarantee light levels, aiming, and energy consumption. Energy consumption must not increase as the system ages. Manufacturer agrees to correct misalignment that occurs subsequent to successful acceptance tests.
- D. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, and unauthorized repairs and alterations from warranty coverage.

1.13 MAINTENANCE SERVICE

- A. Make available to the Owner, in the form of a standard maintenance agreement, a proposal for an extended warranty period from the original 10 years to 25 years from the date of substantial completion. Services, obligations, conditions, and terms must include at a minimum the terms of the original warranty period.
- B. During the warranty period, services shall include periodic illumination maintenance testing, monitoring of on/off status and hours of usage relative to commissioned control system, and repair or replacement of all lighting, alignment, and structural components of the system which may be affected by conditions excluded from the warranty.
- C. The owner agrees to check fuses in the event of a luminaire outage.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Musco
- B. Ephesus
- C. Will

2.2 SPORTS LIGHTING – INTERIOR ROOF STRUCTURE MOUNTED

- A. The interior sports lighting system shall consist of steel galvanized or painted clamps or bolted connections to the building roof structure with a factory pre-wired luminaire support assembly. All wiring and connections should be factory assembled from the fixture mounting location to the connection to the structure. Strain relief devices must be factory installed in pre-wired cross-arm assembly to ensure no weight or tension is placed on electrical connections.
- B. Sports Lighting vendor shall provide all required information to coordinate with the steel roof designer and shall design lighting connections to accommodate the steel roof design.
- C. Connections to the building structure shall be designed and sealed by a licensed engineer in the State of North Carolina.
- D. Remote drivers are acceptable. Should they be employed by the sports lighting vendor, installation and all wiring, conduit and other electrical work between the remote ballasts and all luminaires shall be provided as part of this contract.

2.3 LUMINAIRES

- A. Lighting performance criteria:
 - 1. Luminaire shall have a Correlated Color Temperature (CCT) of 5700K with a tolerance of $\pm 300K$, and a minimum CRI of ≥ 68 .
 - 2. Luminaire shall be third-party verified to be flicker free at super slow-motion speeds up to 2400 FPS and use pulse width modulation greater than 18 KHz with a flicker index rating of less than 0.06.
 - 3. Luminaire shall have lumen depreciation, L90 rating, greater than 50,000 hours as determined in accordance with IES TM-21-11 or L70 rating greater than 100,000 hours certified through CREE Tempo-24 Testing or equivalent.
- B. Construction:
 - 1. Luminaire must be UL Classified for wet locations at an operating temperature range rating between $-40^{\circ}C$ and $+65^{\circ}C$.
 - 2. Luminaire must be 3rd party NEMA 4X rated based on NEMA 250 standards for external icing, hose-down, and 200-hours salt spray test.
 - 3. Luminaire shall have an EPA of 1.4 sq feet or less.
 - 4. Aluminum shall be multi-stage powder coated for long term resistance to corrosion and UV exposure.
- C. Electrical requirements:
 - 1. Manufacturer will supply all drivers and supporting electrical equipment.
 - 2. Remote electrical equipment, if provided, must be mounted a minimum of 10ft above grade in aluminum NEMA 3R enclosures. The enclosures shall be touch-safe and include drivers and fusing with indicator lights on fuses to notify when a fuse is to be replaced for each luminaire. Disconnect per circuit for each pole structure will be in the enclosure.
 - 3. Luminaire shall have a power factor greater than 0.98 @ 277VAC and 0.97 @ 480VAC

4. Luminaire shall have a THD (Total Harmonic Distortion) Less than 10% at 240VAC with full load and less than 14% at 480VAC at full load.

D. Integrated power supply shall have the following features:

1. Efficiency - Greater than 95% from 240VAC to 480VAC with full load applied
2. Hold Up Time – Greater than 25ms
3. Restrike Time - Less than 3.0s to meet UL924 Emergency Lighting requirements

2.4 CONTROL SYSTEM

- A. Provide a wired or wireless control system with the capability to link to external devices such as smartphones and tablets as well as desktop and laptop systems via Bluetooth, Wi-Fi, LAN, or cellular connection to switch lights on/off as well as dimming the system to specified levels via the wireless control hub.
- B. Provide control and monitoring of the LED fixtures via a secure network.
- C. System shall be capable of storing power data, behaviors, alarms and critical events for maintenance and troubleshooting.
- D. Performance criteria:
 1. Allow individual addressing of luminaires to be grouped into zones and scenes for facility scheduling
 2. Zoned into groups to facilitate use of individual athletic venue at the site.
 3. Capable of smooth- or step-dimming with presets for high, medium, low, and off control points.
 4. Provide emergency illumination by means of a low dimming setpoint or specially zoned luminaires to serve this additional purpose or a combination thereof.
- E. System shall be FCC/IC certified
- F. Data shall be secured by dual-layer password protection accessible to the Owner.
- G. Manufacturer shall include any communication costs for monitoring of the system for the entire warranty period.
- H. Remote Monitoring: Control component status (switch position, contactor status, etc.) and lighting performance shall be monitored by the system to notify manufacturer and owner if individual outage is detected so that appropriate maintenance can be scheduled.
- I. Scheduling: Controller shall accept and store 7-day schedules in non-volatile memory and be able to execute curfews and early-off commands.
- J. Management Tools: Manufacturer shall provide software for management of lighting system. At a minimum, the following parameters should be accessible.
 1. Operating hours
 2. Cumulative burn hours
 3. Cumulative Watt-hours
 4. Average Current

5. Peak Current
6. Input Voltage
7. Peak Input Voltage
8. Average Power

2.5 SURGE PROTECTION

- A. Surge Protection: Comply with requirements in Section 264300 "Surge Protective Devices" and include surge suppressors on all electrical distribution equipment serving the sports lighting system.

PART 3 - EXECUTION

3.1 DELIVERY

- A. The entire sports lighting system shall be delivered to the jobsite by the sports lighting supplier. All material (fixtures, cross-arm assemblies, etc.) shall arrive the same day. The supplier shall off-load all material and stage required material at each pole location to eliminate possibility of lost or damaged material. Delivery shall be made within 21 days after notice to proceed.

3.2 INSTALLATION

- A. Erection of structural members and installation of luminaires shall be in accordance with the manufacturer's written instructions. Instructions of this specification may be used only to supplement the manufacturer's instructions with written consent.
- B. Use web fabric slings (not chain or cable) or other protective means to raise and set structural members to protect equipment from corrosion during installation.
- C. Install poles and other structural units level, plumb, and square.
- D. Except for embedded structural members, grout voids where they exist between pole base and foundation. Use non-shrinking or expanding concrete grout firmly packed in entire void space. Use a short piece of 1/2-inch-diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
- E. Install controls and driver housings in cabinets mounted on support structure at least 10 feet above finished grade.

3.3 FIELD QUALITY CONTROL

- A. After installing sports lighting system and after electrical circuits have been energized, Sports Lighting Supplier shall perform proof-of-performance field measurements and analysis for compliance with requirements in accordance with applicable provisions of IES RP-6-15.
- B. Test procedures:
 1. Test methods, instruments, and test intervals shall meet the approval of the Owners representative prior to testing.

2. Testing equipment for measurement of foot-candle levels shall be performed using a Konica Minolta T-10 Illuminance Meter (or equal). Supplier must show proof of calibration prior to testing as required by the manufacturer. Accuracy shall be $\pm 4\%$ or less of recording. Measuring functions shall be in foot-candles.
3. The contractor shall take voltage and current readings at each pole base during the time of the test for ascertaining the approximate fixture operating condition. Voltage at the pole base shall be adjusted within $\pm 5\%$ of rated ballast voltage.
4. The contractor shall provide stakes or other identifiable markings at all test points on the field at the time of the test. The supplier shall aid the contractor in locating these test points to correspond (same quantity and relative location) with the calculated values approved in the shop drawings.
5. Readings shall be recorded for each point and the results confirmed by Owner and/or Engineer.
6. Measurements shall be taken at 36" inches above grade, with meter held horizontally. Dark clothing shall be worn by individuals performing test.
7. Make horizontal and vertical field measurements at established test points in areas of concern for spill light and glare.

C. Acceptance Criteria:

1. The measured values shall be within $\pm 10\%$ of the calculated values indicated on the approved shop drawings.
2. Perform analysis to demonstrate correlation of field measurements with submittal drawings and submit a report of the analysis.

D. Failure to meet acceptance criteria shall require Correction of Illumination Deficiencies:

1. Add or replace luminaires, or change mounting height, revise aiming, or install louvers, shields, or baffles.
2. If luminaires are added or mounting height is changed, revise aiming and recalculate and modify or replace support structures if indicated.
3. Do not replace luminaires with units of higher or lower wattage without Engineer's approval.
4. Retest as specified above after repairs, adjustments, or replacements are made and submit revised report.

E. Any expense associated with Correction of Illumination Deficiencies, if any, shall be borne by the supplier with no additional cost to the Owner or Engineer.

3.4 ADJUSTING

- A. Apparent "hot spots" or "dark spots" shall be eliminated by further fixture adjustment as required.
- B. If in the judgment of the Owner's Representative, the manufacturers computed results cannot be obtained, this contractor shall furnish and install additional fixtures, wire, conduit, breakers, etc., as required to achieve the manufacturers predicted results at no additional cost to the Owner or Engineer.

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3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain exterior athletic lighting system in accordance with terms of warranty and any accepted maintenance contract.

END OF SECTION 265668

SECTION 270000 - GENERAL COMMUNICATIONS REQUIREMENTS

PART 1 - GENERAL

1.1 SCOPE

- A. This section details references, standards, guidelines, requirements and conditions common to all Division 27 work.
- B. Work under this Section and related sections is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.2 DESCRIPTION

- A. Intent of drawings and specifications is to obtain complete systems tested, adjusted, and ready for operation.
- B. Except as otherwise defined in greater detail, terms "provide", "furnish" and "install" as used in Division 27 contract documents shall have the following meanings:
 - 1. "Provide" or "provided" shall mean "furnish and install".
 - 2. "Furnish" or "furnished" does not include installation.
 - 3. "Install" or "installed" does not include furnishing.
- C. Include incidental details not usually shown or specified, but necessary for proper installation and operation.
- D. Check, verify and coordinate work with drawings and specifications prepared for other trades. Include modifications, relocations or adjustments necessary to complete work or to avoid interference with other trades.
- E. Included in this contract are connections to equipment provided by others. Refer to Architectural, Electrical, Integrated Automation, Mechanical, Security and final shop drawings for equipment being furnished under other sections for exact locations of outlets and various connections required.
- F. Information given herein and on drawings is as exact as could be secured but is not guaranteed. Do not scale drawings for exact dimensions.
- G. Where architectural features govern location of work, refer to architectural drawings.
- H. Perform work in "neat and workmanlike" manner as defined in ANSI/NECA 1 "Standard Practices for Good Workmanship in Electrical Contracting".

1.3 RELATED WORK

- A. Utility Services:
 - 1. Services are provided by ECU. Coordinate all service activations and disturbances with ECU's project representative.

B. Temporary Services:

1. Refer to Division 01 - Temporary Facilities and Controls.

C. Continuity of Service:

1. No service shall be interrupted or changed without permission from Architect and Owner. Obtain written permission before work is started.
2. When interruption of services is required, persons concerned shall be notified and shall agree upon a time.

D. Demolition:

1. Division 01 - Selective Demolition.
 - a. Not applicable to this Division of work.
2. Division 02 - Building Demolition
 - a. Not applicable to this Division of work.
3. Perform demolition as required to accomplish new work.
 - a. Remove abandoned wiring to source of supply.
 - b. Disconnect abandoned outlets and remove devices.
 - c. Remove abandoned outlets if conduit servicing them is abandoned and removed.
 - d. Provide blank cover for abandoned outlets that are not removed.
 - e. Disconnect communications systems in walls, floors, and ceilings scheduled for removal.
4. Accomplish work in neat workmanlike manner to minimize interference; annoyance or inconvenience such work might impose on Owner or other contractors.
5. Unless otherwise noted, remove from premises materials and equipment removed in demolition work.
6. Equipment noted to be removed and turned over to Owner shall be delivered to Owner at place and time Owner designates.
7. Where materials are to be turned over to Owner or reused and installed by Contractor, it shall be Contractor's responsibility to maintain condition of materials and equipment equal to that existing before work began. Repair or replace damaged materials or equipment at no additional cost to Owner.
8. Where demolition work interferes with Owner's use of premises, schedule work through Architect, Owner and with other contractors to minimize inconvenience to Owner. Architect must approve schedule before Contractor begins such work.

E. Cleaning and Repair

1. Clean and repair existing materials and equipment that remain or will be reused.

F. Concrete Work:

1. Provide cast-in-place concrete as required by contract documents unless otherwise noted.
2. Concrete shall comply with Division 03 - Concrete.
3. Provide anchor bolts, metal shapes and templates required to be cast in concrete or used to form concrete for support of equipment.

G. Painting:

1. Furnish equipment with factory applied prime finish unless otherwise specified.
2. If factory finish on equipment furnished by Contractor is damaged in shipment or during construction, refinish equipment to satisfaction of Engineer.
3. Furnish one can of touch up paint for each factory finish, which will be final finished surface of product.
4. Contractor is responsible for painting of plywood in Telecommunications Equipment Rooms. Refer to Drawings.

1.4 REQUIREMENTS OF REGULATORY AGENCIES

- A. Rules and regulations of Federal, State and local authorities and utility companies, in force at time of execution of contract shall become part of this specification.

1.5 REFERENCES AND STANDARDS

- A. Design, cable and component selection, and installation practices shall conform with following:

1. ANSI/NFPA 70 - National Electrical Code
2. Local Electrical Code
3. Country, state and local health, safety and building codes
4. UL 444 - Communications Cables
5. Standards identified in individual Technical Sections.
6. BICSI Telecommunications Distribution Methods Manual (TDMM)
7. TIA-568.0-E - Generic Telecommunications Cabling for Customer Pre(including applicable Addenda)
8. TIA-569-E - Commercial Building Standard for Telecommunications Pathways and Spaces

- B. Agencies or publications referenced herein refer to the following:

1. ANSI: American National Standards Institute
2. ASME: American Society of Mechanical Engineers
3. ASTM: American Society for Testing and Materials
4. BICSI: Building Industry Consulting Services International
5. FIPS: Federal Information Processing Standards
6. FCC: Federal Communications Commission
7. ICEA: Insulated Cable Engineers Association
8. IEEE: Institute of Electrical and Electronics Engineers
9. NEC: National Electrical Code
10. NECA: National Electrical Contractors Association
11. NEMA: National Electrical Manufacturers Association
12. NESC: National Electrical Safety Code
13. NETA: National Electrical Testing Association
14. NFPA: National Fire Protection Association
15. NIST: National Institute of Standards and Technology

16. OSHA: Occupational Safety and Health Administration
 17. TIA: Telecommunications Industry Association
 18. UL: Underwriters Laboratories, Inc.
- C. Work shall be in accordance with latest edition of codes, standards or specifications unless otherwise noted.

1.6 DEFINITIONS

- A. The following definitions are applicable to communications environments and shall apply to this document and its companion sections for clarification and direction.
1. Entrance facility - an entrance to building for both public and private network service cables and/or wireless services including entrance point of building and continuing to Entrance Room.
 2. Entrance Room - room where both public and private network service cables and/or wireless services are terminated. Service provider(s) point-of-demarkation (DEMARC) is typically located here.
 3. Equipment Room (Telecom): an environmentally controlled centralized space for telecommunications equipment that usually houses main or intermediate cross-connect. Backbone cabling, cabling to Building Entrance and horizontal cabling may be terminated here.
 4. Guarantee - promise or an assurance that attests to quality or durability of product or service or that task will be performed in specified manner. Used interchangeably with "Warranty" in these documents.
 5. Intra-building - within single building.
 6. Inter-building - between 2 or more buildings.
 7. IP Telephony – Use of Internet Protocol (IP) for two-way transmission of conversations. Sometimes referred to as “Voice over Internet Protocol (VoIP)”.
 8. Rack Unit - standard measurement of vertical mounting space on an equipment rack. Each Rack Unit is 1-3/4" high.
 9. Voice over Internet Protocol – Refer to IP Telephony.
- B. Typical NEMA Enclosures and Usage
1. Refer to Section 260000 - General Electrical Requirements.

1.7 ABBREVIATIONS AND ACRONYMS

- A. The following abbreviations and acronyms shall apply to this document and its companion sections for clarification and direction.
1. AFF: Above Finished Floor
 2. ATM: Asynchronous Transfer Mode
 3. AWG: American Wire Gauge
 4. BAS: Building Automation Systems
 5. BTU: British Thermal Unit
 6. CATV: Community Antenna Television

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7. CCTV: Closed-Circuit Television
8. CDDI: Copper Distributed Data Interface (Cisco Systems trade name for TP-PMD)
9. cm: centimeters
10. °C: degrees Celsius
11. °F: degrees Fahrenheit
12. DTMF: Dual Tone Multi Frequency
13. EIA: Electronic Industries Alliance
14. EF: Entrance Facility
15. ER: Entrance Room
16. EIDF: Equipment Intermediate Distribution Facility
17. FDDI: Fiber Distributed Data Interface
18. ft: feet
19. GbE: Gigabit Ethernet
20. Hz: Frequency in Hertz (k = kilo, M = Mega, G = Giga)
21. ID: Inside Diameter
22. in: inch
23. IPT: IP Telephony
24. kg: kilogram
25. lbs: pounds
26. LAN: Local Area Network
27. MATV: Master Antenna Television
28. MC: Main Cross-connect
29. m: meters
30. mm: millimeters
31. Mbps: Megabits per second
32. μm : micrometer (10^{-6} meter)
33. OD: Outside Diameter
34. PBX: Private Branch Exchange (Telephone Switch)
35. pF: pico-Farad (10^{-12} Farad)
36. PVC: Polyvinyl Chloride
37. RU: Rack Unit
38. sq ft: square feet (area)
39. TP-PMD: Twisted Pair Physical Medium Dependent
40. WAN: Wide Area Network
41. WLAN: Wireless Local Area Network
42. VoIP: Voice over Internet Protocol

B. Refer also to technical sections for additional terminology.

1.8 LISTING

- A. Refer to technical sections of this Division of work for listing requirements.

1.9 SUBMITTALS

- A. Submit shop drawings for equipment provided under this Section:
 - 1. Refer to Division 01 - Submittal Procedures.
 - 2. Note that for satisfying submittal requirements for Division 27, "Product Data" is usually more appropriate than true "Shop Drawings" as defined in Division 01. However, expression "Shop Drawings" is generally used throughout specification.
 - 3. Mark catalog sheets and drawings to indicate specific items submitted.
 - a. Markings shall be reproducible (e.g. arrow, boxed, encircled, checkmark).
 - b. Where sheet includes multiple product options, mark proposed option(s).
 - 4. Include proper identification of equipment by name and/or number, as indicated in specification and shown on drawings.
 - 5. When manufacturer's reference numbers are different from those specified, provide correct cross-reference number for each item. Mark and annotate submittals accordingly.
 - 6. Group submittals by Section to include complete documentation of related systems, products and accessories. Where applicable, dimensions shall be marked in units to match those specified.
 - 7. Submittals shall be in electronic form or on paper per Division 01.
 - a. Documents in electronic form shall be Adobe Acrobat PDF.
 - b. Paper documents shall be original catalog sheets or photocopies thereof.
 - c. Facsimile (fax) sheets will not be accepted.
 - 8. Engineer's Review is to confirm compliance with performance, interoperability, physical, and other pertinent requirements of project. Review is not to confirm quantities nor that all required items have been submitted.
 - 9. When equipment and items specified include accessories, parts and additional items under one designation, submittals shall be complete and include required components.
 - 10. Include wiring diagrams for electrically powered or controlled equipment.
 - 11. Submit equipment room layouts drawn to scale, including equipment, raceways, accessories and clearance for maintenance.
 - 12. Where submittals cover products containing potentially hazardous non-metallic materials, include "Material Safety Data Sheet" (MSDS) from manufacturer stating physical and chemical properties of components and precautionary considerations required.
 - 13. Submit shop drawings or product data as soon as practicable after signing contracts. Submittals must be approved before installation of materials and equipment.
 - 14. Submittals, which are not complete, not permanent, or not properly checked by Contractor, will be returned without review.
 - 15. "Coordination Drawings", which are normally prepared by Contractor to coordinate work among various trades and to facilitate installation, shall not be submitted for Division 27 work unless specifically requested in technical sections. These types of drawings typically include dimensioned piping, ductwork, communications and/or electrical raceway layouts.

- a. Unless specifically requested in Division 27 technical sections, submittals of coordination drawings will be returned without review.
- B. Certificates and Inspections:
 1. Obtain and pay for inspections required by authorities having jurisdiction and deliver certificates approving installations to Owner unless otherwise directed.
- C. Operation and Maintenance Manuals:
 1. Refer to Division 01 - Operation and Maintenance Data.
 2. Upon completion of work but before final acceptance of system, submit to Architect for approval, 3 copies of operation and maintenance manuals in loose-leaf binders. If "one copy" is larger than 2" thick or consists of multiple volumes, submit only one set initially for review. After securing approval, submit 3 copies to Owner.
 3. Manuals shall be organized by specification section number and shall have table of contents and tabs for each piece of equipment or system.
 4. Manuals shall include the following:
 - a. Copies of shop drawings
 - b. Manufacturer's operating and maintenance instructions. Include parts lists of items or equipment. Where manufacturer's data includes several types or models, applicable type or model shall be designated.
 - c. CD ROM's of O&M data with exploded parts lists where available
 - d. Phone numbers and addresses of local parts suppliers and service companies
 - e. Internet/WEB page addresses where applicable
 - f. Wiring diagrams
 - g. Start up and shut down procedure
 - h. Factory and field test records
 - i. Additional information, diagrams or explanations as designated under respective equipment or systems specification section
 5. Instruct Owner's representative in operation and maintenance of equipment. Instruction shall include complete operating cycle on all apparatus.
 6. O&M manuals and instructions to Owner shall be provided prior to request for final payment.
- D. Record Documents:
 1. Refer to General Conditions of Contract, and Division 01 - Closeout Procedures. Prepare complete set of record drawings in accordance with Division 01.
 2. Use designated set of prints of contract documents as prepared by Architect to mark-up for record drawing purposes.

1.10 JOB CONDITIONS

- A. Building Access:
 1. Arrange for necessary openings in building to allow for admittance of all apparatus.
- B. Cutting and Patching:

1. Refer to General Conditions of Contract, and Division 01 - Cutting and Patching.
2. Perform cutting and patching required for complete installation of systems unless otherwise noted. Patch and restore work cut or damaged to original condition. This includes openings remaining from removal or relocation of existing system components.
3. Provide materials required for patching unless otherwise noted.
4. Do not pierce beams or columns without permission of Architect and then only as directed. If openings are required through walls or floors where no sleeve has been provided, hole shall be core drilled to avoid unnecessary damage and structural weakening.
5. Where alterations disturb lawns, paving, walks, etc., replace, repair or refinish surfaces to condition existing prior to commencement of work. This may include areas beyond construction limits.

C. Housekeeping and Cleanup:

1. Refer to Division 01 - Closeout Procedures.
2. Periodically as work progresses and/or as directed by Architect, remove waste materials from building and leave area of work broom clean. Upon completion of work, remove tools, scaffolding, broken and waste materials, etc. from site.

1.11 WORK BY OWNER

A. Owner will provide:

1. Active electronics for interface with building voice and data cabling systems
2. Connections from telephone and data equipment to Contractor provided cabling

1.12 QUALITY ASSURANCE

- A. Refer to the individual technical sections for general product quality requirements, manufacturer qualifications, and contractor qualifications and certification requirements.

1.13 GUARANTEE

- A. Refer to Division 01 for general Guarantee (Warranty) requirements.
- B. Refer to technical sections for Guarantee requirement for each system.
1. Where no guarantee requirements are called out, guarantee as called out in Division 01 equipment, materials, and workmanship to be free from defect.
- C. Repair, replace or alter systems or parts of systems found defective at no extra cost to Owner.
- D. Wherein fulfilling requirements of any guarantee, if Contractor disturbs any work guaranteed under another contract, restore such disturbed work to condition satisfactory to Architect and guarantee such restored work to same extent as it was guaranteed under such other contract.
- E. Guarantees shall include labor, material and travel time.

PART 2 - PRODUCTS

2.1 PRODUCT SUBSTITUTIONS

- A. Refer to Division 01 - Product Requirements.

PART 3 - EXECUTION

3.1 GENERAL

- A. Verify elevations and measurements prior to installation of materials.

3.2 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to site under provisions of Division 01.
- B. Store and protect products under provisions of Division 01.
- C. Store in clean, dry space.
- D. Maintain factory wrapping or provide cover to protect units from dirt, water, construction debris, and traffic.
- E. Handle in accordance with manufacturer's written instructions.
- F. Handle carefully to avoid damage to components, enclosure, and finish. Lift only with lugs provided for the purpose.

3.3 FLOOR, WALL, ROOF AND CEILING OPENINGS

- A. Coordinate location of openings, chases, furred spaces, etc. with appropriate Contractors. Provide during progress of construction sleeves and inserts that are to be built into structure.
- B. Temporary sleeves, if used to form wall openings, shall be removed prior to installation of permanent materials. Permanent sleeves for wall penetrations shall be minimum 24 ga galvanized sheet metal unless otherwise noted.
- C. Steel sleeves, when required, shall be Schedule 40 carbon steel pipe with integral water stop.
- D. For core drilled holes, size and location shall be reviewed and approved by Structural Engineer prior to execution.
- E. Submit product data and installation details for penetrations of building structure. Submittal shall include schedule indicating penetrating materials, (including steel conduit, PVC conduit, cables, cable tray), sizes of each, opening sizes and sealant products intended for use.
- F. Where penetrations of fire-rated assemblies are involved, seal penetrations with appropriate firestopping systems as specified in Division 26.

- G. Submit complete penetration layout drawings showing openings in building structural members including floor slabs, bearing walls, shear walls. Indicate and locate, by dimension, required openings including those sleeved, formed or core drilled. Drawings shall be approved by the structural engineer prior to preparing openings in structural member.
- H. Openings for penetrations shall be minimum 1/2" larger on all sides than outside dimensions of raceways or cables. However, where fire resistant penetrations are required, size openings in accordance with recommendations of firestopping systems manufacturer.
- I. Seal non fire-rated floor penetrations with non-shrink grout equal to Embeco by Master Builders, or urethane caulk, as appropriate.
- J. Seal non-rated wall openings with urethane caulk.
- K. Where penetrations occur through exterior walls into building spaces, use steel sleeves with integral water stop, similar to type "WS" wall sleeves by Thunderline Corporation. Seal annular space between sleeves and pipe with "Link-Seal" modular wall and casing seals by Thunderline Corporation, or sealing system by another manufacturer approved as equal by Architect. Sealing system shall utilize Type 316 stainless steel bolts, washers and nuts.
- L. Finish and trim penetrations as shown on details and as specified hereinafter.
- M. Provide chrome or nickel plated escutcheons where raceways pass through walls, floors or ceilings and are exposed in finished areas. Size escutcheons to fit raceways for finished appearance. Finished areas shall not include mechanical/electrical rooms, janitor's closets, storage rooms, etc., unless suspended ceilings are specified.

3.4 EQUIPMENT ACCESS

- A. Install raceways, junction and pull boxes, and accessories to permit access to equipment for maintenance. Relocation of raceways, or accessories as required to provide access, shall be provided at no additional cost to Owner.
- B. Install equipment with ample space allowed for removal, repair or changes to equipment. Provide ready accessibility to equipment and wiring without moving other equipment, which is to be installed or which is already in place.
- C. Access doors in walls, chases, or inaccessible ceilings will be provided under Division 08 - Access Doors and Frames, unless otherwise indicated. Access doors shall be for purpose of providing access where equipment requiring servicing, repairs or maintenance is located in walls, chases or above inaccessible ceilings.
- D. Provide necessary coordination and information to Trade Contractor under Division 08 - Access Doors and Frames. This information shall include required locations, sizes and rough-in dimensions, without limitations.

- E. Provide access doors where equipment, requiring access for servicing, repairs and maintenance is located in walls, chases or above inaccessible ceilings, unless otherwise noted. Access frames and doors shall be as manufactured by Milcor, Incorporated, or similar, of style applicable to surface. Access doors used in fire-rated construction shall have UL label. Access doors shall be steel, prime coated, except use stainless steel doors in ceramic tile walls, toilet rooms, locker rooms, and in areas subject to excessive moisture. Access doors shall be of sufficient size to allow for total maintenance. Location of access doors shall be coordinated with General Contractor and location of equipment shall be roughed in accordingly.
- F. Locate communications outlets and equipment to fit details, panels, decorating or finish at space. Architect reserves right to make minor position changes of outlet locations before work has been installed.
- G. Verify room door swings before installing wall-mounted communications outlets and install boxes on latch side of door unless otherwise noted.

3.5 EQUIPMENT SUPPORTS

- A. Provide supporting steel not indicated on drawings as required for installation of equipment and materials including angles, channels, beams, hangers.
- B. Concrete anchors, used for attachment to concrete, shall be steel shell with plug type. Plastic, rawhide or anchors utilizing lead are not allowed.
- C. Do not support equipment or cable pathways from metal roof decking.

3.6 SUPPORT PROTECTION

- A. In occupied areas, mechanical rooms and areas requiring normal maintenance access, certain equipment must be guarded to protect personnel from injury.
- B. Provide minimum 1/2" thick Armstrong Armaflex insulation or similar product applied with Armstrong 520 adhesive on lower edges of equipment, including bus duct, cable tray, pull boxes and electrical supporting devices suspended less than 7 feet above floors, platforms or catwalks in these areas.
- C. Threaded rod or bolts shall not extend beyond supporting element and shall be protected as described above.

3.7 CABLE PROTECTION

- A. Protect cabling and termination components from contact with, and potential application of, foreign materials.
 - 1. Foreign material is defined as material that is not part of cabling assembly and termination components when delivered from manufacturer.
 - 2. Examples include paint overspray and drywall compound.
- B. Cabling and components that come into contact with foreign materials shall be replaced at no cost to project.

1. Solvents and other cleaning agents shall not be used to remove foreign materials that have already accumulated on cabling and components.

3.8 HOUSEKEEPING PADS

- A. Not applicable to this Division of work.

3.9 ACCEPTANCE TESTING

- A. Prior to testing, submit to Owner (or Owner's representative) and Engineer, proposed schedule for acceptance testing.
 1. This notification shall be minimum of 30 days in advance to allow for participation by Owner and/or Engineer.
- B. Prior to testing, submit written description of intended test procedures and submit sample test forms to Engineer.
 1. Submitted information shall include proposed file naming format to be used in identifying cable, pair or optical fiber which is subject of test record.
 2. Failure to provide above information shall be grounds for Engineer or Owner to reject any Documentation of related testing and to require repeat of affected test.
- C. Conduct tests during course of construction when identifiable portion(s) of installation is complete.
 1. Alternatively, testing can be conducted after entire installation is complete if this does not delay project schedule.
- D. Provide equipment and personnel necessary to conduct acceptance tests.
- E. Testing shall be completed and accepted by Owner and Engineer before Owner furnished equipment and cross connects are installed.
- F. Document tests.
- G. When equipment or systems fail to meet minimum test requirements, replace or repair defective work or materials as necessary and repeat inspection and test. This shall be at no additional cost to the Owner. Replacement materials shall be new.
- H. This Contractor is responsible for certifying, in writing, equipment and system test results. Certification shall include identification of portion of system tested, date, time, test criteria and name and title of person signing test certification documents.
- I. Maintain copies of certified test results, including those for failed tests, at project site. At completion of project, include copies of test records and certifications in O&M Manuals.

3.10 START-UP

- A. Systems and equipment shall be started, tested, adjusted and turned over to Owner ready for operation.
 1. This includes "Owner-Furnished, Contractor-Installed" (OFCI) and "Contractor-Furnished, Contractor-Installed" (CFCI) systems and equipment.

- B. Follow manufacturer's pre-start-up checkout, start-up, trouble shooting and adjustment procedures.
- C. Contractor shall provide services of technician/installer knowledgeable in start-up and checkout of types of systems and equipment on project.
- D. Provide start-up services, by manufacturer's representative where specified or where Contractor does not have qualified personnel.
- E. Coordinate start-up with trades.

3.11 DOCUMENTATION

- A. Upon completion of installation, Contractor shall provide System Documentation. Documentation shall include:
 - 1. Acceptance Test Results
 - 2. Record Drawings
 - 3. All Approved Submittals
 - 4. Manufacturer's Warranty Documents
- B. Submit System Documentation in accordance with Division 01 "Project Record Documents".
 - 1. Documents shall be submitted in same electronic format in which they were received from Architect and Engineer.
 - 2. Document updates shall be performed in native software format matching original design team documents.
 - a. Scans of hand marked documents shall not be allowed.
 - 3. Update documents to reflect installed conditions for equipment shown on documents.
- C. Submit documentation within ten (10) working days of the completion of testing of each testing phase (e.g. subsystem, cable type, area, floor) or 3 weeks prior to scheduled occupancy of subject area, whichever is sooner. This is inclusive of Test Result and draft Record Drawings.
 - 1. Draft drawings may include mark-ups done by hand.
 - 2. Machine generated (final) copies of Record Drawings shall be submitted within 30 working days of completion of each testing phase.
 - 3. Documentation will include all aspects of systems covered by these specifications that are required for systems to be fully functional.
 - 4. For structured cabling this includes the horizontal link from the TO to the HC, backbone cabling from the HC to the MC, cross-connections, interconnections and/or patch cords that are the responsibility of the contractor.
- D. Submit Acceptance Test Results in electronic form for review and distribution.
 - 1. Interim documentation of Test Results (if applicable) may be submitted via email or on CD-ROM.
 - 2. Final documentation of Test Results shall be submitted on CD-ROM.
 - 3. Test results shall be submitted in format(s) native to test instrument(s) used in performing testing.

4. Where unique software (other than an MS-Word compatible Word Processor or MS-Excel spreadsheet) is required for viewing of test results, Contractor shall provide along with above documentation, three (3) licensed copies of such software. Software shall run on Microsoft Windows-based personal computer.
- E. Acceptance Test results shall include description of sub-system tested, equipment/cable/outlet I.D., reference and test setup, test equipment type/model and serial number(s), equipment location and direction of test (if applicable), test frequencies/wavelengths, date and operator name(s).
- F. Engineer or Owner may request that 10% random re-test be conducted on cable system - at no additional cost - to verify documented findings. Tests shall be a repeat of those defined above and in technical sections.
 1. Owner may also perform independent testing to verify results.
 2. If findings contradict documentation submitted by Contractor, additional testing can be requested to extent determined necessary by Engineer or Owner, including 100% re-test. This re-test shall be at no additional cost to Owner.
- G. Documentation - including hard copy and electronic forms of Test Data and Record Drawings - shall become property of Owner.
- H. Refer also to Technical Sections for requirements specific to covered subsystems.

3.12 CLEANING

- A. After installation is complete, Contractor shall clean all systems.
- B. Vacuum debris from system components, enclosures, junction boxes and pull boxes prior to testing and again prior to completion.
- C. Thoroughly clean equipment of stains, paint spots, dirt and dust. Remove temporary labels not used for instruction or operation.

END OF SECTION 270000

SECTION 270526 - GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SCOPE

- A. This section includes product and execution requirements for Grounding and Bonding that are unique to communications systems and not included in Division 26 sections.

1.2 DESCRIPTION

- A. Grounding and Bonding infrastructure for communications includes Cabling, Busbars and Connectors.

1.3 REFERENCES AND STANDARDS

- A. Refer to Section 270000 - General Communications Requirements which identifies pertinent References and Standards.
- B. In addition, the following apply:
 - 1. IEEE 142/ANSI 142 - Recommended Practice for Grounding of Industrial and Commercial Power Systems.
 - 2. IEEE 837 - Standard for Qualifying Permanent Connections Used in Substation Grounding.
 - 3. UL 467 Electrical Grounding and Bonding Equipment
 - 4. ANSI J-STD-607-A - Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
 - 5. ANSI J-STD-607-D - Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

1.4 DEFINITIONS

- A. Additional definitions (per referenced standards):
 - 1. Telecommunications Main Grounding Busbar: Busbar placed in convenient and accessible location and bonded by means of bonding conductor for telecommunications to building service equipment (power) ground.
 - 2. Telecommunications Grounding Busbar: Interface to building telecommunications grounding system generally located in telecommunications room. Common point of connection for telecommunications system and equipment bonding to ground, and located in telecommunications room or equipment room.
 - 3. Telecommunications Bonding Conductor: Conductor that interconnects telecommunications bonding infrastructure to building's service equipment (power) ground.
 - 4. Telecommunications Bonding Backbone: Conductor that interconnects telecommunications main grounding busbar to telecommunications grounding busbar.
 - 5. Grounding Equalizer: Conductor that interconnects elements of telecommunications grounding infrastructure.
 - 6. Exothermic Weld: Method of permanently bonding two metals together by controlled heat reaction resulting in molecular bond.

7. Irreversible Compression: Permanent mechanical bond between conductors or conductor and connector using mechanical or hydraulic tool.

1.5 ABBREVIATIONS AND ACRONYMS

A. Additional abbreviations and acronyms (per referenced standards):

1. Telecommunications Main Grounding Busbar - TMGB
2. Telecommunications Grounding Busbar - TGB
3. Telecommunications Bonding Backbone - TBB
4. Grounding Equalizer - GE

PART 2 - PRODUCTS

2.1 TELECOMMUNICATIONS BUSBARS

- A. Material: Copper (aluminum not permitted)
 1. 1/4" thick
- B. Pre-drilled
 1. 3/8" Diameter
 2. Hole spacing per ANSI Joint Standard J-STD-607-A
 3. Hole pattern shall accommodate two-hole lugs
- C. Insulators and stand-off brackets shall electrically isolate busbar from wall or other mounting surface.
- D. Busbars shall be listed by nationally recognized testing laboratory.
- E. Size:
 1. Telecommunications Main Ground Busbar (TMGB) – 20" x 4" (minimum)
 2. Telecommunications Grounding Busbar (TGB) – 12" x 4" (minimum)

2.2 CONDUCTORS

- A. Material: Stranded copper (aluminum not permitted)
- B. Bonding Conductors shall be insulated.
 1. Green Jacket or Black Jacket marked with Green Tape or Green adhesive labels per NEC Guidelines
- C. Size:
 1. Telecommunications Bonding Conductor (TMGB to Grounding Electrode): As indicated on Project Drawings
 2. Telecommunications Bonding Backbone (TBB; TMGB to TGB): As indicated on Project Drawings
 3. Grounding Equalizer (GE): As indicated on Project Drawings

2.3 CONNECTIONS

A. Mechanical Connectors

1. Connector Body shall:
 - a. Be high-strength, high-conductivity cast copper alloy
 - b. Be 2 bolt type
2. Bolts, nuts, washers and lock-washers: Silicon Bronze
 - a. Shall be supplied as part of connector body
 - b. Split bolt connector types are not allowed
3. Connector shall:
 - a. Meet or exceed UL 467
 - b. Be clearly marked with catalog number, conductor size and manufacturer.

B. Compression Connectors

1. Connector Body: pure wrought copper.
 - a. Conductivity shall be no less than 99% by IACS standards.
2. Connector shall:
 - a. Meet or exceed performance requirements of IEEE 837, latest revision
 - b. Be factory filled with an oxide-inhibiting compound
 - c. Be clearly marked with manufacturer, catalog number, conductor size and required compression tool settings
3. Connection shall be irreversible.

C. Exothermic Weld Connections

1. Not Allowed for indoor connections.

PART 3 - EXECUTION

3.1 SEQUENCING AND SCHEDULING

- A. Permanently attach communications grounds prior to energizing communications equipment.

3.2 TOPOLOGY

- A. Refer to the project drawings.

3.3 INSTALLATION

- A. Provide required elements and miscellaneous hardware necessary to establish Telecommunication Grounding infrastructure as specified.
- B. Install Products in accordance with manufacturer's instructions.
 1. Install Compression Connectors with compression, tool and die system, as recommended by manufacturer of connectors.

- C. Grounding connections shall be tight and shall be made with UL listed grounding devices, fittings, bushings, etc.
- D. On the Telecommunications Bonding Conductor, Telecommunications Bonding Backbone (TBB) and Grounding Equalizer (GE) all connections shall be Compression type.
- E. Locate TGBs and TMGB per drawings.
- F. Telecommunications Bonding Backbone (TBB) shall be continuous and not interrupted by Telecommunications Grounding Busbars (TGB).
 - 1. TGBs shall be bonded to TBB via tap off of TBB.
 - a. Exception is "last" TGB on TBB (e.g. furthest from TMGB).
 - 2. Grounding Equalizer(s) (GE) shall connect to TGBs to be interconnected.
- G. Insulate Busbars from their support.
- H. Connections shall be bare metal to bare metal contact.
 - 1. Clean surfaces of paint, dirt, oil, etc.
- I. Connections shall be exposed and visible for inspection at all times.
 - 1. Do not install insulation over ground connections.
- J. Terminate each grounding conductor on its own terminal lug.
 - 1. Multiple conductors on single lug not permitted.

3.4 FIELD QUALITY CONTROL

- A. Inspect grounding and bonding system conductors and connections for tightness and proper installation.
- B. Test resistance of each TGB to ground.
 - 1. Maximum resistance to ground shall be less than 5 Ohms.

3.5 DOCUMENTATION

- A. Accurately record actual locations of grounding electrode(s), busbars and backbone grounding conductors.

END OF SECTION 270526

SECTION 270528.29 - HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SCOPE

- A. This section includes product and execution requirements for items unique to communications systems and not included in Division 26 sections.
- B. Refer to Section 270000 - General Communications Requirements and 260529 - Hangers and Supports for Electrical Systems - Part 1 for requirements for Reference Standards, Submittals, Quality Assurance, Delivery/Storage/Handling, and Guarantee.

PART 2 - PRODUCTS

2.1 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

- A. Refer to Section 260529 - Hangers and Supports for Electrical Systems - Part 3 for:
 - 1. Hanger Rods
 - 2. Beam Clamps
 - 3. Wall Anchors
 - 4. Metal Framing

2.2 J-TYPE CABLE SUPPORT HOOKS

- A. Cable support hooks shall be a wide-base type for use in a non-continuous pathway.
- B. Hook material shall be Galvanized metal or Nylon for smooth cable pull and corrosion resistance.
 - 1. Hook may be coated to reduce cable friction.
 - 2. Hook material shall be rigid. Flexible material not allowed.
- C. Hooks shall:
 - 1. Comply with UL, cUL, NEC and TIA requirements for structured cabling systems.
 - 2. Be designed to limit cable bending per cable manufacturers' recommendations.
 - 3. Be capable of being installed in a single- or multiple-hook ("tree") configuration.
 - 4. Incorporate a latch or other mechanism to retain cable.

PART 3 - EXECUTION

3.1 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

- A. Refer to Section 260529 - Hangers and Supports for Electrical Systems - Part 3 for all products identified in Part 1.

3.2 J-TYPE CABLE SUPPORT HOOKS

- A. Where installed free-air above suspended ceiling or below raised floor, support cables using J-hook type cable supports installed in accordance with manufacturer's installation requirements.
- B. Support hooks from structure. Do not support from ceiling grid, conduit or other trades work.
- C. Space J-hook cable supports every 4 ft or in accordance with cable manufacturer's specifications, whichever distance is shorter.
- D. J-hook fill capacities shall be per manufacturer's recommendations and shall consider diameter of cable type(s) being installed.

END OF SECTION 270528.29

SECTION 270528.33 - RACEWAY AND BOXES FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SCOPE

- A. This section includes product and execution requirements for items unique to communications and not included in Division 26 sections.

1.2 DESCRIPTION

- A. Refer to Section 260533 - Raceway and Boxes for Electrical Systems - Part 1 for requirements for Standards, Submittals, Quality Assurance, Delivery/Storage/Handling, and Guarantee for:
 - 1. Outlet Boxes
 - 2. Pull and Junction Boxes
 - 3. Raceways and Wireways (including sleeves, expansion fittings, penetrations and seals)
 - 4. Floor Boxes
 - 5. Cable Supports

PART 2 - PRODUCTS

2.1 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

- A. Refer to Section 260533 - Raceway and Boxes for Electrical Systems - Part 2 for Outlet Boxes for Communications, Pull and Junctions Boxes for Communications, Raceways for Communications, and other products identified in Part 1.

2.2 COMMUNICATIONS RACEWAYS

- A. OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY (INNERDUCT)
 - 1. UL 2024; flexible type, approved for plenum installation
 - 2. Outdoor Innerduct: Smooth outside and ribbed inside
 - 3. Indoor Innerduct: Ribbed or Corrugated high density polyethylene
 - 4. Color:
 - a. General Purpose: Orange
 - b. Flame-retardant: Orange
 - c. Riser: Orange
 - d. Plenum: Orange
 - 5. Manufacturers: Carlon; Pyramid; Approved equal

PART 3 - EXECUTION

3.1 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

- A. Refer to Section 260533 - Raceway and Boxes for Electrical Systems - Part 3 for Outlet Boxes for Communications, Pull and Junctions Boxes for Communications, Raceways for Communications, and other products identified in Part 1.

3.2 COMMUNICATIONS RACEWAYS

- A. Optical Fiber Communications Cable Raceway (Innerduct):
1. Minimum innerduct size: 1", unless otherwise noted on drawings.
 2. Provide four 1" diameter innerducts in each 4" conduit intended for Telecom cabling, unless otherwise noted.
 3. Extend innerduct to termination and/or storage enclosure.
 4. Provide couplings designed for innerduct size and type where innerduct enters a termination and/or storage enclosure.
 5. Splice innerduct segments using couplings designed for that purpose, where not installed in a continuous length.
 6. Provide 200 lb nylon pull cord in empty innerduct. Leave at least 12" of slack at each end of pull wire. Cap innerduct at both ends.
 7. Label innerduct with tags indicating cable type and cables contained therein.
 - a. Label in each maintenance hole, pull box and communications equipment room, where exiting a conduit and at 10 ft intervals in cable tray or where otherwise exposed.

END OF SECTION 270528.33

SECTION 270553 - COMMUNICATIONS SYSTEMS IDENTIFICATION

PART 1 - GENERAL

1.1 SCOPE

- A. This section details product and execution requirements for labeling of communications cabling, termination components, pathways and spaces for Communications Systems.

1.2 DESCRIPTION

- A. All components shall be clearly labeled to identify them as unique throughout the project.
- B. Labeling requirements include identification of Rooms, Equipment Racks, Telecommunications Outlets, Horizontal and Backbone Cabling, Termination Hardware (Patch Panels, Blocks) and Grounding.

1.3 REFERENCES AND STANDARDS

- A. Refer to Section 270000 - General Communications Requirements which identifies pertinent References and Standards.
- B. Other applicable references and standards include:
 - 1. TIA-606-D - Administration Standard for the Telecommunications Infrastructure of Commercial Buildings.

1.4 SUBMITTALS

- A. Refer to Section 270000 - General Communications Requirements and Section 271000 - Structured Cabling which provide general guidelines for product and/or installation information to be submitted by Contractor.
- B. Prior to installation, provide samples of label types planned for the project.
 - 1. Samples shall include examples of lettering to be used and shall follow standards detailed below.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Labels and markings shall be physically and chemically resistant to damage that would make label unreadable.
- B. Cable labels shall be self-laminating, White/Transparent Vinyl (or other substrates facilitating easy application and flex as cables are bent) and incorporate an integrated clear lamination which covers printed part of label when label is wrapped around cable.
 - 1. If cable jacket is white, provide cable label with printing area that is a color other than white to easily distinguish label from cable jacket.

2. Labels shall be of adequate size to accommodate circumference of cable(s) being marked and properly self-laminate over full extent of printed area of label.
 3. Labels on larger cables (e.g. Copper Backbone) may be wrapped with clear non-removable tape.
- C. Labels shall use aggressive adhesives that stay attached even to the most difficult to adhere to jacketing. Tags shall be non-removable.
1. Exceptions:
 - a. Telecommunications Outlet labels that are placed in recessed label holders.
 - b. Telecommunications Ground tags secured with cable ties.
 - c. Innerduct Tags secured with cable ties.
- D. Labels for 110-type Termination Blocks shall be Color-coded to indicate the cable type (inter-building, intra-building backbone, horizontal, etc.). Refer to Part 3.

PART 3 - EXECUTION

3.1 GENERAL

- A. Labeling shall be by mechanical means.
1. Hand lettered designations are not allowed.
- B. Tags shall be non-removable.
1. Exceptions:
 - a. Telecommunications Outlet labels that are placed in recessed label holders.
 - b. Telecommunications Ground tags secured with cable ties.
 - c. Innerduct Tags secured with cable ties.
- C. Characters shall be Black Ink and printed on background of contrasting color.
- D. Labels shall match hardware layout and design.
- E. Labels shall be as large as practicable while fitting properly.
- F. No lettering shall be smaller than 10-point.
- G. Label cables with tag which is wrapped around cable sheath.
1. Clean cable sheath thoroughly before applying label.
 2. Labels shall not be obscured by termination hardware.

3.2 ROOM IDENTIFICATION

- A. Label Communications Backboard or Equipment Rack closest to entry door with unique identifying code.
- B. Characters shall be 1" minimum.
- C. Room ID shall be the room numbering scheme indicated on the Drawings.

3.3 EQUIPMENT RACK IDENTIFICATION

A. Label each Equipment Rack with unique identifying code as follows:

1. TR-##, where:

- a. "TR" is identifier for room where rack is located
- b. "##" is sequential number for rack starting at "01".

B. Position Labels at top of rack.

C. Characters shall be 1" minimum.

3.4 TELECOMMUNICATIONS OUTLET

A. Label each Telecommunications Outlet (TO) connector with unique identifying code.

B. Telecommunications Outlet connector numbering shall result in logical numbering sequence in work area.

1. Labeling plans that results in random TO numbering in work area are not acceptable.

C. Place Faceplate labels on outside of cover.

D. Position Labels in recessed label holders on faceplate and covered with clear plastic covers.

1. Where Communications Outlet Faceplates not incorporating recessed holders are allowed, faceplate labels shall be protected with clear laminate.

E. Telecommunications Outlet labeling code shall be as follows:

1. TR-R#-PP-##, where:

- a. "TR" is identifier for room where cable terminates in horizontal cross-connect.
- b. "R#" is identifier for Equipment Rack where cable terminates
 - 1) Alpha character starting at "A".
- c. "PP" is Patch Panel on which cable is terminated at HC.

1) Number starting at "01".

2) Panel numbering shall be from Top (of Rack) to Bottom.

d. "###" is sequential POSITION of Jack on Panel

1) 1 - 48 is typical

2) Position sequence shall be Left-Right and Top-Bottom.

2. Example: "3W-R2-C-25" represents 25th Jack Position in 3rd Panel on Equipment Rack "2" in Telecom Room "3W".

- a. Faceplate labels can use common TR identifiers on each label strip. For example, two data jacks served from TR 3W sharing common label strip may be represented by:

3W-R2-C-25,26

3.5 HORIZONTAL CABLING

A. Label each horizontal cable at Telecommunications Outlet and at horizontal cross-connect with unique identifying code.

- B. Cable shall be labeled at both ends within 4" of cable choke (end of jacket).
- C. Horizontal labeling code shall be as follows:
 - 1. RM-#J, for CAT 6A cables where:
 - a. RM is the room number where the outlet is located
 - b. # is the sequential outlet number within each room, starting with "1" on the left as you enter the room
 - c. J is the jack position on the faceplate (A, B, C or D)
 - 2. RM-F-#, for fiber cables where:
 - a. RM is the room number where the outlet is located
 - b. F designates a fiber connection
 - c. # is the sequential outlet number within each room, starting with "1" on the left as you enter the room
 - 3. RM-V-#, for fiber cables where:
 - a. RM is the room number where the outlet is located
 - b. V designates a coaxial video connection
 - c. # is the sequential outlet number within each room, starting with "1" on the left as you enter the room

3.6 MODULAR PATCH PANEL

- A. Assign alphabetical identifier to patch panels in each rack, starting with the top patch panel as "A" in each rack.
- B. Label patch panel port at horizontal cross-connect with unique identifying numerical code from 1-48.
- C. Patch panel labeling code shall be as follows:
 - 1. Label Panel I.D.
 - a. Panel numbering shall be from Top (A) to Bottom (Z)
 - 2. Label Individual Port I.D.
 - a. Port I.D. shall be from Left to Right, Top to Bottom (1-48).
 - b. Manufacturers port labeling is acceptable.
- D. Room number is not required on modular patch panels.
- E. Equipment Rack number is not required on modular patch panels.
- F. Additional labels are to be provided on each port of each patch panel to indicate the location of the telecommunications outlet at the other end of the cable.
 - 1. Labeling is to utilize room number and be organized from low numerical room numbers to high
 - 2. RM-#J, where:
 - a. RM is the room number

- b. # is the sequential outlet number within each room, starting with “1” on the left as you enter the room
- c. J is the jack position on the faceplate (A, B, C or D)

3.7 BACKBONE COPPER CABLE

- A. Label each backbone cable at both ends at termination point with unique identifying code.
- B. Label cable sheath:
 - 1. At point where sheath ends
 - 2. At point on cable where viewing of label is not obscured by termination blocks or other visual barrier.
- C. Label shall be on plastic tag tie-wrapped to cable sheath, or placed on adhesive labels adhered to cable sheath.
 - 1. If adhesive labels are used, place clear plastic tape over label to protect it and maintain adhesion to sheath.
- D. Label Intra-building cables with:
 - 1. From and to locations,
 - 2. Pair numbers
 - a. Where multiple cables are installed between same end-points, labeling shall indicate sequential pair numbering.
 - 1) For example 400-pair provided as two 200-pair cables would be labeled "001-200" and "201-400".
 - 3. Date installed.
 - a. Example 200-pair cable from ER106 to TR3164 installed October 2009:

ER106-TR3164
001-200
10/2009

- E. Label Inter-building (between buildings) cables with:
 - 1. From and to locations,
 - 2. Pair numbers
 - a. Where multiple cable is installed between same end-points, labeling shall indicate sequential pair numbering.
 - 1) For example 400-pair provided as two 200-pair cables would be labeled "001-200" and "201-400".
 - 3. Date installed.
 - a. Example 600-pair Cable from Building 108 ER to Building 110 ER installed October 2009:

ER180-ER110

001-600
10/2009

3.8 TERMINATION BLOCKS

- A. Provide color-coded designation strips with Termination Blocks.
- B. Label termination positions on designation strips with position identifier.
- C. Horizontal Cabling Blocks shall incorporate BLUE Designation Strips and shall identify:
 - 1. Telecommunications Outlet / Jack I.D.s
- D. Intra-Building (within building) Backbone Cabling Blocks shall incorporate WHITE Designation Strips.

- 1. Label Designation Strips with:
 - a. Cable Origin & Destination
 - 1) Repeat on every designation strip.
 - b. Pair Count.
 - 1) Label 1st and 25th Positions on each row (e.g. 001 & 025, 026 & 050, etc.).
- 2. Example ER106 to TR3164:

001	ER106-TR3164	025
026	ER106-TR3164	050

- E. Inter-Building (between buildings) Backbone Cabling Blocks shall incorporate BROWN Designation Strips.
- 1. Label Designation Strips with:
 - a. Cable Origin & Destination
 - 1) Repeat on every designation strip.
 - b. Pair Count
 - 1) Label 1st and 25th Positions on each row (e.g. 001 and 025, 026 and 050, etc.).
- 2. Example cable linking Building 123 ER and Bldg. 456ER:

001	123ER-456ER	025
026	123ER-456ER	050

3.9 BACKBONE FIBER OPTIC CABLING

- A. Label each backbone cable at both ends at termination point with unique identifying code.
- B. Label shall be placed on adhesive labels adhered to cable sheath.
- C. Label Intra-building cables with:
 - 1. From and to locations,
 - 2. Fiber type (core/cladding diameter)
 - 3. Fiber count

- a. Where multiple cable is installed between same end-points, labeling shall indicate sequential fiber numbering.
 - 1) For example 144-fibers provided as two 72-fiber cables would be labeled "001-072" and "073-144".
4. Date installed.
5. Example 72-fiber cable from ER106 to TR3164 installed October 2009:

ER106-TR3164
50/125 001-072
10/2009

D. Label Inter-building cables with:

1. From and to locations,
2. Fiber type (core/cladding diameter)
3. Fiber count
 - a. Where multiple cable is installed between same end-points, labeling shall indicate sequential fiber numbering.
 - 1) For example 144-fibers provided as two 72-fiber cables would be labeled "001-072" and "073-144".
4. Date installed.
5. Example 72-fiber cable from Building 108 ER to Building 110 ER installed October 2009:

ER108-ER110
50/125 001-072
10/2009

3.10 FIBER OPTIC PATCH PANELS

- A. Label each fiber coupling in patch panel or workstation outlet with unique identifying code.
- B. Patch panel labels shall be visible from front of panel without opening panel cover.
- C. Place labels in manufacturer designated labeling areas.
- D. Label Fiber Optic Patch Panels with unique labeling code to identify:
 1. Cable Destination and Cable Number
 2. Fiber type (core/cladding diameter)
 3. Fiber (or coupler) number of each panel position.
 - a. Port I.D. shall be from Top to Bottom, Left to Right,
 - b. Manufacturers port labeling is acceptable.
- E. Label Fiber Optic Patch Panels with unique labeling code to identify:
 1. Patch panel number in rack
 2. Fiber (or coupler) number of each panel position.

- a. Port I.D. shall be from Top to Bottom, Left to Right,
 - b. Manufacturers port labeling is acceptable.
- F. Room number is not required on fiber optic patch panels.
- G. Equipment Rack number is not required on fiber optic patch panels.

3.11 INNERDUCT

- A. Innerduct containing fiber optic cable installed under this project shall be labeled where exposed.
- 1. Includes areas where innerduct is installed in trays and in equipment rooms.
- B. Label innerduct with durable Yellow Polyethylene tag that reads “CAUTION FIBER OPTIC CABLE”
- 1. Tag shall provide blank spaces for adding fiber count and cable destination information.
- C. Label Tag to include:
- 1. Identifier(s) of cable(s) contained therein.
 - a. Use Backbone Cable labeling formats as described above.
- D. Hand lettering is acceptable on tag
- 1. Use an indelible type ink.
- E. Tag shall be secured to Innerduct using self-locking ties.

3.12 TELECOMMUNICATIONS GROUNDS

- A. Label Grounds as close as practicable to point of termination.
- B. Labels shall be non-metallic and include the following:

WARNING

IF THIS CONNECTOR OR CABLE IS LOOSE OR MUST BE REMOVED, PLEASE
CALL THE BUILDING TELECOMMUNICATIONS MANAGER.

END OF SECTION 270553

SECTION 271000 - STRUCTURED CABLING

PART 1 - GENERAL

1.1 SCOPE

- A. This section details product and execution requirements for Structured Cabling for Communications Systems.

1.2 DESCRIPTION

- A. Systems shall include cabling, termination hardware and active components, installed as indicated on drawings and specifications.
- B. Cables and equipment shall be provided, tested, and terminated, including proper grounding and bonding.

1.3 REFERENCES AND STANDARDS

- A. Refer to Section 270000 - General Communications Requirements which identifies pertinent References and Standards.
- B. In addition:
 - 1. TIA-568.0-E - Generic Telecommunications Cabling for Customer Premises (including applicable Addenda)
 - 2. TIA-569-E - Telecommunications Pathways and Spaces.
 - 3. BICSI TDMM (Telecommunications Distribution Methods Manual)
 - 4. TIA-758-B- Customer-Owned Outside Plant Telecommunications Infrastructure Standard
 - 5. TIA-862-C - Structured Cabling Infrastructure Standard for Intelligent Building Systems
 - 6. TIA-942-B - Telecommunications Infrastructure Standard for Data Centers
 - 7. TIA-598-D: Optical Fiber Cable Color Coding.
 - 8. TIA-455-21-A: Mating Durability for Fiber Optic Interconnecting Devices
 - 9. TIA-526-14-D: Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant
 - 10. TIA-526-7-A: Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
 - 11. UL 910: Tests for Flame Propagation and Smoke-Density Values for Electrical and Optical-Fiber Cables used in Spaces Transporting Environmental Air
 - 12. UL 1666: Tests for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts
 - 13. IEEE 802.3 Ethernet, including applicable Addenda .

1.4 DEFINITIONS

- A. Refer to Section 270000 - General Communications Requirements for general terminology used in Division 27 sections.

- B. In addition, the following definitions are applicable to communications environments and shall apply to this document and its companion sections for clarification and direction:
1. Backbone Cabling - cable or conductors between telecommunications rooms, or floor distribution terminals, entrance facilities, and equipment rooms within or between buildings. Backbone cabling may be twisted pair copper, fiber optic or coaxial.
 2. Cable - assembly of 1 or more conductors or optical fibers within enveloping sheath, constructed so as to permit use of conductors singly or in groups.
 3. Cable ID - unique alpha-numeric identification used for tagging of backbone or horizontal cabling.
 4. Channel - end-to-end transmission path to which application-specific equipment is connected. Same as "Permanent Link", but also includes patch cords at Telecommunications Outlet and in Telecom Room.
 5. Consolidation Point (CP): A location for interconnection between horizontal cables extending from the horizontal cross-connect and horizontal cables extending to the telecommunication outlet at the workstation.
 6. Contractor: Telecommunications Contractor or sub-contractor(s) responsible for installation, termination, test and documentation of communications cabling, termination components, pathway hardware, telecommunications equipment room hardware and related components detailed in technical sections of this Division of work.
 7. Cross-Connect - group of connection points between cabling runs and/or equipment used to administer building wiring using patch cords or wire jumpers.
 8. Horizontal Cabling - Cables connecting Telecommunications Outlets to horizontal or intermediate cross-connect. Sometimes referred to as "Station Cabling".
 9. Horizontal Cross-connect (HC) – Connection of horizontal cabling to other cabling (e.g. horizontal, backbone or equipment) using patch cords or wire jumpers.
 10. Interconnection - Connection scheme using connecting hardware for the direct connection of a cable to another cable without a patch cord or jumper
 11. Main Cross-connect (MC) – Connection between backbone cables, entrance cables and equipment cables using patch cords or wire jumpers.
 12. Outlet ID - unique alpha-numeric identification used for referencing Telecommunications Outlet or connectors therein.
 13. Permanent (Cable) Link - includes Telecommunications Outlet, horizontal (station) cable and termination hardware in Telecom Room.
 14. Service Loop - Surplus cable, typically located at or near point of termination to enable future changes.
 15. Telecommunications Outlet (TO) - device assembly located in work area on which horizontal cabling terminates and which can receive modular connectors. It is interface between Station Cable and end user's equipment.
 16. Telecom Room - an enclosed space for housing telecommunications equipment, horizontal and backbone cable terminations, and cross-connect cabling, that is recognized location of horizontal cross-connect.
 17. Zone Box - An enclosure used to house one or more of the following; a) a consolidation point, b) a horizontal connection point, c) building automation system outlets.

18. Zone Cabling - Extends permanent horizontal cabling to a shared termination (consolidation) point in the work area. Passive system extends link to workstation through at interconnect at the Consolidation Point (CP). Active system includes system electronics at the CP.
- C. "10-gigabit" or "10G" performance criteria, if applicable, refers to support of 10GBASE-T application over 4-conductor channel up to 100 meters and meeting requirements of TIA-568.2.

1.5 ABBREVIATIONS AND ACRONYMS

- A. Refer to Section 270000 - General Communications Requirements for general terminology used in Division 27 sections.
- B. In addition, the following abbreviations and acronyms shall apply to this document and its companion sections for clarification and direction:
 1. 8P8C: Eight-Position, Eight-Conductor. Used in clarifying jack type; a.k.a. "RJ-45".
 2. CM: Communications cable rated for General Purpose use
 3. CMP: Communications cable rated for use in Plenum areas
 4. CMR: Communications cable rated for use in Risers and vertical runs
 5. CP: Consolidation Point
 6. ELFEXT: Equal-Level Far-End Cross Talk (pair-to-pair)
 7. FEXT: Far-End Cross Talk
 8. F/UTP: Foiled Unshielded Twisted Pair
 - a. No shielding around individual pairs and an overall foil shield under the cable jacket
 9. HC: Horizontal Cross-connect
 10. HCP: Horizontal Connection Point (e.g. for TIA-862)
 11. IDF: Intermediate Distribution Frame
 12. MC: Main Cross-connect
 13. MDF: Main Distribution Frame
 14. MPTL: Modular Plug Terminated Link
 15. N: Newton
 16. NEXT: Near End Cross Talk
 17. OFNP: Optical Fiber Nonconductive Plenum
 18. OFNR: Optical Fiber Nonconductive Riser
 19. OTDR: Optical Time Domain Reflectometer
 20. PBX: Private Branch Exchange (Telephone Switch)
 21. PoE: Power-over-Ethernet
 22. PSNEXT: Power Sum Near End Cross Talk
 23. S/FTP: Screened Foiled Twisted Pair
 - a. (Individual foil shield around each individual pair and an overall braided shield under the cable jacket.)
 24. S/UTP: Screened Unshielded Twisted Pair

- a. (No shielding around individual pairs and an overall braided shield under the cable jacket.)
- 25. SF/UTP: Screened Foiled Unshielded Twisted Pair
 - a. (No shielding around individual pairs and overall foil and braided shields under the cable jacket.)
- 26. TO: Telecommunications Outlet
- 27. TR: Telecommunications Room
- 28. USOC: Universal Service Order Code
- 29. UTP: Unshielded Twisted Pair
 - a. (No shielding around pairs nor overall under cable jacket.)
- 30. U/FTP: Unshielded Foiled Twisted Pair
 - a. (Individual foil shield around each individual pair and no overall braided shield under the cable jacket.)

1.6 SUBMITTALS

- A. Refer to Section 270000 - General Communications Requirements which provides general guidelines for product or installation information to be submitted by Contractor.
- B. In addition, Submit:
 - 1. Contractor Certification documents which document their participation in Installers Program operated by Manufacturer of Cabling or Termination Components used.
 - a. Upon request, Certified Installer(s) assigned to Project shall be identified to Engineer.

1.7 QUALITY ASSURANCE

- A. General:
 - 1. Cable and Equipment Manufacturer(s) shall be company specializing in communications cable, accessories and/or equipment with minimum of 5 years documented experience in producing cable, accessories and/or equipment similar to those specified herein.
- B. Contractor Qualifications:
 - 1. Qualified personnel utilizing state-of-the-art equipment and techniques shall complete cable and equipment installation and termination.
 - 2. Contractor shall have been in this business for minimum of 5 years and shall have successfully completed 4 projects equal in magnitude of system specified in the following sections.
- C. Contractor shall have necessary certifications to provide for Warranty as specified herein.
 - 1. Contractor shall be an active participant in Installers Program operated by Manufacturer of Cabling or Termination Components used.
 - a. Contractor shall be participant in this program at time of Bidding and remain so throughout project.

1.8 GUARANTEE

- A. Refer to Division 01, General Conditions, and General Requirements - Guarantee Documents and Section 270000 - General Communications Requirements for general guarantee requirements.
- B. Warranty structured cable system as follows:
 - 1. 4-pair Category-rated Horizontal Copper Permanent Link for no-less than 25 years from date of final acceptance.
 - 2. Copper Backbone for no-less than 25 years from date of final acceptance. Cabling and Connecting Components shall carry 25 yr component warranty.
 - 3. Fiber Optic Backbone for no-less than 25 years from date of final acceptance.
- C. Warranty shall be direct from manufacturer(s) of cabling and connecting components to Owner.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Refer to individual Technical Sections.

2.2 POWER OVER ETHERNET

- A. All cable and connecting components that comprise the TIA horizontal cabling "Permanent Link" from Horizontal Cross-connect to Telecommunications Outlet shall be compliant with the applicable requirements for "DTE Power via the MDI" to provide at least 51W at the Powered Device as defined by the IEEE 802.3bt standard.
- B. Cabling shall be UL-LP listed at a minimum of 0.5A.
- C. Connecting hardware shall comply with IEC 60512-99-002 for engaging and separating connectors under electrical load and connectors used in twisted pair communication cabling with remote power.

2.3 SYSTEM REQUIREMENTS

- A. Structured cabling products shall be designed to work together as a fully-warranted system.
- B. Under Bid Alternate, acceptable Structured Cabling and Enclosures components shall be as per the East Carolina University Construction Standards, Schedule of Components, Section 27 06 10 - 1.1. In order to provide consistent support to ECU's communications infrastructure, it is necessary that some components be manufacturer and part number specific. These components are specified to maintain compatibility with existing installed systems and components. Substitutions will only be accepted with prior approval from ECU-ITCS.
- C. Under base bid, provide equal Category 6A systems from manufacturers listed below:
 - 1. Belden REVConnect 10GX12
 - 2. CommScope SYSTIMAX GigaSPEED X10D
 - 3. Hubbell Premise Wiring NEXTSPEED 6A

4. Leviton CX6700 Cat 6A Enhanced+ UTP System
5. Panduit Category 6A MaTriX system (Panduit cable only)
6. Siemon Z-MAX 6A

PART 3 - EXECUTION

3.1 GENERAL

- A. Refer to individual technical specification sections for detailed Cable Routing and Installation, Testing and Documentation requirements. The following apply to communications cabling and termination work.
- B. Installation shall be per manufacturers' recommendations.
- C. Label cables and termination components per Section 270553 - Communications Systems Identification.

3.2 REMOVAL AND RECYCLING OF ABANDONED CABLE

- A. Remove and recycle unused, undocumented and otherwise “abandoned” cables prior to the completion of the project.
 1. Definition of Abandoned Cable is contained in NEC 2002 Articles: 640, 645, 725, 760, 770, 800, 810, 820 and 830. Further definition is contained in NFPA 75, NFPA 76 and NFPA 90A.
- B. Owner shall be available to assist in the identification of these cables.

3.3 CABLE INSTALLATION

- A. Run cabling in raceways provided, or as designated on floor plans, and support from building structure.
 1. Where installed in free-air, support cables using J-hook type cable supports installed in accordance with manufacturer's installation requirements. Refer to Section 270528.29 - Hangers and Supports for Communications Systems for installation requirements.
 - a. J-hook fill capacities shall be per manufacturer's recommendations and shall consider diameter of cable type(s) being installed.
 - b. Route cable/hooks at right angles, parallel to construction.
 2. Where installed in Cable Tray, lay cables neatly in tray.
 - a. Secure cable bundles using hook and loop ties at 10 ft intervals
 - b. Provide sufficient slack in cables to allow for unequal expansion coefficients of cable tray and cables. This requirement is in addition to slack required at cable tray expansion joints.
- B. Route and support cable in Equipment Rooms and Telecom Rooms utilizing “D-type” mounting rings, J-hooks and overhead cable runway.
- C. Cable shall be free of tension at both ends.

1. In cases where cable must bear stress, provide Kellems grips to spread stress over longer length of cable.
- D. Provide required installation tools to facilitate cable pulling without damage to cable jacket.
- E. Keep cables clear of other trades work.
- F. During pulling operation provide an adequate number of workers to allow cable observation at points of raceway entry and exit, as well as to feed cable and operate pulling machinery.
- G. Pull cables in accordance with cable manufacturer's recommendations and ANSI/IEEE C2 Standards.
- H. Pull cable by hand unless installation conditions require mechanical assistance.
- I. Do not exceed recommended pulling tensions and bending radii.
 1. Where mechanical assistance is used, ensure that maximum tensile load for cable is not exceeded.
 - a. This may be in form of continuous monitoring of pulling tension, use of "break-away" or other approved method.
 2. Replace cables bent or kinked to radius less than recommended dimension.
 - a. This shall be at no expense to Owner.
- J. Install cables splice-free unless otherwise specified.
- K. Avoid abrasion and other damage to cables during installation.
 1. Visually inspect cables for cuts, blisters and abrasions during installation.
- L. Pulling lubricant may be used and shall:
 1. Be non-injurious to cable jacket and other materials used.
 2. Not harden or become adhesive with age.
- M. Repair damage to interior spaces caused by installation of cable, raceway or other hardware. Repairs must match preexisting color and finish of walls, floors and ceilings.
- N. Replace contractor-damaged ceiling tiles to match color, size, style and texture.
- O. Provide pull cord (200 lb minimum) with cable installed in conduit or innerduct.
- P. Neatly lace, dress and support cabling.
- Q. In vertical pathway, support cables on each floor using industry recognized support methods designed specifically for that purpose.
 1. Strap vertical runs as required, to prevent sagging of cables.
- R. To reduce effects of EMI, adhere to the minimum cable separation distances defined in TIA-569.

3.4 FIELD TESTING

- A. Refer to Section 270000 - General Communications Requirements for general guidelines regarding requirements for scheduling and performing compliance testing.
- B. Cabling shall be 100% fault free unless otherwise noted. If any Link is found to be outside specification defined herein, identify and correct problem up to and including replacement of cable and associated termination(s). Then repeat applicable tests.
- C. Test each cabling sub-system (e.g. backbone, horizontal, etc.) end-to-end.
- D. Where sub-systems are to be interconnected or cross-connected by the contractor, test individual sub-system followed by a test of the connected links
 - 1. Performance and documentation requirements shall default to the lesser of the two connected systems if different.
 - 2. Example 1: Combined Backbone-Horizontal Link
 - a. Test and document individual Backbone and Horizontal Cabling Sub-systems.
 - b. Cross-connect sub-systems.
 - c. Repeat testing on combined cabling from MC - TO through HC.
 - d. Performance and documentation requirements shall be based in this example on backbone cabling (continuity, pair integrity, etc.).
 - 3. Example 2: Interconnected Zone Cabling Link
 - a. Test and document individual HC – CP links.
 - b. Install interconnect cabling CP – TO
 - c. Repeat testing on combined cabling from HC – TO through CP.
 - d. Performance and documentation requirements shall be based in this example on TIA Permanent Link for Horizontal Cabling.
- E. Test instrument shall be configured using template for exact cable under test (e.g. by manufacturer product designation).
 - 1. If no template is available, enter cable parameters for the cable per manufacturer's product data.
 - a. Nominal Velocity of Propagation (NVP) used for copper cable type under test shall be traceable to manufacturers' product data.
 - b. Refractive Index used for fiber optic cable type under test shall be traceable to manufacturers' product data.
 - 2. Test results obtained using incorrect cable parameters will be rejected.
- F. Test instrument shall be calibrated as defined by instrument manufacturer at least once every 12 months or as required by test instrument manufacturer if that results in more frequent calibration runs.
 - 1. Test instrument calibration date shall be present in test results documentation.
- G. Refer to individual Technical Sections for system-specific guidelines regarding requirements for scheduling and performing compliance testing.

3.5 DOCUMENTATION

- A. Refer to Section 270000 - General Communications Requirements for general guidelines regarding requirements for project Documentation.
- B. Refer to individual Technical Sections for system-specific guidelines regarding requirements for project Documentation.
- C. Information added by Contractor to Record Drawings shall include:
 - 1. Backbone and horizontal cable routes
 - 2. Telecommunications outlet locations and identification
 - 3. Other detail necessary to document cable installation

3.6 OWNER TRAINING

- A. Provide training for Owner's personnel on operation and maintenance of total system and each component.
- B. Training to include:
 - 1. Overview of System Topology and General Concepts
 - 2. Overview of Product Used
 - 3. Overview of Equipment Room Layouts
 - 4. Overview of Labeling Formats
 - 5. Overview of Test Results and their meaning
 - 6. Overview of Documentation
- C. Training shall be held at Project Site and shall be conducted during normal working hours.
- D. Training session duration shall be not less than one (1) h.
 - 1. Provide 2 such sessions.
 - 2. Coordinate with owner to schedule session(s). Provide adequate notification to allow owner to schedule staff.
- E. Attendance shall be by owner staff and/or contract maintenance personnel.
 - 1. Number of Students per session shall be 6.
 - 2. Materials shall be provided for the number of students indicated.
- F. Provide example course materials and instructor background in advance of training session(s).
- G. Owner may videotape session(s) for use as future refresher materials for owner technical staff.

END OF SECTION 271000

SECTION 271100 - COMMUNICATIONS EQUIPMENT ROOM FITTINGS

PART 1 - GENERAL

1.1 SCOPE

- A. This section details product and execution requirements for Communications Equipment Room Fittings for Communications Systems.

1.2 DESCRIPTION

- A. Communications Equipment Room Fittings include:
 - 1. Cabinets, Racks, Frames and Enclosures
 - 2. Cable Runway
 - 3. Termination Blocks
 - 4. Patch Panels
 - 5. Entrance Protection
- B. Refer to Project Drawings for Equipment Room layout and equipment placement.

PART 2 - PRODUCTS

2.1 ALTERNATES

- A. Under preferred brand alternate, provide the following items:
 - 1. Equipment Racks: CPI 55053-503
 - 2. Horizontal Cable Management: Panduit WMP1E
 - 3. Vertical Cable Management: Panduit PR2VD6 / PR2VD10
 - 4. Termination Blocks: ADC KRONE
 - 5. Modular Patch Panels: Siemon UltraMAX UP6A-F2-48L-RS
 - 6. Fiber Optic Housing: Corning CCH-01U / 02U / 03U / 04U
 - 7. Fiber Splice Housing: Corning CSH-03U / 04U
 - 8. Fiber Splice Tray: Corning M67-078
 - 9. Heat Shrink Protectors: Corning P322467 Qty50
 - 10. Fiber SC SM Module: Corning CCH-CS12-59-P00RE
 - 11. Fiber SC MM Module: Corning CCH-CS12-91- P00KE w/Pigtails
- B. Under base bid, provide equal products from manufacturers listed and as described in sections below.

2.2 CABINETS, RACKS, FRAMES AND ENCLOSURES

- A. Manufacturers: Rittal, CPI, Ortronics, Wrightline, Panduit, Damac or Siemon.
- B. Equipment racks shall be:

INDOOR PRACTICE FACILITY
EAST CAROLINA UNIVERSITY, GREENVILLE, NC
SCO ID# 23-26345-01A
AIM # 1752

1. Constructed of painted aluminum
 2. Clear Coated
 3. Supplied with ground bar (19" wide by 1" high) and #6 AWG (16 mm²) ground lugs
 4. Supplied with minimum of 12 releasable cable support ties (e.g. "hook and loop")
 5. Supplied with spare screws (minimum of 50)
 6. Configured with Channel uprights spaced to accommodate industry standard 19" mounting
- C. Free Standing Equipment Rack shall comply with general requirements above and shall:
1. Be 84" in height
 - a. Have minimum of 45 usable rack mounting units (RU)
 2. Be self-supporting
 3. Have Minimum base footprint of 15" x 20"
 4. Be double-sided drilled and tapped to accept 12-24 screws
 - a. Uprights shall be drilled on back to accept cable brackets, clamps, power strip(s).
 - b. Hole pattern on rack front and back shall be per EIA/TIA specifications (5/8" – 5/8" – 1/2").
- D. Cable Management
1. Manufacturers: Rittal, CPI, Wrightline, CommScope, Ortronics, Panduit or Simon.
 2. Horizontal Cable Management Panels shall:
 - a. Be painted steel
 - b. Be 3.5" high
 - c. Have minimum of 5 distribution rings (3.75" x 3.75" minimum dimension)
 - 1) Distribution rings shall be plastic
 3. Vertical Cable Management shall:
 - a. Provide for cable routing on front and rear of each rack
 - b. Be 10" wide (minimum) when installed between two racks
 - c. Be 6" wide when installed at end of rack row
 - d. Mount on spacers attached to rack uprights and not on upright
 - e. Be accessible from front and rear of rack
 - f. Be designed to space slots/fingers at 1 RU intervals to align with rack-mounted equipment
- E. Equipment Rack Ground Busbar
1. Material: Copper
 2. Mounts horizontally in rack
 3. Mounting configuration EIA universal mounting hole pattern , tapped #12-24.
- F. Miscellaneous
1. Releasable Cable Support Ties shall be:
 - a. Hook & Loop type
 - b. Individual units with latch

- 1) Roll of hook & loop material is not acceptable.

2.3 CABLE RUNWAY

- A. Manufacturers: CPI, B-Line or Hoffman.
- B. Cable Runway shall:
 1. Be constructed of 0.065" thick steel
 2. Utilize tubular stringers to support rungs.
 - a. Stringers shall be 1-1/2" high.
 - b. Rungs shall be welded to stringers and shall be spaced 9" on center.
 3. Be painted with black epoxy.
- C. Runway width(s) shall be as shown on drawings.

2.4 TERMINATION BLOCKS

- A. Manufacturers: ADC, Siemon, Ortronics or Panduit.
- B. Blocks shall be 110-style high-density cross-connect blocks with lightning protection attached to the plywood backboard for OSP copper cabling.
- C. Each horizontal row of block shall be capable of terminating one 25 pair binder group of Backbone Copper Cable, or six 4 pair Copper Cables.
- D. Mechanical termination on blocks shall:
 1. Have ability to terminate 22-26 AWG plastic insulated, solid and stranded copper conductors.
 2. Provide direct connection between horizontal or backbone cable and jumper wires.
 3. Be designed to maintain cable pair twists as closely as possible to point of mechanical termination.
- E. Blocks for Horizontal Cabling shall use 4-pair connecting blocks; blocks for backbone cabling shall use 5-pair connecting blocks.
 1. Blocks shall identify pair position by color designation.
 - a. Colors shall be Blue, Orange, Green and Brown for Horizontal Cables.
 - b. Colors shall be Blue, Orange, Green, Brown and Slate for Backbone Cables.
 - c. Markings shall designate Tip and Ring conductors.
- F. Horizontal Voice Blocks shall:
 1. Be rack-mounted with no legs
 2. Meet or exceed TIA Category 6A performance criteria
 3. Terminate up to 100 pairs (each block)
- G. Backbone Voice Blocks shall:
 1. Be rack-mounted with no legs
 2. Meet or exceed TIA Category 5e performance criteria

3. Terminate up to 100 pairs (each block)
- H. Horizontal Cable Managers (Jumper Troughs) designed for use with blocks shall be:
 1. Manufactured with high-strength, flame-retardant thermoplastic
 2. Designed for easy cable insertion or withdrawal
 3. 2 RUs high
 4. Rack- or wall-mountable (with legs) to match block configuration
- I. Horizontal Cable Managers designed for use at top of column of blocks shall be 188B type. 188B type cable manager shall:
 1. Be constructed of metal with two plastic distribution rings
 2. Have legs to allow space for routing cables behind Backboard
 3. Have dimensions 6.5" high x 10.7" wide
- J. Vertical Cable Managers for wall-mounted Termination Blocks shall utilize distributing rings.
 1. Rings shall be metal and be split to facilitate passage of jumper wires.
 2. Minimum Dimension of each ring shall be 5" square (minimum).

2.5 MODULAR PATCH PANELS

- A. Manufacturers: Siemon, Ortronics or Panduit.
- B. Panels shall:
 1. Consist of Modular-to-IDC connector system
 2. Be rack-mountable in standard EIA 19" equipment racks
 3. Be 2 RUs high
 4. Accommodate 48-port modular jacks in two rows of 24-ports
 5. Be designed to terminate 4-pair, 100-Ohm UTP cables
 6. Have ability to terminate 22-26 AWG plastic insulated, solid and stranded copper conductors.
 7. Be designed to maintain cable's pair twists as closely as possible to point of mechanical termination.
 8. Have cable support and strain relief devices to secure cables at IDC connector.
 - a. Panel and cable support hardware shall ensure that cabling minimum bend radius requirements are satisfied.
 9. Have port identification numbers on both front and rear of panel.
 10. Have color-coded pair designations on rear of panel.
- C. Modular Jacks in Panel shall:
 1. Be non-keyed, 8 position, 8-conductor (8P8C)
- D. Panels shall meet or exceed TIA Category 6A performance criteria.

2.6 FIBER OPTIC PATCH PANELS

- A. Manufacturers: Corning, Siemon, Panduit or Ortronics.

- B. Patch Panels shall:
 - 1. Be enclosed assemblies
 - 2. Incorporate hinged or retractable front cover
 - 3. Be rack mountable on standard TIA 19" equipment racks
 - 4. Provide for strain relief of incoming cables
 - 5. Incorporate radius control mechanisms to limit bending of fiber to manufacturer's recommended minimums of 1.2", whichever is larger
 - 6. Provide protection to both "facilities" and "user" sides of couplings.
 - 7. Be configured to require only front access when patching
 - 8. Incorporate patch cable routing space internal to patch panel enclosure.
 - a. Routing space shall be front-accessible.
 - 9. Include provisions for permanent labeling of fiber optic cables.
 - a. Labeling shall be accessible from front of patch panel and shall not require disassembly of patch panel enclosure or removal of front cover.
- C. Couplings shall be mounted on assembly that snaps into patch panel enclosure.
 - 1. This assembly shall be designed to accept variety of coupler types including, ST, SC, duplex SC and high-density mini-connectors.
 - 2. Coupling type shall be duplex SC
 - 3. Coupling Color shall be as follows:
 - a. Multimode: BEIGE
 - 1) Exception: LASER-optimized 50/125 Multimode couplings shall be AQUA
 - b. Single-mode: BLUE
- D. Access to inside of panel enclosure during installation shall be from front and rear.
 - 1. Panels that require disassembly of cabinet to gain entry will not be accepted.
- E. Incoming cables shall not be accessible from patching area of panel.
 - 1. Enclosure shall provide physical barrier to access of such cables.
 - 2. Where factory-terminated cable assemblies ("pigtailed") are spliced to cable, enclosure shall incorporate hardware for securing of splice tray and required cable, buffer tube and pigtail slack.

2.7 ENTRANCE PROTECTION

- A. Manufacturers: Corning, Porta Systems, CommScope or Circa.
- B. Interface on Protection devices shall be as follows:
 - 1. Input: 110-type block
 - 2. Output: 110-type block
- C. Entrance protection shall:
 - 1. Be listed primary protector
 - 2. Accommodate industry standard 5 pin protection modules

3. Be provided with grounding lug
- D. Covers on protector housing are required as follows:
 1. On input side
- E. Protection modules shall:
 1. Be Solid-State type
 2. Have nominal DC Breakdown voltage of 230 V
 3. Be self-resetting
 4. Provide effective protection against “sneak current” events
 5. Have fail-safe design to protect personnel and equipment from exposure to sustained high voltages and currents

PART 3 - EXECUTION

3.1 GENERAL

- A. Refer to project Drawings for communications equipment room layout and equipment placement.
- B. New communications equipment rooms must be free from dust, dirt, and other foreign materials before installation of any termination hardware or termination of copper or fiber optic cables.
 1. Door to room must be closed during termination if area outside room is not dust-free.
- C. Follow manufacturer’s recommended installation and termination practices.
- D. Provide necessary assistance to allow Owner or Carrier personnel to establish service on new cable system.
 1. Includes general wiring overview, cable pair identification, and cross connect documentation (if applicable).

3.2 EQUIPMENT RACKS AND CABLE MANAGEMENT

- A. Provide equipment racks as shown on project Drawings.
- B. Assemble racks per manufacturer’s recommendations. Remove paint at the point(s) of contact of assembly hardware or use internal-external tooth lock washers to pierce paint to maintain ground continuity.
- C. Bolt racks to floor.
- D. Secure racks to cable runway as described below.
- E. Provide Horizontal and Vertical Cable Management in equipment racks as per project Drawings and as follows.
 1. Provide horizontal cable management above and below each rack mounted patch panel.

2. Provide vertical cable management between adjacent equipment racks and at rack row ends.
- F. Provide each rack with:
 1. Ground bar and #6 AWG Ground lug,
 2. Minimum of fifty (50) 12/24 mounting screws,
 3. Minimum of twelve (12) releasable (e.g. "hook & loop") cable support ties.
- G. Bond each rack mounted ground bar to telecommunications ground bus bar (TGB).
 1. Use #6 AWG or larger copper conductor (green jacket).

3.3 CABLE RUNWAY

- A. Provide cable runway and accessories necessary for complete system.
- B. Size and layout of cable runway shall be as shown on project Drawings.
- C. Install above equipment racks as shown on drawings.
- D. Align with equipment racks as follows:
 1. Where parallel to rack row, align center of runway with center of rack.
 2. Where at right-angle to rack, align center of runway with center of rack.
- E. Brace to racks with support brackets made by runway or rack manufacturer intended for this purpose.
- F. Use radius drops where cables drop from tray to rack and at elevation changes of 6" or more.
- G. Maximum allowable deviation of runway from level horizontal plane measured across length of cable runway shall be 1/2", with tray loaded to capacity.
- H. Where cable runway is supported from building structure:
 1. Provide 3/8" threaded rods for support of 12" wide or smaller runway.
 2. Provide 1/2" threaded rods for support of runway greater than 12" in width.
- I. Bond runway components together using manufacturer's standard accessories.
- J. Fasten cables to runway at intervals not to exceed 4 ft.

3.4 TERMINATION BLOCKS

- A. Provide blocks to accommodate an additional 20% growth at each location.
- B. Terminate Backbone Voice Cables and Horizontal Voice Cables on rack-mounted patch panels.
 1. Strip lengths & termination of all cabling to be per manufacturers recommendations.
- C. Provide 110 blocks as follows:
 1. Terminate OSP cabling from the existing Brody Server Room (MDF) on wall mounted 110-style wiring blocks

2. All other voice cabling is to terminate on rack mounted patch panels.
- D. Install Blocks:
 1. No higher than 72" AFF to top-most block
 2. Top to bottom, left to right beginning no closer than 12" from left wall
- E. Provide horizontal troughs between each termination block.
- F. Provide horizontal troughs at top of each block column.
- G. Provide vertical managers to right and left of each block column.
- H. Cabling entering and exiting fields shall be neatly laced, dressed and supported.
- I. Contractor shall be responsible for jumper wiring between horizontal and backbone cabling.
- J. Provide System Terminal Blocks as shown on drawings.
 1. Contractor shall not be responsible for jumper wiring between System Terminal Blocks and Backbone Voice Cable Blocks.
 2. Contractor shall not be responsible for connection of 50-pin telco connectors to Owner furnished telephone equipment.
- K. Provide Feed Blocks as shown on drawings.
 1. Connect Feed Blocks to Carrier Demarcation (DEMARC).

3.5 MODULAR PATCH PANELS

- A. Provide panels to accommodate an additional 20% growth at each location.
- B. Mount patch panels in 19" equipment racks.
- C. Position cables in sequence of:
 1. Telecommunications Outlet ID for horizontal cabling
 2. Pair number for backbone cabling
- D. Terminate cables using 568A wiring standard.
- E. Provide horizontal management above and below each patch panel.
- F. Provide minimum of 4 screws to secure each patch panel onto rack.

3.6 FIBER OPTIC PATCH PANELS

- A. Provide Fiber Optic Patch Panels and coupling assemblies at horizontal and main cross-connect locations.
 1. Provide minimum of 4 screws to secure each patch panel onto rack.
- B. Provide couplings in coupling assemblies and mount coupling assemblies and blank covers in patch panels.

- C. Position fibers consecutively - starting with lowest number - and mapped "position for position" between patch panels.
 - 1. There shall be no transpositions in cabling.
- D. Keyways on duplex couplings shall be oriented to establish "cross-over" in cabling system.
 - 1. Convention defined by TIA-568.0 (Annex B, Section B.3.2) shall be used.
 - 2. Reverse-pair positioning shall not be used.
- E. Provide blank covers for unused coupling assembly spaces in panels.
- F. Follow manufacturer's guidelines for connector type(s) provided.
 - 1. Clean connectors with specialized dry-cleaning product from Fluke or Cletop.
- G. Provide dust caps for couplings.
- H. Where factory-terminated cable assemblies ("pigtails") are spliced to cable, prepare and splice cables and fibers per manufacturers' guidelines.

3.7 ENTRANCE PROTECTION

- A. Provide protector at each end on inter-building backbone copper pairs.
 - 1. Position protector as close as possible to building entrance.
- B. Install per manufacturers recommendations.
- C. Ground protector assemblies to Telecommunications Grounding Busbar via #6 AWG (minimum) conductors.
- D. Provide Protector Modules for all pairs terminated.
- E. If special tool is required to open protector housing, provide 2 such tools to Owner at completion of work.

3.8 FIELD TESTING

- A. General
 - 1. Refer to Section 270000 - General Communications Requirements and 271000 - Structured Cabling for guidelines regarding documentation requirements.
 - 2. Refer to referenced technical sections for detailed requirements to testing of each cable sub-system.

3.9 DOCUMENTATION

- A. General
 - 1. Refer to Sections 270000 - General Communications Requirements and 271000 - Structured Cabling for guidelines regarding documentation requirements.

END OF SECTION 271100

SECTION 271300 - COMMUNICATIONS BACKBONE CABLING

PART 1 - GENERAL

1.1 SCOPE

- A. This section details product and execution requirements for backbone cabling for Communications Systems.

1.2 DESCRIPTION

- A. Backbone Cabling links telecommunications rooms or floor distribution terminals, entrance facilities, and equipment rooms within or between buildings.
- B. Backbone cable types include:
 - 1. Twisted-Pair Copper
 - 2. Fiber Optic
- C. Refer to Project Drawings which detail Backbone Cable System topology and conductor/fiber counts.

1.3 SUBMITTALS

- A. Refer to Section 270000 - General Communications Requirements and Section 271000 - Structured Cabling which provide general guidelines for product or installation information to be submitted by Contractor.
- B. In addition, submit:
 - 1. One 3 ft section of each cable type from cable reels sent to site for Engineer's final approval.
 - a. Section shall have manufacturer's cable markings visible.

PART 2 - PRODUCTS

2.1 ALTERNATES

- A. Under preferred brand alternate, provide the following items:
 - 1. Twisted Pair Cabling: General, Superior Essex or AT&T
 - a. Copper OSP Feeder Cable: General PE-89
 - b. Copper Riser Cable: General CAT 3 PVC Inside 25/24 LV3 non-plenum
 - 2. Single-Mode Fiber Optic Cabling: Corning
- B. Under base bid, provide equal products from manufacturers listed and as described in sections below.

2.2 GENERAL

- A. Cables and Termination hardware shall be technically compliant with and installed in accordance with referenced TIA documents.
- B. Cables shall be Underwriters Laboratory (UL) listed, comply with Article 800 (Communications Circuits) of National Electrical Code and shall meet specifications of NEMA (low loss), UL 444, and ICEA (where applicable).

2.3 TWISTED PAIR CABLING

A. General:

- 1. Manufacturers: CommScope, Superior Essex or AT&T.
- 2. Cable shall be standard exchange type telephone cable.
 - a. This is defined as paired multi-conductor, thermoplastic insulated, copper cable characterized by an average mutual capacitance of 83 (+4/-5) nano-Farads per mile at 1000 Hz.
- 3. Cabling shall:
 - a. Be constructed of individually twisted pairs.
 - b. Be suitable for installation in environment defined.
 - c. Be packaged to minimize tangling and kinking of cable during installation.
- 4. Identify conductors by insulation color.
- 5. Color code shall follow industry standard of 10 distinctive colors to identify 25 pairs.
 - a. Marking of each mate of primary conductor in pair with color of that primary conductor is optional.
- 6. When cables of larger than 25 pairs are required, cable core shall be assembled into 25-pair sub-units.
- 7. Wrap super units with solid color thread that follows primary color scheme of white, red, black, yellow and violet.
- 8. Cable jacket shall be marked at 2 ft intervals indicating manufacturers' identification, pair count, AWG and sequential footage.

B. Backbone UTP Cable (Intra-building):

- 1. Cable shall meet following minimum requirements:
 - a. Size: 24 AWG solid annealed copper pairs
 - b. Number of Pairs: as shown on Project Documents
 - c. Impedance: 100 Ohms \pm 15%
 - d. Jacket Color: Black or Grey
 - e. Shield: Overall, continuous corrugated aluminum bonded to outer jacket
 - f. Cable Rating: NEC Article 800 Type CMR, UL listed

2.4 FIBER OPTIC CABLE

A. General

1. Manufacturers (Cable): Corning, Siemon, Berk-Tek, CommScope
2. Manufacturers (Optical Fiber): Corning, Alcatel
3. Fibers utilized in installed cable shall be traceable to manufacturer.

B. Optical Fiber - General

1. Optical fibers shall:
 - a. Be sufficiently free of surface imperfections and occlusions to meet optical, mechanical, and environmental requirements of this specification.
 - b. Have been subjected to minimum tensile proof test by fiber manufacturer equivalent to 100 kpsi.
2. Factory optical fiber splices are not allowed.
3. Coatings shall be mechanically strippable without damaging optical fiber.

C. Single-mode Optical Fibers:

1. Single-mode Optical Fibers:
2. Fiber Type: Single-mode
3. Strand Count: as shown on Drawings
4. Transmission Windows: 1310 nm, 1550 nm
5. Core Diameter: 8.3 micron
6. Cladding Diameter: 125 micron \pm 1 micron
7. Coating Diameter: 245 micron \pm 10 micron
8. Attenuation:
 - a. 1310 nm: Between 0.35 and 0.6 dB/km (at $23^{\circ} \pm 5^{\circ}\text{C}$)
 - b. 1550 nm: Between 0.2 and 0.5-dB/km (at $23^{\circ} \pm 5^{\circ}\text{C}$)
 - c. When tested in accordance with FOTP 3, "Procedure to Measure Temperature Cycling Effects on Optical Fibers, Optical cable, and Other Passive Fiber Optic Components", average change in attenuation over rated temperature range of cable shall not exceed 0.05 dB/km at 1550 nm. Maximum attenuation change shall not exceed 0.15 dB/km at 1550 nm.
 - d. Water Peak Attenuation: 1383 ± 3 nm (dB/km) ≤ 0.4
9. Point Discontinuity: < 0.1 dB at specified wavelengths

D. Indoor Backbone Fiber Optic Cable

1. Cable shall:
 - a. Be suitable for installation in free air, in building risers, in conduit, in cable tray and in innerduct.
 - b. Be dielectric materials (no conductive materials).
2. Cable shall meet the following specifications:
 - a. Buffer Diameter: 900 micron (tight buffer)
 - b. Jacket Color
 - 1) Single-mode: YELLOW
 - c. Cable Rating: OFNR
 - d. Strength Member: Aramid Yarn

- e. Storage Temperature: -40°F to 158°F (no irreversible change in attenuation)
- f. Operating Temperature: -34°F to 158°F (no irreversible change in attenuation)
- g. Humidity Range: 0 to 100%
- h. Maximum Tensile Strength:
 - 1) During Installation – 2700 N (no irreversible change in attenuation)
 - 2) Long Term – 1000 N
- i. Bending Radius:
 - 1) During Installation - 20 times cable diameter
 - 2) No Load - 10 times cable diameter

E. Indoor-Outdoor Backbone Fiber Optic Cable

- 1. Cables shall:
 - a. Incorporate dry water-blocking materials
 - b. Incorporate an interlocking metal tape under outer jacket to provide crush resistance and rodent protection.
 - c. Be all dielectric (no conductive materials).
 - d. Be suitable for installation in underground conduit, in innerduct and indoor.
- 2. Cable shall meet the following specifications:
 - a. Buffer Type: Loose Tube
 - b. Jacket Color: Black or Gray
 - c. Cable Rating: OFNR
 - d. Strength Member: Aramid Yarn
 - e. Anti-buckling element: fiberglass
 - f. Operating and Storage Temperature: -40°F to 158°F (no irreversible change in attenuation)
 - g. Humidity Range: 0 to 100%
 - h. Maximum Tensile Loading:
 - 1) During Installation - 2700 N (no irreversible change in attenuation)
 - 2) Long Term - 600 N
 - i. Bending Radius:
 - 1) During Installation - 20 times cable diameter
 - 2) No Load - 10 times cable diameter

2.5 FIBER OPTIC CONNECTORS

- A. Manufacturers: Corning, Siemon, Panduit, Ortronics.
- B. Connectors shall:
 - 1. Be SC-type.
 - 2. Accept fibers having clad diameter of 125 micron.
 - 3. Accept fibers having buffered diameter of 900 micron.
 - 4. Sustain minimum of 200 mating cycles.

- C. Connector ferrule shall be ceramic or glass-in-ceramic.
- D. Connectors shall meet the following performance criteria:

Test Procedure	Max Attenuation Change
Cable Retention (FOTP-6)	0.2 dB
Durability (FOTP-21)	0.2 dB
Impact (FOTP-2)	0.2 dB
Thermal Shock (FOTP-3)	0.2 dB
Humidity (FOTP-5)	0.2 dB

- E. Optical fiber shall be:
1. Secured within connector ferrule with adhesive, or
 2. Mechanically secured and mated to a factory-installed fiber stub that is fully bonded into the ferrule. Mechanical "splice" inside connector shall include an index matching gel.
- F. Attenuation per connector shall not exceed 0.5 dB.
- G. Reflectance (maximum) when mated with patch-cord made up of connectors of comparable design shall be as follows:
1. Single-mode: -26 dB
- H. Color of SC Connector shall be as follows:
1. Single-mode: BLUE
- I. Strain-relief boot of ST Connector shall indicate fiber type as follows:
1. Single-mode: YELLOW

PART 3 - EXECUTION

3.1 CABLE INSTALLATION AND TERMINATION

- A. General
1. Provide cables as shown on Project Documents.
 2. Size cables as shown on Project Documents.
 3. Refer to Section 270000 - General Communications Requirements and Section 271000 - Structured Cabling for general cable installation requirements.
- B. Backbone UTP Voice Cable:
1. Terminate cables on backbone voice cable blocks.
 - a. Maintain cables pair twists to within 1" of termination.
 - b. Remove cable jacket only to extent required to make terminations.
 2. Ground metallic cable sheath (if applicable) per Code.
 - a. Provide armored cable ground kit for armored cable terminations. Install as directed by kit manufacturer.
 - 1) Ground inter-building cable at one end

- 2) Ground intra-building cabling at both ends
3. Connect armored cable ground kit to wall-mounted TGB located in telecom room.
- C. Fiber Optic Cable
 1. Route backbone fiber optic cable in innerduct.
 2. Ground metallic cable sheath (if applicable) per Code.
 - a. Provide armored fiber ground kit for armored cable terminations. Install as directed by kit manufacturer.
 - 1) Ground inter-building cable at one end
 - 2) Ground intra-building cabling at both ends
 - b. Connect armored fiber ground kit to rack mounted grounding reference.
 3. Terminate fiber strands on Fiber Optic Connectors mated to couplings mounted in Fiber Optic Patch Panels.
 - a. Terminate all fibers.
 4. Follow manufacturer's guidelines for connector type(s) provided.
 - a. Clean connectors with specialized dry-cleaning product from Fluke or Cletop.
 5. Fibers with coatings <900 micron shall be furcated (fanned-out) to minimum of 900 micron before termination.
 - a. Provide buffer tube fan-out kits for fibers terminated in patch panel couplings.
 6. Provide cable slack in each backbone fiber optic cable.
 - a. Slack shall be in addition to length of fiber required for termination requirements.
 - b. Store cable slack in enclosure designed for this purpose.
 - c. Slack required shall be as follows:
 - 1) Backbone Intra-Building: Minimum of 16 ft (each cable if applicable) coiled and secured at one end (preferably at Telecom Room).
 - 2) Backbone Inter-Building: Minimum of 50 ft (each cable if applicable) coiled and secured at one end (preferably at Equipment Room).
 - 3) Maintenance Holes/Manholes: Minimum of 1-1/2 times inside dimension of Maintenance Hole/Manhole.

3.2 FIELD TESTING

- A. General
 1. Refer to Section 270000 - General Communications Requirements for general guidelines regarding requirements for scheduling and performance of compliance testing.
 - a. Contractor shall be responsible for testing each system end-to-end.
- B. Backbone UTP Cable Testing
 1. Verify voice cable pairs for wire map (transposed/reversed/split pairs) and shorts through toning of each conductor.
 2. Verify cable shield or coupled bonding conductor for end-to-end continuity.
- C. Backbone Fiber Optic Cable Testing
 1. Pre-Installation Testing

- a. Pre-installation testing shall be done at contractor option.
 - b. Submit cable manufacturer's test report for each reel of cable provided.
 - 1) Verify fiber attenuation, bandwidth and length values as specified on cable data sheets supplied with cable reels.
 - c. Visually inspect reels and packaging for damage.
2. Post-Installation Testing
- a. Clean fiber optic connectors before beginning testing.
 - 1) Using fiber tester capable of fiber end face inspection is strongly encouraged to help minimize requirement for retesting due to dirty connectors.
 - b. Testing shall include:
 - 1) Optical Attenuation
 - 2) Optical Time Domain Reflectometry (OTDR)
 - c. Optical Attenuation
 - 1) Light Source: LED
 - 2) Measure Optical Attenuation on terminated fibers.
 - a) Include optical connectors and couplings installed at fiber endpoints.
 - 3) Test single-mode fibers using TIA-526-7-A. Annex E (Method A).
 - 4) Test fibers in both transmission directions.
 - 5) Test single-mode fibers at 1310 ± 10 nm and 1550 ± 10 nm wavelengths.
 - 6) Fiber lengths less than or equal to 300 ft shall test to ≤ 2.0 dB loss.
 - 7) Fiber lengths greater than 300 ft shall test to loss value less than link loss budget for installed connectors and fibers.
 - d. Optical Time Domain Reflectometry (OTDR)
 - 1) OTDR testing shall not be used as the sole method for establishing optical attenuation link loss.
 - 2) Verify fiber integrity using an Optical Time Domain Reflectometer (OTDR).
 - a) Includes terminated and (if applicable) un-terminated fibers.
 - 3) OTDR(s) shall incorporate high-resolution optics and short pulse-width options optimized for viewing of short cable sections.
 - a) Pulse-width shall be 10-ns or less for cable lengths greater than 100 meters.
 - b) Pulse-width shall be 5-ns or less for cable lengths less than 100 meters.
 - 4) OTDR traces shall be performed in one direction using access jumpers at transmit and receive ends.
 - a) Remote end of tail cord has no requirement for reference grade termination
 - 5) OTDR traces shall be performed in two directions using access jumpers at transmit and receive ends
 - a) Remote end of tail cord shall meet same reference grade requirements as launch end cord.
 - b) Perform bi-directional OTDR measurements according to requirements of TIA-526-7-A, clauses H.6 and H.7.

- c) Minimum length of access jumper at launch end shall be minimum 330 ft long for multimode or 990 ft long for single-mode, unless recommended otherwise by test equipment manufacturer.
- 6) Test single-mode fibers at 1310 ± 10 nm wavelengths.
- 7) Examine traces for continuity and anomalies to confirm fiber link integrity.
 - a) Point discontinuities in excess of 0.2 dB for multimode fibers or 0.1 dB for single-mode fibers shall be cause for rejection of cable.
 - b) Any reflection in trace - except at patch panels - shall be cause for rejection of cable.
 - c) Submitted test results shall show only fiber under test and shall have trace boundaries set to show fiber under test and not launch cords or other extraneous data.
 - d) Set event markers to accurately reflect overall attenuation of installed fiber optic cable and connectors.
- 8) OTDR tested links showing excessive backscatter immediately following connector shall have connector cleaned and/or re-polished and then retested.
- e. Optical Return Loss
 - 1) Testing shall include Optical Return Loss (ORL) measurement for each installed single mode fiber optic connector. Follow OTDR manufacturer's requirements for required tester settings, including scattering coefficient.
 - 2) Perform ORL with a Back Reflection Meter or an OTDR.
 - a) OTDR shall be capable of measuring fiber connector reflectance and produce accurate (± 2 dB) reflectance measurements
 - 3) Test result cursors shall be placed at appropriate locations before tests are submitted for review. OTDR testers including automatic cursor positioning functions shall use said functions to position cursors accurately for measurement.

3.3 DOCUMENTATION

A. General

- 1. Refer to Section 270000 - General Communications Requirements for general guidelines regarding documentation requirements.

B. Backbone Copper Cable

- 1. Document pair count assignments by cable.
- 2. Document cross-connects between backbone, and horizontal or tie cabling.
 - a. Documentation shall be in the form of a spreadsheet which relates backbone pair count with horizontal cable or tie cable information. Base horizontal cable information on outlet designation and pair count.

C. Backbone Fiber Optic Cable

- 1. Files containing Attenuation and OTDR traces of individual optical fiber "signatures" shall be so named as to identify each individual fiber by location in cable system and fiber number or color.
- 2. OTDR test results shall be consistent in format and presentation, including:

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- a. Scale
 - 1) Scale or window of test result view shall show only enough trace to view fiber under test plus launch cords at both ends.
 - 2) View shall not show backscatter beyond end of fiber.
- b. Pulse width
- c. Units (English or Metric)
- d. Cursor placement
- e. Labeling

END OF SECTION 271300

SECTION 271500 - COMMUNICATIONS HORIZONTAL CABLING

PART 1 - GENERAL

1.1 SCOPE

- A. This section details product and execution requirements for Horizontal (Station) Cabling subsystem for Communications Systems.

1.2 DESCRIPTION

- A. Horizontal cabling subsystem is portion of communication link that connects horizontal or intermediate cross-connect (typically at Telecom Room) and Telecommunications Outlet.
- B. Horizontal Cable types include:
 - 1. 4-pair Copper Unshielded Twisted Pair (UTP)
 - 2. Fiber Optic

1.3 DEFINITIONS

- A. In this section, "Telecommunications Outlet" is considered to consist of Frame/Faceplate into which Modular Jacks or other couplings snap, Modular Jacks, blanks fitted to unused jack positions, and labeling/identification components.

1.4 SUBMITTALS

- A. In addition to general submittal requirements, provide:
 - 1. Samples of each Telecommunications Outlet Faceplate type to confirm color and material.
 - 2. One 3 ft section of each cable type from cable reels sent to site for Engineer's final approval.
 - a. Section shall have manufacturer's cable markings visible.
 - 3. Nominal Velocity of Propagation (NVP) for 4-pair Horizontal Copper Cable.

PART 2 - PRODUCTS

2.1 ALTERNATES

- A. Under preferred brand alternate, provide the following items:
 - 1. Horizontal CAT 6A Station Cabling: CommScope CS44P, Yellow Jacket
 - 2. Communications CAT 6A UTP Outlet Modules: Siemon U6A-K02NS
 - 3. Single Cable Communications Faceplate: Siemon KFP-S-01-02-S
 - 4. Dual Cable Communications Faceplate: Siemon KFP-S-02-02-S
 - 5. Quad Cable Communications Faceplate: Siemon KFP-S-04-02-S
- B. Under base bid, provide equal products from manufacturers listed and as described in sections below.

2.2 GENERAL

- A. Cables and Termination hardware shall be technically compliant with and installed in accordance with referenced TIA documents.
- B. Cables shall be Underwriters Laboratory (UL) listed, comply with Article 800 (Communications Circuits) of National Electrical Code and shall meet specifications of NEMA (low loss), UL 444, and ICEA (where applicable).
- C. Horizontal (Station) Cable and Termination Components (Jack, Patch Panel) are specified to function as System.
 - 1. Where required for warranty purposes, manufacturers of cabling and termination components used (if more than one) shall recognize each other in their Certification Programs.
- D. 4-Pair Horizontal Copper Cables and Modular Jacks are application dependent as detailed below.

2.3 4-PAIR HORIZONTAL COPPER CABLE

- A. Manufacturers: Refer to System Requirements list in 27 1000
- B. Cables shall be suitable for installation in environment defined. All indoor horizontal copper cabling shall be plenum rated.
- C. Cabling shall be packaged to minimize tangling and kinking of cable during installation.
- D. Configuration:
 - 1. Number of Pairs: 4 twisted pair
 - a. Pair twists of any pair shall not be same as any other pair.
 - b. Pair twist lengths shall be selected by manufacturer to ensure compliance with crosstalk requirements of TIA-568 (SET).
 - 2. Conductors: insulated solid annealed copper pairs
 - a. Category 3 - 5e: 24 AWG
 - b. Category 6 & 6A: 23 AWG
 - c. Pairs of 4-pair cables shall be identified by banded color code in which conductor insulation is marked with dominant color and banded with contrasting color.
 - 1) By pair number, pair colors or dominant band are:
 - a) Pair 1: Tip - White/Blue; Ring - Blue (or Blue/White)
 - b) Pair 2: Tip - White/Orange; Ring - Orange (or Orange/White)
 - c) Pair 3: Tip - White/Green; Ring - Green (or Green/White)
 - d) Pair 4: Tip - White/Brown; Ring - Brown (or Brown/White)
 - 3. Shield: None
 - a. Drain Wire: None
 - 4. Cable Rating: NEC Article 800 Type CMP, UL listed
 - 5. Maximum outside diameter:

- a. 0.22"
- b. 0.25"
- c. 0.28"

E. Horizontal Data Cable:

- 1. Shall meet or exceed TIA Category 6A performance requirements.
- 2. Shall not incorporate an overall shield.
- 3. Jacket Color: Yellow

F. Horizontal Voice Cable:

- 1. Shall meet or exceed TIA Category 6A performance requirements.
- 2. Shall not incorporate an overall shield.
- 3. Jacket Color: Yellow

2.4 HORIZONTAL FIBER OPTIC CABLE

A. Fiber Optic Cable

- 1. Cable shall:
 - a. Incorporate 2 tight-buffered fiber strands in single jacket.
 - b. Incorporate duplex design with 1 tight buffered fiber strand in each jacket.
 - c. Allow direct terminations on specified fiber optic connectors.

2.5 TELECOMMUNICATIONS OUTLET

A. Manufacturers: Refer to System Requirements list in 27 1000

B. Connectors (modular jacks, fiber optic couplings and coaxial connectors (as applicable)) shall snap onto faceplate.

- 1. In surface-mount designs (if applicable) Jacks and connectors may mount to frame onto which coverplate is mounted.

C. Work Area Faceplate

- 1. Wall-mounted faceplates intended to be used in general work areas shall:
 - a. Be configured to mount on standard, single gang opening when wall mounted.
 - b. Accommodate minimum of 4 modular jacks and connectors.
 - c. Be constructed of high impact plastic (except where otherwise noted).
 - d. Incorporate recessed designation strips at top and bottom of frame for identifying labels.
 - 1) Triple row faceplates with no provisions for labeling of middle outlet row are not acceptable.
 - 2) Designation strips shall be fitted with clear plastic covers.
 - 3) Designation strips and covers shall be positioned over faceplate mounting screws.
- 2. Faceplate Color: White.

D. Wall-mount Telephone Faceplate

1. Faceplates intended to be used in locations where wall mounted telephone set is required shall:
 - a. Be stainless steel construction.
 - b. Accommodate 1 modular jack meeting performance requirements for “Voice” jack as defined above.
 - 1) Modular jack shall be positioned to mate with wall-mounted telephone.
 - c. Mount on standard single gang opening.
 - d. Include mating lugs for mounting wall-mounted telephone.
- E. Faceplate - Wireless Access Point Location
 1. Faceplates supporting Wireless Access Point (AP) shall:
 - a. Accept 2 modular jacks or connectors.
 - b. Be flush-mounted.
 - c. Be made of High Impact thermoplastic.
 - d. Incorporate recessed designation strips at top and bottom of frame for identifying labels.
 2. Faceplate Color: White.
- F. Faceplate - Modular Furniture
 1. Faceplates intended to be used on modular furniture shall:
 - a. Accept 4 modular jacks or connectors.
 - b. Snap into modular furniture opening and be retained by integral latching tabs.
 - c. Match standard opening of furniture type(s) to be installed.
 - d. Have an optional extender bracket available to increase mounting depth as required to maintain cable bend radius within manufacturers’ recommendations.
 - e. Be made of High Impact thermoplastic.
 - f. Incorporate recessed designation strips for identifying labels. Have optional port designation stencils.
 - 1) Modular furniture faceplate color shall be Black.

2.6 MODULAR JACK

- A. Manufacturers: Refer to “Telecommunications Outlet” above.
- B. Modular Jacks shall be:
 1. 8-position, 8-conductor (8P8C)
 2. Non-keyed
- C. Jacks shall have an attached color-coded wiring instruction label as an aid to installer.
- D. Interface between jack and station cable shall be insulation displacement type contact.
- E. Termination components shall maintain cable's pair twists as closely as possible to point of mechanical termination.
- F. Jack contacts shall have minimum of 50 micro-inches of gold plating.

- G. Jacks shall be supplied with installed dust covers to protect jack opening and internal elements during installation until jack is in use.
 - 1. No damage to Jack pinning shall result from insertion or removal of covers.
- H. Data Jack shall:
 - 1. Meet or exceed performance requirements of TIA Category 6A.
 - 2. Be color White.
 - 3. Be provided as a pair of angled jacks in a coupler insert designed for the faceplate.
- I. Voice Jack shall
 - 1. Meet or exceed performance requirements of TIA Category 6A.
 - 2. Be color White.
 - 3. Be provided as a pair of angled jacks in a coupler insert designed for the faceplate.
- J. MPTL connector shall
 - 1. Meet or exceed performance requirements of TIA Category 6A.
 - 2. Comply with Annex F of TIA-568.2-D.

2.7 FIBER OPTIC CONNECTOR

- A. Manufacturers: Corning, Siemon, Panduit or Ortronics.
- B. Connectors shall:
 - 1. Be SC-type.
 - 2. Accept fibers having clad diameter of 125 micron.
 - 3. Accept fibers having buffered diameter of 900 micron.
 - 4. Sustain minimum of 200 mating cycles.
- C. Multimode Connectors shall:
 - 1. Secure optical fiber in ferrule and connector body using epoxy
- D. Single-mode Connectors shall:
 - 1. Secure optical fiber in ferrule and connector body using epoxy.
- E. Connector ferrule shall be ceramic or glass-in-ceramic.
- F. Connectors shall meet the following performance criteria:

<u>Test Procedure</u>	<u>Max Attenuation Change</u>
Cable Retention (FOTP-6)	0.2 dB
Durability (FOTP-21)	0.2 dB
Impact (FOTP-2)	0.2 dB
Thermal Shock (FOTP-3)	0.2 dB
Humidity (FOTP-5)	0.2 dB

- G. Attenuation per connector shall not exceed 0.5 dB.

PART 3 - EXECUTION

3.1 GENERAL

- A. Refer to project Drawings for outlet locations.
- B. Provide Modular Jacks, Coaxial Connectors (if applicable) and Fiber Optic couplings (if applicable) in faceplates as shown on Project Documents.
 - 1. Provide 1 faceplate per Telecommunications Outlet symbol shown on Project Documents.
 - 2. Provide 1 modular furniture mounted faceplate per modular furniture symbol shown on Project Documents.
- C. Maximum 4-pair Category-rated horizontal cable length shall not exceed 295 ft measured from horizontal cross-connect (typically at TR) to Telecommunications Outlet.
 - 1. Includes slack required for installation and termination.
 - 2. Contractor is responsible for installing station cable to avoid unnecessarily long runs.
 - 3. Any area that cannot be reached within above constraints shall be identified and reported to Engineer prior to installation.
- D. Follow manufacturers recommended termination practices.

3.2 CABLE INSTALLATION AND TERMINATION

- A. General
 - 1. Refer to Section 270000 - General Communications Requirements and Section 271000 - Structured Cabling for general cable installation requirements.
 - 2. Provide "Service Loop" for every Horizontal Cable in ceiling above outlet.
 - a. Loop length shall be 3.3 ft
 - b. Total length of 4-pair Category-rated horizontal cable including loop shall not exceed 295 ft.
 - c. Place loop in ceiling at last support (e.g. J-Hook) before cables enter fishable wall, conduit, surface raceway or box.
 - d. Coil loop in figure 8 configuration.
 - e. Loop radius (minimum) shall be 4X minimum bend radius for cable.
 - 3. During installation, minimum bend radius shall be eight times outside diameter of UTP cables and 20 times outside diameter of fiber cables.
 - 4. Limit size of cable bundles along cable pathways and in communications equipment rooms to maximum of 12-24 cables.
- B. Horizontal Copper Twisted-Pair Cabling
 - 1. Provide horizontal copper twisted pair cable between horizontal cross connect (typically at Telecommunications Room) and Telecommunications Outlet.
 - 2. At Telecommunications Outlet, terminate each 4-pair Horizontal Cable on 8P8C Modular Jack.
 - a. Terminating one cable on more than one jack is not allowed.

3. At horizontal cross-connect, terminate:
 - a. Each 4-pair cable on 8P8C Modular Jack in Patch Panel.
 - b. Each 4-pair cable designated as for "Data" on 8P8C Modular Jack in Patch Panel.
 - c. Each 4-pair cable designated as for "Voice" on 8P8C Modular Jack in Patch Panel.
4. Terminate cables using 568A wiring standard.
5. Cable jacket shall be continuous to within 1/2" of termination.
6. Preserve pair twists to point of termination.
7. Refer to Section 271100 - Communications Equipment Room Fittings for termination instructions for Modular Patch Panel and Termination Block.

C. Horizontal Fiber Optic Cable

1. Terminate cables on specified fiber optic connectors at Telecommunications Outlet and at horizontal cross-connect.
 - a. Cable termination shall carry fiber buffer into connector strain relief mechanism.
2. Mount connectors in fiber patch panels at horizontal cross-connect as shown on drawings.
3. Refer to Section 271100 - Communications Equipment Room Fittings for termination instructions.

3.3 TELECOMMUNICATIONS OUTLET

- A. Faceplates shall be configured to provide connectivity as required by location. Refer to details and drawings.
- B. Mount modular jacks and connectors into faceplates and secure faceplates to outlet box, raceway or modular furniture.
 1. Use faceplate extender if required to provide adequate clearance between jack and furniture or raceway panel to maintain minimum cable bend radius.
 2. Provide blank(s) in unused jack/connector positions. Match color of blank to faceplate color.
- C. Position Telecommunications Outlet for wall-mounted telephone in area clear of other utilities and wall mounted hardware.
 1. Coordinate with other trades to maintain 8" clear space (minimum) on all sides from faceplate centerline.
- D. MPTL connectors shall be installed following connector manufacturer requirements.
 1. Contractor shall ensure installed MPTL will fit in available space at outlet-end of cable while maintaining cable bend radius requirements.

3.4 FIELD TESTING

- A. Refer to Sections 270000 - General Communications Requirements and 271000 - Structured Cabling for guidelines regarding testing requirements common to all Division 27 Structured Cabling sections.
 1. In addition, refer to sub-sections below for cable type under test.
- B. 4-Pair Horizontal Copper Cable

1. Test from:
 - a. Horizontal Cross-connect (HC) to Jack at Telecommunications Outlet (TO).
2. Testing shall be per TIA-568 (SET) Permanent Link test configurations.
3. Maximum length of station cable shall not exceed 300 ft.
4. Cables shall be free of shorts within pairs, and be verified for Continuity, Pair Validity and Polarity, and Wire Map (Conductor Position on Modular Jack).
 - a. Identify and correct defective, split or mis-positioned pairs.
5. In addition to above, Performance Testing shall be performed on all cables. Testing of Transmission Performance shall include the following:
 - a. Length
 - b. Insertion Loss / Attenuation
 - c. Pair-to-pair NEXT
 - d. PSNEXT
 - e. Pair-to-pair ELFEXT (Equal Level Far End Cross-talk)
 - f. PSELFEXT
 - g. Return Loss
 - h. Propagation Delay
 - i. Delay Skew
 - j. Alien Crosstalk (AXTalk) – 10G Cable Systems only
 - 1) AXTalk measurement method shall be as required by the manufacturer(s) of cabling/connecting components installed to certify the system for warranty.
 - k. DC Loop Resistance and DC Resistance Unbalance (Pair and Pair-to-Pair values)
 - 1) Configure test equipment to include DC Loop Resistance and DC Resistance Unbalance as criteria for setting PASS/FAIL for each item under test.
 - a) For example, when using Fluke test equipment, select “+PoE” test limit, and when using IDEAL test equipment select “MAX” test limit when setting test parameters.
6. Test cables to maximum frequency defined by standards covering specified performance category.
7. Perform Transmission Performance Testing using test instrument designed for testing to specified frequencies.
 - a. Test records shall verify “PASS” on each cable and display specified parameters - comparing test values with standards based “templates” integral to unit.
8. MPTL cables shall be tested in accordance with TIA-568.2-D, Annex F, and test procedure shall follow recommended guidelines of test equipment manufacturer.
 - a. Select MPTL test limit on test equipment when testing MPTL terminated cables.

C. Horizontal Fiber Optic Cable

1. Testing shall include
 - a. Optical Attenuation
 - 1) Light Source: LED
 - 2) Measure Optical Attenuation on terminated fibers.

- a) Include optical connectors and couplings installed at fiber endpoints.
 - 3) Test multimode fibers using EIA/TIA-526-14 A, Method B.
 - 4) Test single-mode fibers using EIA/TIA-526-7-1998. Method A.1.
 - 5) Test all fibers in both transmission directions.
 - 6) Test multimode fibers at 850 ± 30 nm and 1300 ± 20 nm wavelengths.
 - 7) Test single-mode fibers at 1300 ± 20 nm and 1550 ± 10 nm wavelengths. .
 - 8) Fiber lengths less than or equal to 300 ft shall test to ≤ 2.0 dB loss.
 - 9) Fiber lengths greater than 300 ft shall test to loss value less than link loss budget for installed connectors and fibers.
2. Perform inspection with OTDR if end-to-end readings are higher than expected to determine source of attenuation. Correct problem(s) and repeat Attenuation measurement until results within specified limits are obtained.

3.5 DOCUMENTATION

- A. Refer to Sections 270000 - General Communications Requirements and 271000 - Structured Cabling for documentation guidelines.
- B. Information added by Contractor to Record Drawings relating to Horizontal Cabling shall include cable routes, outlet locations and numbering and other detail necessary to document cable installation.

END OF SECTION 271500

SECTION 275319 - EMERGENCY RESPONDER RADIO REINFORCEMENT SYSTEM

PART 1 - GENERAL

1.1 SCOPE

- A. This section includes product and execution requirements for Emergency Responder Radio Reinforcement system.

1.2 DESCRIPTION

- A. Design and provision of a complete, turnkey Emergency Responder Radio Reinforcement system compliant with all applicable codes and standards referenced herein and as indicated on drawings.
- B. The Emergency Responder Radio Reinforcement system shall include the following major components:
 - 1. Donor Antenna(s)
 - 2. Surge Protection
 - 3. Bi-Directional Amplifier / Repeater
 - 4. Splitters
 - 5. Directional Couplers/Taps
 - 6. Coverage Antennas
 - 7. Uninterruptible Power Supplies

1.3 REFERENCES AND STANDARDS

- A. Unless otherwise noted, design, products, installation, and completed work shall conform with the current version of the following, including applicable addenda and errata:
 - 1. United States Table of Frequency Allocations, current version
 - 2. Federal Communications Commission Table of Frequency Allocations, current version
 - 3. FCC 47 CFR 90.219
 - 4. FCC OET Bulletin 65
 - 5. IFC International Fire Code
 - 6. UL 2524 UL 2524 Standard for In-building 2-Way Emergency Radio Communication Enhancement Systems
 - 7. NFPA 1: Fire Code
 - 8. NFPA 72: National Fire Alarm and Signaling Code
 - 9. NFPA 1221 NFPA 1221: Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems

1.4 ABBREVIATIONS AND ACRONYMS

- A. Refer to Section 270000 - General Communications Requirements for general terminology used in Division 27 sections.

B. In addition, following abbreviations and acronyms shall apply to this document:

1. ACG: Automatic Gain Control
2. AHJ: Authority Having Jurisdiction
3. ATP: Acceptance Test Plan
4. AWS: Advanced Wireless Service
5. BDA: Bi-Directional Amplifier
6. BOM: Bill-of-Material
7. BRS: Broadband Radio Service
8. BTS: Base Transceiver Station
9. CDMA: Code Division Multiple Access
10. C/N: Carrier-to-Noise Ratio
11. CWDM: Coarse Wave Division Multiplexing
12. DAS: Emergency Responder Radio Reinforcement System
13. DAS: Two-way Radio Communications Enhancement System
14. DAQ: Delivered Audio Quality
15. DWDM: Dense Wave Division Multiplexing
16. EBS: Educational Broadband Service
17. ESMR: Enhanced Specialized Mobile Radio
18. ERRC: Emergency Responder Radio Coverage
19. FCC: Federal Communications Commission
20. GUI: Graphical User Interface
21. iDEN: Integrated Enhanced Digital Network
22. LMR: Land Mobile Radio
23. LTE: Long Term Evolution
24. MIMO: Multiple-Input and Multiple-Output
25. MTBF: Mean Time Between Failure
26. NFPA: National Fire Protection Association
27. NMS: Network Management System
28. NTIA: National Telecommunications and Information Administration
29. PCS: Personal Communications System
30. PSE: Public Safety Entity
31. PSN: Public Safety Network
32. RF: Radio Frequency
33. RoF: Radio-over-Fiber
34. RoHS: Restriction of Hazardous Substances
35. RSL: Received Signal Level
36. RX: Receive
37. SISO: Single-Input, Single-Output
38. SMR: Specialized Mobile Radio

- 39. SMS: Short Message Service
- 40. SNMP: Simple Network Management Protocol
- 41. SOW: Statement of Work
- 42. TSL: Transmit Signal Level
- 43. TX: Transmit
- 44. VSWR: Voltage Standing Wave Ratio

1.5 DEFINITIONS

- A. Refer to Section 270000 - General Communications Requirements for general terminology used in Division 27 sections.
- B. In addition, the following definitions are applicable to this document:
 - 1. Active: DAS components that require AC/DC power for operation
 - 2. Channel: A path for an RF transmission between two points
 - 3. Component: A main system element of the DAS
 - 4. Contractor: The prime contractor bidding the project
 - 5. Passive: DAS components that do not require AC/DC power for operation

1.6 SUBMITTALS

- A. Refer to Section 270000 - General Communications Requirements which provides general guidelines for product or installation information to be submitted by tor.
- B. In addition, Submit:
 - 1. Initial RF site survey and analysis report, to include:
 - a. Data collection point locations
 - b. RF spectrum shots
 - c. RF data plot maps
 - 2. Floor plans documenting proposed coverage antenna locations
 - 3. Floor plans documenting proposed donor antenna location
 - 4. RF propagation modeling maps
 - 5. Documentation that each PSN has reviewed and approved proposed equipment and Contractor's design
 - 6. Follow-up RF site survey and analysis report, to include:
 - a. Data collection point locations
 - b. RF spectrum shots
 - c. RF data plot maps
 - d. Documentation of changes to initial system design required due to results of follow-up RF site survey, where required, to include as applicable:
 - 1) Floor plans documenting proposed coverage antenna locations
 - 2) RF propagation modeling maps
 - 3) Documentation that each PSN has reviewed and approved proposed equipment and Contractor's design

PART 2 - PRODUCTS

2.1 GENERAL

- A. Equipment required to provide emergency responder radio coverage shall be listed in accordance with UL 2524.
- B. System shall be a BDA style turnkey system capable of integral support of RF signals for PSNs managed by FCC.
- C. System shall support each PSN on each frequency currently being used by PSEs serving project area.
 - 1. Coordinate directly with each PSE prior to the commencement of design work to confirm frequencies active on the project's scheduled date of substantial completion.
- D. System shall be expandable to support each frequency band allocated by FCC for PSN use without replacement of or addition to the system's passive infrastructure.
- E. System shall be capable of receiving PSN AHJ approval.
- F. System shall include filtering of all frequencies unused by PSN signals in area in which project is located.
- G. System shall be capable of upgrade, without need for additional hardware or software, to support changes to other frequencies within deployed frequency bands to maintain PSN coverage as originally designed.
- H. System shall be expandable to extend coverage for all Public Safety frequencies supported to future new additions without need for additional head end equipment.
- I. Passive system components shall be:
 - 1. Broadband
 - 2. PIM (passive intermodulation) compliant
- J. Active RF emitting devices used in emergency responder radio coverage systems shall have built-in oscillation detection and control circuitry.

2.2 ANTENNAS

- A. General
 - 1. Antennas shall feature multi-band design accommodating multiple frequency bands in a single wall-mounted antenna
- B. Broadband Donor Antenna
 - 1. Antennas shall feature multi-band design accommodating applicable Public Safety frequencies in a single pole-mounted antenna.
 - 2. Temperature range: -40°F to 140 °F.
 - 3. Rated for outdoor use.

- C. Coverage Antennas – Omnidirectional
 - 1. Antenna beam width:
 - a. Horizontal: 360° omnidirectional
 - b. Vertical: 65-80° nominal
 - 2. Temperature range: -40°F to 140 °F.
 - 3. Rated for indoor use.
- D. Coverage Antennas - Directional
 - 1. Antenna beam width:
 - a. Horizontal: 110° directional
 - b. Vertical: 90° nominal
 - 2. Temperature range: -40°F to 140 °F.
 - 3. Rated for indoor use.

2.3 BI-DIRECTIONAL AMPLIFIERS

- A. Where BDA is used to drive DAS, BDA shall be modular design and use digital filtering to mitigate interference.
- B. BDA shall be standard 19” rack or wall mountable.
- C. BDA shall be able to individually control power level of each frequency band amplified.

2.4 CABLING

- A. Feeder and riser coaxial cables shall be plenum rated.
- B. Backbone, antenna distribution, radiating, and fiber optic cables shall be plenum rated.

PART 3 - EXECUTION

3.1 PSN SUPPORT COORDINATION MEETING

- A. Prior to Contractor’s design work commencement, Contractor shall arrange and conduct coordination meeting to review and coordinate Emergency Responder Radio Reinforcement system support of PSN frequencies.
 - 1. At minimum, attendees shall include:
 - a. AHJ and representatives of public safety entities utilizing supported PSN frequencies
 - b. Owner’s project manager, facilities/buildings and grounds/maintenance representative, security representative, and information technology/information systems representative
 - c. Contractor project manager and site superintendent/field foreman
 - d. Division 26 site superintendent/field foreman
 - e. Division 27 project manager and site superintendent/field foreman
 - f. Emergency Responder Radio Reinforcement subcontractor/supplier project manager

2. At minimum, meeting agenda topics shall include:
 - a. Confirmation of PSN frequencies and channel loading currently being used by PSEs serving project area
 - b. Identification of planned or potential changes in active frequencies and/or channel loading that may be implemented prior to scheduled date of substantial project completion
 - c. Identification and discussion of proposed system's functional capabilities and limitations
 - d. Step-by-step review of system design and deployment execution plan
 - e. Review of survey, design, installation, configuration, programming, and testing schedule and of how those relate to overall construction schedule, including identification of interdependencies, project milestones, and critical dates.
3. Meeting shall be scheduled with minimum of two weeks' notice.
 - a. Contractor shall publish meeting agenda and distribute agenda and configuration and programming guide to invited attendees minimum of one week prior to meeting.
4. Contractor shall take detailed notes during meeting and publish meeting minutes within one week after meeting. Minutes shall be distributed to attendees, Architect, and Engineer, and be included in Operation and Maintenance Manual.

3.2 PRE-DESIGN SITE SURVEY

- A. After specified coordination meetings and before completion of design, Contractor shall conduct pre-design site survey.
- B. Data collection points shall:
 1. Include potential donor antenna locations and elevations
 - a. Every effort shall be made to be accurate in locating potential donor antenna locations and elevations on site during survey, to ensure survey measurements are conducted within 10 feet of actual locations, including elevation.
 2. Be sufficient in quantity and location to provide accurate and sufficiently granular data throughout coverage areas
 3. Be sufficient in quantity and location to properly inform Contractor's design
- C. Survey measurements shall include:
 1. Baseline RF noise at and adjacent to supported frequencies
 2. Signal strength of each supported PSN's macro signals, at supported frequencies
- D. Survey data shall be submitted to Architect and Engineer and be included in Operation and Maintenance Manual.

3.3 DESIGN

- A. Where DAS is used in lieu of a two-way in-building wired emergency communications system, DAS design shall be approved by AHJ.
- B. Contractor is solely responsible for design of Emergency Responder Radio Reinforcement System.

- C. Contractor shall design Emergency Responder Radio Reinforcement System in accordance with manufacturer's instructions and recommendations, industry standard best practices, and requirements of supported PSNs. Where discrepancies arise, more stringent requirement will govern.
- D. Contractor shall design Emergency Responder Radio Reinforcement System to provide performance specified herein throughout the coverage areas and to meet approval of all supported PSNs.
- E. Refer to Architectural drawings for building occupant information.

3.4 PRE-INSTALLATION SITE SURVEY

- A. Contractor shall conduct pre-installation site survey no more than thirty (30) days prior to commencement of installation work on site to acquire updated measurement data.
 - 1. Pre-installation site survey shall be conducted after walls are built and after glazing is installed.
 - 2. Where pre-design site survey is conducted within thirty days of commencement of installation work and fulfills all requirements for both pre-design site survey and pre-installation site survey, separate pre-installation site survey is not required.
- B. Data collection points shall:
 - 1. Include potential donor antenna locations and elevations
 - a. Every effort shall be made to be accurate in locating potential donor antenna locations and elevations on site during survey, to ensure survey measurements are conducted within 10 feet of actual locations, including elevation.
 - 2. Be sufficient in quantity and location to provide accurate and sufficiently granular data throughout coverage areas
 - 3. Be sufficient in quantity and location to properly verify Contractor's design
- C. Survey measurements shall include:
 - 1. Baseline RF noise at and adjacent to supported frequencies
 - 2. Signal strength of each supported PSN's macro signals, at supported frequencies
 - 3. Continuous wave (CW) testing to validate propagation modeling
- D. Survey data shall be submitted to Architect and Engineer and be included in Operation and Maintenance Manual.
- E. Contractor shall update their design as required by updated survey data.

3.5 WORK SEQUENCE

- A. Coordinate schedule of Emergency Responder Radio Reinforcement system work to ensure Certificate of Occupancy is obtained in accordance with project schedule.

3.6 EQUIPMENT SUPPORTS

- A. Donor Antenna Mounts

1. Donor antenna assemblies including antenna(s), antenna cable, antenna mount/mast, and associated accessories and hardware shall be designed and installed to withstand sustained winds of ≥ 100 miles per hour from any direction with all devices, equipment, and material installed and with up to 6" of radial ice accumulated.
2. Make donor antenna mounts/masts and associated components, accessories, and hardware electrically continuous and properly ground to lightning protection system. Refer to Section 264113 - Lightning Protection for Structures for conductor sizing and termination requirements, and for additional information and requirements.

3.7 INSTALLATION

- A. Design and installation shall be performed and overseen by FCC GROL licensed technician employed by installing contractor.
- B. Equipment Locations
 1. Install antenna(s) in coverage areas. .
 2. Install main system head end equipment where indicated on drawings. .
 3. Install system floor-level equipment (splitters, directional couplers / taps, etc.) where indicated on drawings in telecommunications rooms. Refer to drawings for additional information.
 4. Active system components, including transmitter, receiver, signal booster components, external filters and battery system components, shall be contained in NEMA 4 or 4X enclosures.
- C. Power Supplies
 1. Primary power source
 - a. Emergency Responder Radio Reinforcement system active electronics shall be fed via minimum 20-amp emergency power electrical circuit(s), dedicated to Emergency Responder Radio Reinforcement system head end equipment.
 2. Secondary power source
 - a. System shall include battery back-up sufficient to power system at 100 percent system operation for minimum of twenty-four (24) hours.
 3. Power supply system shall be equipped with emergency power off (EPO) switch in location approved by fire code official. EPO shall disconnect both circuit breaker and secondary power supply simultaneously.
 4. Coordinate power requirements, quantities, connection locations, and schedule for activating power with on-site Division 26 Contractor prior to commencement of work on site.
- D. Cabling
 1. Where DAS is used in lieu of two-way in-building wired emergency communications system, DAS shall have pathway survivability of Level 1, Level 2, or Level 3.
 2. Riser cables shall be routed through 2-hour rated enclosure.
 3. Connection between riser and feeder cables shall be made within 2-hour rated enclosure.
 - a. Passage of feeder cable in and out of 2-hour rated enclosure shall be fire-stopped to 2-hour ratings.

- E. Properly ground system components with minimum 6 AWG bonding conductor terminated with two-hole compression lugs.
 - 1. Refer to Section 270526 for additional information and requirements.
- F. Provide and configure filtering to maximize composite power for PSN frequencies being supported.
- G. Properly terminate unused RF ports on system devices, including amplifiers, splitters, directional coupler / taps, etc.
- H. Donor Antennas
 - 1. Coordinate donor antenna locations and mounting method with Architect and GC prior to rough-in.
 - 2. Fasten donor antennas and associated mounting components with stainless steel fasteners.
 - 3. Bond donor antenna cables to ground at point where cable connects to antenna and at point where cable transfers off antenna mounting structure.
 - 4. Provide in-line surge protection on antenna cables, at point where cable enters building.
 - a. Properly ground surge protection components with minimum 6 AWG bonding conductor terminated with two-hole compression lugs.
 - b. Refer to Section 270526 for additional information and requirements.
 - 5. Weatherproof exterior antenna cable connections with manufacturer-approved assembly.
- I. Coverage Antennas shall be installed in accessible ceilings. Coordinate antenna locations with work by other trades to ensure that direct access to antenna is maintained after project completion.
- J. System shall provide uniform coverage. Radio coverage shall be provided throughout building as percentage of floor area.
 - 1. Building shall be considered to have acceptable emergency responder radio coverage when signal strength measurements in 95 percent of all areas on each floor of building meet signal strength requirements.
 - 2. Minimum signal strength of -95 dBm shall be receivable within the building.
 - 3. Minimum signal strength of -95 dBm shall be received by agency's radio system when transmitted from within building.
 - 4. Critical areas, including fire command centers, fire pump rooms, exit stairs, exit passageways, elevator lobbies, standpipe cabinets, sprinkler sectional valve locations, and other areas deemed critical by AHJ, shall be provided with 99 percent floor area radio coverage.
 - a. General building areas shall be provided with 90 percent floor area radio coverage.
 - 5. Minimum inbound signal strength sufficient to provide usable voice communications, as specified by AHJ, shall be provided throughout coverage area. Inbound signal level shall be sufficient to provide minimum of DAQ 3.0 for either analog or digital signals.
 - 6. Minimum outbound signal strength sufficient to provide usable voice communications, as specified by AHJ, shall be provided throughout coverage area. Outbound signal level shall be sufficient to provide minimum DAQ 3.0 for either analog or digital signals.

7. Isolation shall be maintained between donor antenna and inside antennas to minimum of 20 dB under operating conditions.

K. System shall not interfere with operation of other electronic systems.

3.8 SYSTEM MONITORING

A. Fire Alarm System

1. System shall include automatic supervisory signals for malfunctions of emergency responder radio reinforcement system annunciated by fire alarm system in accordance with NFPA 72.
 - a. Monitoring for system integrity shall comply with NFPA 72, Chapter 10.
 - b. Provide visual and labeled indications for each supervised system component.
 - c. System supervisory signals shall include:
 - 1) Donor antenna malfunction
 - 2) Active RF emitting device failure
 - 3) Low-battery capacity indication when 70 percent of the 24-hour operating capacity has been depleted
 - 4) System component failure
 - d. Power supply supervisory signals shall include the following for each RF emitting device and system component:
 - 1) Loss of normal AC power
 - 2) Failure of battery charger
 - e. Communications link between fire alarm system and emergency responder radio reinforcement system shall be monitored for integrity.

B. Dedicated Panel

1. Dedicated monitoring panel shall be provided adjacent to FACP to annunciate status of RF emitting devices and system component locations. Monitoring panel shall provide visual and labeled indications of following for each system component and RF emitting device:
 - a. Normal AC power
 - b. Loss of normal AC power
 - c. Battery charger failure
 - d. Low battery capacity (to 70 percent depletion)
 - e. Donor antenna malfunction
 - f. Active RF emitting device malfunction
 - g. System component malfunction
2. Communications link between dedicated monitoring panel and emergency responder radio reinforcement system must be monitored for integrity.

3.9 INSPECTION AND TESTING

- A. Test plan shall include tests necessary to verify that installed system meets specified requirements and requirements of each PSE.

B. Scheduling

1. Testing shall be scheduled minimum of two weeks prior to scheduled date of final completion.
 - a. Contractor shall coordinate with each PSE to arrange for them to observe system testing.

C. Data collection points

1. Data collection points shall include:
 - a. All donor antenna locations
 - b. Signal level at each stair landing and elevator lobby
 - c. Signal level at locations as required by AHJ
2. Be sufficient in quantity and location to properly verify that system's performance meets specified requirements and requirements of each PSE.
 - a. At a minimum, each floor shall be divided into twenty equal areas and data shall be collected at or as near as is practical to the center of each area.

D. Survey measurements shall include:

1. Baseline RF noise at and adjacent to supported frequencies
2. Signal strength of each supported PSN's macro signals, at supported frequencies
3. Signal strength of each supported PSN's system coverage signals, at all supported frequencies

E. At no additional cost to Owner, Contractor shall adjust, modify, and/or add to system as necessary to achieve performance required by AHJ.

3.10 ATTIC STOCK

A. Contractor shall provide following spare devices and equipment as Owner's attic stock:

1. Donor Antennas: One (1) of each type provided
2. Coverage Antennas: Five (5) of each type provided
3. Surge Suppressors: 100% of the quantity installed of each type provided.
4. Fuses: 20% of each type provided as part of system devices and equipment, minimum ten (10) of each type provided.

3.11 TRAINING

- A. Contractor shall provide to Owner's designated representative(s) a minimum of one (1) 4-hour on-site training session related to work under this section within thirty (30) days of substantial completion.

END OF SECTION 275319

SECTION 283116 - MULTIPLEXED FIRE DETECTION AND ALARM SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. In general, work consists of:
 - 1. Provide complete Multiplexed Fire Alarm System as shown on plans.
 - 2. System shall:
 - a. Be an intelligent analog system
 - b. Allow for loading and editing special instructions and operating sequences as required
 - c. Be capable of on-site programming to accommodate system expansion and facilitate changes in operation
 - d. Be wired, connected, and left in operating condition
 - e. Support signaling interconnection to existing Fire Alarm System Existing in the existing portion of the building.
 - 3. System includes:
 - a. Control Panel(s)
 - b. Annunciator Panel(s)
 - c. Manual Stations
 - d. Heat Detectors
 - e. Smoke Detectors
 - f. Alarm Indicating Devices
 - g. Terminations
 - h. Other necessary material for complete operating systems
 - 4. Software operations shall be stored in non-volatile programmable memory within fire alarm control panel. Loss of primary and secondary power shall not erase instructions stored in memory.

1.2 REFERENCE STANDARDS

- A. IBC - 2000 - International Building Code
- B. ICC (IFC) - 2000 - International Fire Code
- C. NECA 305 - Standard for Fire Alarm System Job Practices
- D. NFPA 72 - National Fire Alarm Code
- E. NFPA 101 - Life Safety Code
- F. UL 268 - Smoke Detectors for Fire Protective Signaling Systems
- G. UL 497B - Protectors for Communications and Fire Alarm Circuits
- H. UL 521 - Heat Detectors for Fire Protective Signaling Systems

- I. UL 864 - Control Units for Fire Protective Signaling Systems
- J. UL 1480 - Speakers for Fire Protective Signaling Systems
- K. UL 1481 - Power Supplies for Fire Protective Signaling Systems
- L. UL 1711 - Amplifiers for Fire Protective Signaling Systems

1.3 QUALIFICATIONS

- A. Equipment shall be supplied by company specializing in fire alarm and smoke detection systems with 5 yrs documented experience
- B. Work shall be performed by licensed Contractor, regularly engaged in installation and servicing of fire alarm systems.
- C. Furnish proof of 5 yrs documented experience and factory authorization to provide equipment proposed.
- D. Contractor shall be located within 100 miles of Project site.
- E. On-site supervisor shall be NICET Level II certified. Personnel implementing any programming shall be NICET Level III certified.

1.4 SUBMITTALS

- A. Submit bill of materials listing part number and quantity of components and devices.
- B. Submit general catalog cutsheets of all devices that are to be provided as part of system. Mark cutsheets with items specific to the project when multiple items are identified.
- C. Submit block diagrams showing layout and operation of entire system.
- D. Submit schematic diagrams, of circuits from field devices to terminal strip(s) associated with control panel.
 - 1. Diagrams shall show schematic wiring of equipment; and connections to be made to devices.
 - 2. Terminal connections in equipment shall be numbered to correspond to diagrams.
 - 3. Wiring diagrams shall be coordinated so that terminal numbering, circuit designation and equipment or device designations are same on drawings.
- E. Submit standby battery power calculations.
- F. Submit sound amplifier and strobe power supply calculations showing current draws for every device and module during standby, alarm and trouble conditions.
- G. Submit voltage drop calculations for both initiating and alarming circuits.
- H. Submit list of device addresses with location labeling as they will appear in 2 line, 40 character display of fire alarm panel and remote annunciator.

- I. A minimum of 7 business days prior to requested start of acceptance testing, Submit the following to the Designer. If deficiencies are found, contractor must allow time for corrections to be made prior to the start of acceptance testing. Discrepancies between submitted documents and field conditions during acceptance testing will be sufficient grounds for a failed inspection and re-start of this review process.
 1. Copy of as-built shop drawings as required to show component locations, device addresses, etc.
 2. Completed system test record and report
 3. Completed audible notification verification survey report
 4. Device sensitivity report
 5. Completed NFPA 72 record of completion form (acceptable to submit without signatures)
 6. Programming report showing all devices and the program description for each device.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Simplex
- B. Notifier
- C. Honeywell

2.2 SYSTEM OPERATIONS

- A. Alarm Initiation
 1. System alarm operation after activation of any manual station, automatic detection device, or sprinkler flow switch shall be:
 - a. Appropriate initiating device circuit red LED shall flash on Control Panel and remote annunciator until the alarm has been acknowledged at Control Panel or remote annunciator.
 - b. Once acknowledged, this same LED shall latch on.
 - c. Subsequent alarm received after acknowledging shall flash subsequent zone alarm LED on Control Panel and remote annunciator.
 - d. Acknowledgment of alarm shall not reset activated device.
 - e. Pulsing alarm tone shall occur within Control Panel and remote annunciator until event has been acknowledged and remote annunciator.
 - f. Alarm audible-indicating devices shall sound in three pulse temporal pattern until silenced by alarm silence switch at Control Panel or remote annunciator.
 - g. Visual alarm indicating devices shall operate in continuous flashing pattern until system is reset.
 - h. Signal to notify the supervising station in the Fire Command Center shall be activated. Signal shall also be passed to Head End of existing building system equipment to facilitate actionable sequence(s) in that portion of the building.
 - i. Doors held open by door control devices shall close.

- j. Mechanical controls shall activate air handling systems as specified by Division 23.
 - 2. System shall have single key to allow operator to display alarms, troubles, and supervisory service conditions, including time and date of each occurrence.
 - 3. Alarm shall be displayed on an 80-character LCD display as follows:
 - a. 40 characters for:
 - 1) Point address and loop number
 - 2) Type of device
 - 3) Point status
 - b. 40 characters for:
 - 1) Custom location label
- B. Silencing
- 1. Alarm audible indicating devices shall be silenced by operating alarm silence switch or by use of key operated switch at remote annunciator.
 - 2. Strobes shall remain active until system is reset.
 - 3. Subsequent zone alarm shall reactivate alarm signals.
- C. Reset
- 1. SYSTEM RESET button shall return system to its normal state after an alarm condition has been remedied.
- D. Supervision
- 1. System shall independently supervise:
 - a. Initiating device circuits
 - b. Sprinkler flow and tamper switches
 - c. Independently fused indicating appliance circuits for alarm horn/strobe units
 - d. Auxiliary manual controls. "Off normal" position of any switch shall cause an "off normal" system trouble
 - e. Auxiliary circuits for addressable relays. Blown fuse or open in circuit shall be visibly and audibly annunciated.
 - f. Remote annunciator panel. Any ground, short, or open in the wiring to fire alarm Control Panel, as well as malfunction of the annunciator panel, shall be annunciated at control panel.
 - g. Incoming power. Power failure shall be audibly and visually indicated at Control Panel and remote annunciator. Green "power on" LED shall be displayed continuously while incoming power is present.
 - h. System Modules for module placement. Should modules become disconnected, system trouble indicator shall illuminate and audible trouble signal shall sound.
 - i. System batteries. Low battery condition or disconnection of battery shall be audibly and visually indicated at Control Panel and remote annunciator.
 - 2. Device activation shall be annunciated at Control Panel and remote annunciator.
 - 3. Independently supervised circuits shall include visible amber "Trouble" LED to indicate disarrangement conditions per circuit.
 - 4. Disarrangement conditions of any circuit shall not affect operation of other circuits.

5. Alarm activation of any initiation circuit shall not prevent subsequent alarm operation of any other initiation circuit.
6. System shall have provisions for disabling and enabling circuits individually for maintenance or testing purposes.

E. Power Requirements

1. Provide 120 VAC power via dedicated branch circuit in emergency panel.
2. Branch circuit shall have "breaker lock" to prevent accidentally de-energizing of power to fire alarm panel.
3. Circuit breaker shall be painted red and labeled "FIRE ALARM."
4. Provide disconnect switch for AC power near panel or within Fire Alarm Control Panel itself. Switch shall be labeled "Fire Alarm Power Disconnect."
5. Where new Control Panel is to remain at same location as existing panel, Contractor may use existing branch circuit, if it meets requirements stated above.
6. Provide power surge and transient protection.
7. Provide back-up battery capacity to operate entire system in normal supervisory mode for period of 24 h with 10 minutes of alarm operation at end of period.
8. System shall automatically transfer to standby batteries upon power failure.
 - a. Battery charging and recharging operations shall be automatic.
9. Provide power limited, filtered and regulated battery charger.
 - a. Charger shall:
 - 1) Be combination high rate/float maintenance type
 - 2) Charge fully discharged battery to 70% in 12 h
 - 3) Monitor for AC fail/disconnect, low/no battery, and high battery level
 - 4) Include switches and associated LEDs for high rate and AC disconnect
 - 5) Provide 5 amps of regulated 24 VDC for peripheral devices requiring $\pm 5\%$ regulation and 8 amps at 24 VDC for standard peripheral devices.
 - 6) Be compatible with lead acid batteries
10. External circuits requiring system operating power shall be 24 VDC and shall be individually supervised and fused at Control Panel.

F. Smoke Detection Operation

1. Smoke detector alarms shall be processed and reported immediately.
2. Upon building completion, alarm verification shall be added to detector(s) as directed by project engineer.
3. Control Panel shall:
 - a. Be capable of displaying number of times (tally) detector has gone into verification mode from the system history
 - b. Download alarm set point to detector
 - c. Determine condition of each detector by comparing detector's value to stored values.
 - d. Maintain moving average of detectors' smoke chamber value to automatically compensate for dust and dirty conditions
 - e. Continuously perform an automatic self-test routine on each detector

- f. Have capability of being programmed for pre-alarm or two-stage function
 - g. Clear “detector dirty” trouble after detector has been removed from its base cleaned and replaced
 - 4. System shall maintain constant smoke obscuration sensitivity for each detector by compensating for environmental factors.
 - 5. Photoelectric detector's smoke obscuration sensitivity shall be adjustable to within 0.3% of either limit of UL window (0.5% to 4.0%) to compensate for any environment.
 - 6. System shall indicate when individual detector needs cleaning. When detector's average value reaches predetermined level, trouble MESSAGE shall be audible and visibly indicated at Control Panel. LED on detector base shall glow steady giving visible indication.
 - 7. For scheduling of maintenance, Control Panel shall generate MESSAGE indication for any detector approaching trouble condition due to dirt or contamination.
 - 8. Operator shall have capability to manually access the following information for each detector:
 - a. Primary status
 - b. Device type
 - c. Present average value
 - d. Present sensitivity value selected
 - e. Detector range (normal, dirty, etc.)
 - 9. Values at Control Panel shall be in “percent of smoke obscuration” format, so that no interpretation is required by operator.
 - 10. Operator shall be able to manually control following for each detector:
 - a. Enable or disable detector
 - b. Establish alarm sensitivity
 - c. Control detector's relay driver output
 - 11. It shall be possible to program Control Panel to automatically change sensitivity settings of each detector based on time-of-day and day-of-week. There shall be 3 sensitivity settings available for each detector.
- G. System Response
- 1. Maximum elapsed time from sensing fire at non-smoke detector initiating device or second smoke detector until it is recorded at Control Panel shall not exceed 5 seconds, and not exceed 15 seconds for remote station reporting.
- H. Air Handling Unit System Operation/Interface
- 1. Control Panel shall provide alarm interface to air handling/energy management system controllers, which shall perform automatic functions as specified in Division 23.
 - 2. Fire Alarm Control Panel shall provide manual control mode to override fire alarm panel's signal so that air handling units can be restarted.
- I. Sprinkler System Operation/Interface

1. Activation of any standpipe or sprinkler system tamper or water flow switch shall activate system supervisory service audible signal and illuminate LED at Control Panel and remote annunciator.
 2. Control Panel shall provide differentiation between switch operation and opens and/or grounds on initiation circuit wiring.
 3. Pressing acknowledge key will silence audible signal while maintaining supervisory service LED "on" indicating off-normal condition.
 4. Restoring valve to normal position shall cause supervisory service audible signal to pulse indicating restoration to normal position.
 5. Acknowledge key shall silence audible signal.
- J. Manual Evacuation (Drill) Operation
1. Manual evacuation (drill) switch shall be provided to operate alarm indicating appliances without causing other control circuits to be activated.
 2. Should true alarm occur, alarm functions would occur.
- K. LED and LCD Test Operation
1. Activation of Lamp Test switch shall turn on all LED indicators, LCD display, and the local sounder and then return to previous condition.
- L. System Diagnosis
1. System shall include special software to detect, diagnose and report failures and isolate such failures to printed circuit board level.
- M. Watch-Dog Timers
1. System shall include independent "Watch-Dog" timers to detect and report failure of any microprocessor circuit, memory, or software.
- N. Walk Test Operation
1. Actuation of "Walk Test" switch/program at Control Panel shall activate "Walk Test" mode of system, which shall cause following to occur:
 - a. Supervising station circuit connection shall be bypassed.
 - b. Control relay functions shall be bypassed, such as _____, door holders, elevator capture, and fan shut down, etc.
 - c. Audio and visual circuits shall be bypassed.
 - d. Control Panel shall show trouble condition.
 - e. Alarm activation of initiation device shall cause audible signals to sound for 2 seconds.
 - f. Control Panel shall automatically reset itself after signaling is complete.
 - g. Momentary opening of initiating or indicating appliance circuit wiring shall cause audible signals to sound for 2 seconds indicating trouble condition.
 - h. If system becomes inactive for period of longer than 10 minutes, Control Panel shall default to normal fire alarm functions.
 - i. Activation of any initiation device shall be silently logged as an alarm condition in historical data file.

2. Panel shall have capability of dividing system into distinctive walk test groups, minimum of 8 groups.

O. One-Way Voice Communications

1. Automatic voice evacuation sequence shall be as follows:
 - a. Audio alarm signal shall consist of alarm tone for maximum of 2 seconds followed by temporal code-three. Temporal code-three shall sound until alarm silence switch at Fire Alarm Control Panel or the remote annunciator has been operated.
 - b. Audio alarm operations of speaker circuit selection and alarm tone timing variations shall be activated by system software so that required future changes to evacuation sequence or re-arrangements of audio circuits can be facilitated by authorized personnel without additional components or rewiring.
 - c. System shall be configured to allow for "All Call" and selective voice paging from the main Control Panel.
2. Selective Paging:
 - a. Upon activation of any speaker manual control switch(es), 2 seconds of tone shall sound over selected speakers. At end of this tone, operator shall be able to make announcements via push-to-talk paging microphone over pre-selected speakers.
 - b. Strobes shall flash only in selected area(s) or floor(s).
 - c. Each floor, stairwell and elevator car shall be separate selectable zones.
3. All Call:
 - a. Upon activation of "All Call" switch, 2 seconds of tone shall sound over all speakers in system. At end of this tone, the operator shall be able to make announcements via push-to-talk paging microphone over all system speakers.
 - b. Strobes shall flash in all areas or floors.
 - c. System shall default to normal operations if the microphone becomes inactive for more than 1 minute.

2.3 ENCLOSURE

- A. Provide cabinets of sufficient size to accommodate equipment.
- B. Cabinet shall be equipped with door, with lock and transparent door panel, providing tamper proof enclosure and allowing full view of various lights and controls.
- C. Provide documentation cabinet for drawings and other system documentation, located adjacent to fire alarm control cabinet.

2.4 CONTROL PANEL

- A. Control Panel shall be modular, expandable with solid state, microprocessor based electronics.
- B. Control Panel shall provide the following features:
 1. Support intelligent (analog) detection devices.
 2. Number of initiating device loops required for specified quantity of initiating devices, plus 1 spare loop for each 5 active loops. Each active loop shall include 5% spare capacity.

3. Number of indicating device (horn/speaker) circuits required for quantity of horns/speakers alarm, plus 1 spare circuit for each 10 active circuits. Each active circuit shall include 25% spare capacity.
 4. Number of indicating device (strobe) circuits required for specified quantity of strobes plus one (1) spare circuit for each 10 active circuits. Each active circuit shall include 25% spare capacity.
 5. 80-character liquid crystal display
 6. Printer interface
 7. History log file with minimum of 600 events
 8. Field programmable
 9. Drift compensation
 10. Sensitivity display in %
 11. Sensitivity adjustment
 12. Day/night sensitivity adjustment
 13. Auto detector test
 14. Silent walk test
 15. Maintenance alerts
- C. System shall provide ability to recall alarms and trouble conditions in chronological order.
- D. Under normal condition viewing window shall display "System is Normal" message and current time and date.
- E. When an abnormal condition occurs appropriate LED (Alarm, Supervisory or Trouble) shall flash.
- F. Audible signal shall pulse for alarm conditions and sound steady for trouble and supervisory conditions.
- G. Panel shall display the following information relative to abnormal condition of a point in system prior to acknowledgement:
1. 40 characters for:
 - a. Point address and loop number
 - b. Type of device (i.e. smoke, pull station, water-flow)
 - c. Point status (i.e. alarm, trouble)
 2. 40 characters for:
 - a. Custom location label (i.e. 4th Floor - Room 444)
- H. Keyboards or keypads shall not be required to operate the system during fire alarm conditions.
- I. Following software functions shall be provided:
1. Setting of time and date
 2. LED testing
 3. Alarm, trouble, and abnormal condition listing
 4. Enabling and disabling of each monitor point separately

5. Activation and deactivation of each control point separately
 6. Changing operator access levels
 7. Walk Test enable
 8. Running diagnostic functions
 9. Displaying historical logs
 10. Point listing
- J. Following hardware functions shall be provided:
1. Acknowledge alarm or trouble
 2. Silence alarm or trouble
 3. Reset system after alarm
 4. Provide manual evacuation (drill)
 5. Bypass elevator recall and shunt trip operation
 6. Bypass door holders
 7. Allow computer interface

2.5 STATUS INDICATORS AND DISPLAYS

- A. Audible device shall sound during Alarm, Trouble or Supervisory conditions.
- B. Audible device shall sound during each key-press.
- C. Visual display shall distinguish between alarm, trouble and supervisory conditions.
- D. Indicators and displays to be visible:
1. One red system alarm LED
 2. One yellow supervisory service LED
 3. One yellow trouble LED
 4. Green "power on" LED
 5. Eighty-character LCD
- E. 2-line by 40-character LCD shall be backlit.
- F. Cursor shall be visible on LCD when entering information.
- G. Scrolling through menu options shall be in self-directing manner in which prompting messages shall direct user.
- H. Controls shall be located behind an access door.
- I. Status data to be available on display:
1. Initiating device circuits
 2. Indicating device circuits
 3. Auxiliary relays
 4. Primary State of point
 5. Zone information

6. Class "A" Status
7. Current priority of outputs
8. Disable/Enable status
9. Automatic/Manual Control Status of output points
10. Acknowledge status

2.6 CONTROLS

- A. Controls (one switch per function per system) visible through front viewing window:
 1. Alarm Acknowledge key
 2. Trouble Acknowledge key
 3. Alarm Silence key
 4. System Reset key
- B. Controls accessible with front door open:
 1. supervising station
 2. Manual evacuation (drill)
 3. Key pad for data input and microprocessor control

2.7 LED SUPERVISION

- A. Slave module LEDs shall be supervised. When problem occurs, LCD shall display module and LED location.

2.8 ACKNOWLEDGMENT

- A. Two methods of acknowledgment for each abnormal condition shall be provided:
 1. Acknowledge one event at a time from an unacknowledged list of events.
 2. Pressing acknowledge button shall display first unacknowledged condition in list (either alarm, supervisory or trouble), and require another acknowledge button. Press to acknowledge only displayed point.
- B. After all points have been acknowledged, LEDs shall glow steadily and alarm will be silenced. Total number of alarms, supervisory and trouble conditions shall be displayed.
- C. Pressing appropriate acknowledge button shall acknowledge all points
- D. Acknowledge functions shall be behind locked door or pass-code protected.

2.9 SILENCING

- A. If an alarm condition exists and "Alarm Silence" button is pressed, all alarm signals shall cease operation. Strobes shall remain active until system is reset.
- B. If trouble conditions exist in system and "Trouble Silence" button has been pressed, audible trouble signal shall cease, but shall resound at timed intervals to act as reminder that fire alarm system is not in normal operating mode.

2.10 RESET

- A. SYSTEM RESET button shall be used to return system to normal state after alarm condition has been remedied.
- B. Should an alarm condition continue to exist, system shall provide indications that resetting can not be completed and shall remain in an abnormal state.
- C. Sonalert and Alarm LED shall remain activated.
- D. Display shall indicate total number of alarms and troubles present in system along with prompt to use ACK keys to review points.
- E. Points shall not require acknowledgment if they were previously acknowledged.
- F. Should Alarm Silence Inhibit function be active, system shall ignore all key presses. An indication of enabling and disabling inhibit state shall be provided as feedback to operator.

2.11 ACCESS LEVELS

- A. Provide 4 access levels with level 4 being highest level. Level 1 actions shall not require pass-code.
- B. Pass-codes shall consist of up to 5 digits.
- C. Pass-code digits entered shall be displayed as an X to indicate that digit has been accepted.
- D. Key presses shall be acknowledged by local audible sound.
- E. When correct pass-code is entered, system shall indicate to operator "Access Granted."
- F. Access level shall be in effect until operator manually logs out or keypad has been inactive for 5 minutes.
- G. Operator entering invalid code shall be notified with message "Incorrect Pass- Code" and shall be allowed three chances to enter valid code. After three unsuccessful tries, the message "Access Denied" shall be displayed.
- H. Following keys/switches shall have associated access levels:
 - 1. Alarm Silence
 - 2. System Reset
 - 3. Set Time/Date
 - 4. Manual Control
 - 5. On/Off/Auto Control
 - 6. Disable/Enable
 - 7. Programming functions
 - 8. Clear Historical Alarm Log
 - 9. Clear Historical Trouble Log
 - 10. Walk Test

- I. Acknowledge keys shall require pass code access to acknowledge points. If operator presses an (ACK) key with insufficient access, an error message shall be displayed.

2.12 POINT LISTING

- A. Point list menu includes:
 - 1. All points list by address
 - 2. Monitor point list
 - 3. Signal/speaker list
 - 4. Auxiliary control list
 - 5. Feedback point list

2.13 HISTORY LOGGING

- A. System shall be capable of logging and storing the last 400 events (alarm and trouble) in history log. These events shall be stored in battery protected random access memory.
- B. Following historical alarm log events shall be stored:
 - 1. Alarms
 - 2. Alarm Acknowledgment
 - 3. Alarm Silence
 - 4. System Reset
 - 5. Alarm Historical log cleared
- C. Following historical trouble log events shall be stored:
 - 1. Trouble conditions
 - 2. Supervisory alarms
 - 3. Trouble acknowledgment
 - 4. Supervisory acknowledgment
 - 5. Walk Test results
 - 6. Trouble Historical log cleared

2.14 COMPUTER INTERFACE

- A. Control Panel shall operate as proprietary local system with capability of sending status data to and receiving control data from Central Processing Unit (CPU).
- B. CPU shall monitor all alarms and troubles and control selected functions of Control Panel.
- C. CPU shall supervise all data communication wiring between CPU and Control Panel for opens, shorts and grounds.

2.15 FIELD PROGRAMMING

- A. System shall be fully programmable, configurable, and expandable in field and shall not require replacement of memory IC's.

- B. Programming may be accomplished through Control Panel keyboard or keyboard at printer, or use of PC.
- C. Programs shall be stored in non-volatile memory.
- D. Programming or reprogramming shall be done by supplier at no charge until system is accepted by Owner.

2.16 TERMINAL/PRINTER INTERFACE

- A. Control Panel shall be capable of operating remote monitors and/or printers.
- B. Output shall be ASCII from RS-232-C connection with an adjustable baud rate.
- C. Each RS-232-C port shall be capable of supporting and supervising up to 4 remote CRTs and Printers.
- D. Data amplifiers shall be used to increase CRT or printer line distance.

2.17 INTELLIGENT NETWORK

- A. System shall provide communications with intelligent initiating and control devices individually.
- B. Devices shall be individually annunciated at control panel.
- C. Annunciation shall include the following conditions for each point:
 - 1. Alarm
 - 2. Trouble
 - 3. Open
 - 4. Short
 - 5. Device missing/failed
- D. Devices shall have capability of being disabled or enabled individually.
- E. There shall be no limit to number of detectors, stations, or addressable modules, which may be activated or "in alarm" simultaneously.
- F. Multiple intelligent devices shall be connected to a single pair of wires.
- G. Provide the Digital Alarm Communications Transmitter (DACT), to communicate with existing campus public safety systems. All components must be compatible with fire alarm system supplied and existing campus receiving station
 - 1. Provide Bosch D9068 DACT and C900V2 capture module.
 - 2. Provide Altronix VR3T power conversion module.
 - 3. Refer to drawings for additional details.

2.18 ONE-WAY VOICE COMMUNICATION SYSTEM

- A. Provide central audio control module for:

1. Alarm message/tone generation
 2. Main and remote microphone connections
 3. Mixer/pre-amplifier circuits
 4. Continuous supervision shall be provided for all circuits, amplifiers and modules.
- B. Hand-held, push-to-talk microphone:
1. Recessed in panel-mounted enclosure
 2. Dynamic communication type with frequency range of 200 Hz to 4000 Hz
 3. Equipped with self-winding 5 ft coiled cable
 4. LED indicator shall be provided to indicate microphone push-to-talk button has been pressed and speaker circuits are ready for transmission.
 5. Supervised for disconnection
- C. Audio control switch module:
1. Provide manual access to audio operations personnel.
 2. Include "All circuits" switch, "Aux Tone" switch and tone generator stop switch
 3. Switches and LED indicators shall be supervised for disarrangement on failure.
- D. Automatic message player:
1. Provide a pre-recorded digitized voice message to building occupants during alarm conditions
 2. Not rely on tape or other mechanical means of transmitting evacuation message
 3. Be capable of transmitting a custom message of up to 3 minutes long
- E. Self-contained speaker and switching arrangement shall provide testing of message(s) without disturbing occupants of the facility.
- F. Provide standard message, approved by Authority Having Jurisdiction.
- G. Audio power amplifiers:
1. Be furnished with self-contained filtered 24 VDC power supply, transformer and amplifier monitoring circuits
 2. Provide 25 or 75 VRMS output with frequency response of 100 Hz to 7000 Hz
 3. Be constantly monitored
 4. Be current limited or disconnected from circuit should a short develop on speaker circuit
 5. Individual speaker circuits shall not be loaded more than 70% of rated amplifier power output.
- H. Provide amplifiers to operate system speakers at 1-watt tap simultaneously plus 50% reserve capacity.
- I. Provide at least one back-up amplifier capable of automatically replacing any failed amplifier. Stand-by amplifier shall be rated at same output capacity as the largest amplifier in evacuation system.

- J. Speaker and strobe circuits shall be zoned by floor or as noted on plans, with isolating module on each circuit.
- K. Audio Evacuation Supervision:
 - 1. Each speaker zone, amplifier, preamplifier, and power supply shall be supervised for component or circuit failure.
 - 2. Detection of amplifier failure shall automatically cause substitution of stand-by amplifier and shall activate trouble light and audible signal at console and initiate trouble alarm on fire alarm system.
 - 3. Provide minimum of one circuit for each zone or area of distinct communication.
- L. Manual Voice Paging Sequence
 - 1. System shall allow selective voice paging.
 - 2. An "All Call" switch shall be provided to allow for activation of all speakers.
 - 3. Control Panel shall provide a method for remote fire fighters telephone patch-in to one-way voice communication speakers.
 - 4. Manual operation shall be controlled at Fire Alarm Control Panel, or remote microphone; if provided.
- M. Tones
 - 1. Main evacuating tone shall be temporal code-three.
 - 2. Optional tones shall include:
 - a. Hi/Lo
 - 1) Free running tone with high frequency of 544 Hz and low frequency of 440 Hz
 - 2) "On time" (Hi) shall be 100 milliseconds while the "off time" (Lo) is 400 milliseconds.
 - b. Slow whoop
 - 1) Slowly ascending tone from 200 to 830 Hz in 2.5 seconds
 - 3. One primary and one secondary tone generator shall be furnished.
 - a. Automatic transfer to secondary unit should primary unit fail
 - b. Trouble signals shall indicate a failure of either primary or secondary unit.

2.19 REMOTE ANNUNCIATOR PANEL

- A. Provide 80-character LCD remote annunciator panel.
 - 1. LED annunciators will not be accepted.
- B. Annunciator shall provide:
 - 1. Control push-button switches for; alarm silence, trouble silence, system reset and LED and LCD test.
 - 2. Tone Alert - Duplicates Control Panel tone alert during alarm and trouble conditions
 - 3. System trouble LED
 - 4. System alarm LED
 - 5. Power on LED

- C. Annunciator shall communicate to Control Panel over one shielded twisted pair cable.
- D. Operating power shall be 24 VDC and be fused at control panel.
- E. Annunciator shall have red finish.
- F. Wiring between annunciator panel and Control Panel shall be supervised for opens, grounds and shorts.
- G. Under normal operating conditions, LCD shall indicate time, date and "SYSTEM IS NORMAL" label.
- H. During abnormal conditions, LCD shall indicate type and number of abnormal conditions, such as alarms, troubles, and supervisory services.

2.20 MULTIPLEXED PERIPHERAL DEVICES

- A. Devices shall be supervised for trouble conditions.
- B. Failure of device shall not hinder operation of other system devices.
- C. Device Identification
 - 1. Each intelligent device shall be identified by an address code.
 - 2. Location of end-of-line device shall be indicated on device that containing same.
 - 3. System must verify that proper type device is in place and matches software configuration.
- D. Intelligent Detector Bases
 - 1. Either base or head shall contain electronic circuits that communicate detector's status (normal, alarm, sensitivity status, trouble) to Control Panel over two wires. Same two wires shall also provide power to base and detector.
 - 2. Contacts between base and head shall be of bifurcated type using spring-type, self-wiping contacts.
 - 3. Base shall have locking capability. Locking feature must be field removable when not required.
 - 4. Upon removal of detector's head, trouble signal shall be transmitted to Control Panel.
 - 5. Detector base or head shall contain LED(s) that flash when detector is being scanned by Control Panel.
 - 6. LED(s) shall turn on steady when detector is in alarm condition.
- E. Intelligent Detector Heads - General
 - 1. Intelligent detector heads shall be low-profile type.
 - 2. Heads shall be plug-in units, which mount to common base.
 - 3. Heads shall be 24 VDC type.
 - 4. Heads may be reset by actuating Control Panel reset switch.
 - 5. To minimize false alarms, voltage and RF transient suppression techniques shall be employed.
 - 6. Smoke detectors:

- a. Listed for sensitivity testing from Control Panel. Sensitivity test results shall be logged and downloaded to printer.
- b. Include an insect screen.
- c. Communicate actual smoke chamber values to Control Panel.
- d. Covered with plastic bags after installation to maintain cleanliness. Bags shall be red for quick visual identification for removal at time of occupancy.

F. Intelligent Photoelectric Smoke Detectors

1. Detectors:
 - a. Contain no radioactive material
 - b. Be of solid state photoelectric type and shall operate on light scattering photodiode principle using pulsed infrared LED light.

G. Intelligent Heat Detectors

1. Detectors:
 - a. Be a combination rate-of-rise and fixed temperature (135°F unless noted).
 - b. Sense within temperature range of 32° to 158°F. The control panel shall be capable of sensing either a set point of 135 °F, or a rate-of-rise of 20°F per minute for fire sensing.

H. Intelligent Duct Smoke Detectors:

1. Duct detectors shall be of photoelectric ionization type.
2. Detectors shall be rated for air velocity to be expected.
3. It shall be possible to alarm duct detector by using remote or local test switch.
4. It shall be possible to clean sampling tubes by access through duct housings front cover.
5. Provide relays adjacent to motor controller, and remote keyed test switch and alarm LED indicator.
6. In mechanical rooms, alarm LED indicators shall be grouped on a stainless steel cover plate.
 - a. Mount adjacent to main mechanical room door.
 - b. Each LED shall be labeled with detectors loop and address.
 - c. Floor plan of room showing detectors and addresses shall be located adjacent to cover plate.
 - d. Provide Plexiglas cover over plan.

I. Air Sampling Smoke detection:

1. Air-sampling early smoke detection systems shall be provided to cover detection requirements in select areas of the building, as indicated on the drawings. The system(s) shall consist of highly sensitive laser-based smoke detectors with aspirators connected to networks of sampling pipes. The detector will be able to identify which pipe (zone) is carrying smoke. A display unit shall be provided to monitor each detector, and a programmer shall be supplied to configure the system. The fire alarm system shall monitor the air-sampling smoke detection system for trouble and alarm conditions.

J. Manual Stations

1. Manual stations:
 - a. Double action
 - b. Constructed of high impact, red Lexan with raised white lettering and smooth high gloss finish
 - c. Contain circuits that communicate station's status (alarm, normal) to Control Panel over two wires
 - d. Mechanically latch upon operation and remain so until manually reset. Stations that use Allen wrenches or special tools to reset shall not be accepted.
 - e. Fitted with screw terminals for field wire attachment
2. Address shall be field programmable on station.

K. Interface Modules - General

1. Interface Modules:
 - a. Receive 24 VDC power from separate two wire circuit
 - b. Available in either Class B or Class A supervision version
 - c. Supervised and identified by Control Panel
 - d. Capable of being programmed for its "address" location
 - e. Compatible with addressable manual stations and intelligent detectors on same intelligent initiating circuit
2. Class A wiring shall be looped back and connected to module.
3. Class B wiring shall be supervised by an end-of-line device.
4. Should interface module become non-operational or removed, trouble signal shall be transmitted to Control Panel.
5. Interface module LED's shall be clearly visible on the face of the trim plate.

L. Interface Modules - Supervised Control

1. Interface Modules shall be used for control of indicating appliances, door holders, and AHU systems.
2. For signals, speakers, fire fighter phone jacks and other device control interface module shall provide double-pole/double-throw relay switching that can connect any of the following through 2 amp fuses:
 - a. Zone of signals to power source
 - b. Speakers to audio source
 - c. Fire fighter phone jacks to communications channel
 - d. Variety of controlled devices to appropriate controlling circuits.
3. Interface modules:
 - a. Communicate supervised wiring status (normal, trouble) to fire alarm control panel.
 - b. Receive from fire alarm control panel command to transfer relay.

M. Interface Modules - Supervised Monitoring

1. Interface Modules:
 - a. Suited for monitoring of water-flow, valve tamper, and non-intelligent detectors.

- b. Addressable interface module shall be provided for interfacing normally open direct-contact devices to an intelligent initiating circuit.
 - c. Provide power to and monitor status of zone consisting of conventional 2-wire smoke or heat detectors and N/O contact devices.
 - d. Communicate zone's status (normal, alarm, trouble) to Control Panel.
2. Supervision of zone wiring shall be Class B or Class A.

N. Interface Modules - Non-Supervised Control

- 1. Interface module shall provide double-pole/double-throw relay switching for loads up to 120VAC. It shall contain 2 amp fuses, one on each common leg of relay.

2.21 SPEAKER/STROBE DEVICES

A. Combination Speaker/Strobe Devices

- 1. Speakers:
 - a. Operate on 24 V DC circuit
 - b. Include separate wire leads for in/out wiring for each leg of associated signal circuit. Tappings of signal device conductors shall not be acceptable.
 - c. Be suitable for rear mounting behind audio-visual assemblies, which shall be flush or semi-flush mounted, with manufacturer back boxes and flush trim ring.
 - d. Have field adjustable output taps, 3 taps minimum.
 - e. Provide minimum sound pressure level of 85.7 dBA at 10' using 1-watt tap.
 - f. Speakers located in mechanical room shall have 3 taps minimum with 8W being the highest.
 - g. Provide a minimum sound pressure level of 90 dBA at 10' using the 2-watt tap.
 - h. Include a blocking capacitor for line supervision and screw terminal for in-out wiring.
- 2. Strobes shall be:
 - a. Multi-tap units with taps at 15, 30, 75, and 110 cd.
 - b. Tapped at 15-candela peak power or as noted on drawings.
 - c. Have flash synchronization module on circuit when more than one strobe is visible at a time.
 - d. On separate supervised circuit from speaker circuit.
- 3. White Lexan lens shall have "FIRE" in red lettering visible from a 180° field of view.
- 4. Have off-white semi flush housing.
- 5. Strobe circuit loading shall be calculated at 75 cd tap for all devices, except in mechanical, interstitial spaces where circuit loading shall be calculated at 110 cd tap

B. Speaker Devices

- 1. Speakers without strobe units:
 - a. Include above-listed features
 - b. Flush ceiling mounted white baffle and recessed back box for installation in suspended ceiling system.
 - c. Red baffle with surface mounted back box, furnished by speaker manufacturer, where installed in areas with exposed structure.

- d. Cast metal grille and back box where installed in mechanical/interstitial spaces.

2.22 CONVENTIONAL PERIPHERAL DEVICES

A. Sprinkler Waterflow Switches - Wet Systems

1. To be furnished and installed by Fire Protection Contractor under Division 21.
2. To prevent false alarms, flow switch shall incorporate adjustable time delay mechanism between the paddle-operated stem and alarm initiating contacts.
3. Tapped 1/2" conduit connection

B. Sprinkler Valve Tamper Switches - Wet Systems

1. Sprinkler valve tamper switches shall be furnished and installed by Fire Protection Contractor under Division 21.
2. Switch shall be provided with either 1 or 2 sets of S.P.D.T. micro switches as required.

C. Door Holders

1. Magnetic door holders:
 - a. Provided by the General Contractor. Refer to Section 08 7110 - Door Hardware.
 - b. Capable of being surface, flush, or semi-flush mounted as required
2. Power for door holders shall be 24 V.

D. Fault Isolator Module

1. Provide Fault Isolator Module (FIM) on initiating device circuits in following situations:
 - a. Loop extends to another floor
 - b. Loop extends to another building
 - c. For each 25 devices on a loop
2. Fault Isolator Module shall:
 - a. Automatically re-connect isolated section of loop upon correction of fault conditions.
 - b. Not require any address setting
 - c. Operations shall be totally automatic. It shall not be necessary to replace or reset FIM after its normal operation.
 - d. Include LED, which shall flash under normal operation and illuminate steady to indicate short circuit.

2.23 ISOLATED LOOP CIRCUIT PROTECTORS (ILCP)

A. Fire Alarm Control Panel shall include Isolated Loop Circuit Protector (ILCP) on circuits which extend beyond building. Circuits include, initiating device circuits, alarm notification appliance circuits, and signaling line circuits.

B. ILCP shall:

1. Be located as close as practical to point where circuits leave or enter building.
2. Have line-to-line response time of less than 1 nanosecond.
3. Have #12 AWG grounding conductor with maximum length of 25'. It shall be run in straight line and connected to building grounding electrode system.

- C. Spark gap devices or devices incorporated in or installed within control panel in lieu of ILCP are not acceptable.

2.24 SURGE PROTECTION

- A. Provide power surge and transient protection on AC input to all fire alarm components:
 - 1. Feed-through (not a shunt-type), branch circuit surge protection such as DiTech DTK-DF120S1, EFI 75LC120V20S, Leviton 51020-WM-DN or an equivalent UL listed device submitted for approval by the Engineer and Owner.
- B. On DC Circuits Extending Outside Building (Including wiring to PIV, tamper switches and similar devices located outside the building):
 - 1. Provide "pi" type filter on each leg, consisting of a primary arrestor, a series impedance, and a fast acting secondary arrestor which clamps at 30v to 40v. Some acceptable models: Simplex 2081-9027, Simplex 2081-9028, Transtector TSP8601, Ditek DTK 2MHLP24B series, Citel America B280-24V, and Northern Technologies DLP-42. Submit detailed specifications for any proposed equals to the engineer for approval. UL 497B listing is a prerequisite for alternate device consideration. Devices using only MOV active elements are not acceptable.

2.25 PRINTERS AND TERMINALS

- A. Multiplex/intelligent systems shall be provided with printer and terminal (keyboard and CRT).
- B. Printer
 - 1. Desktop 80-column, impact dot matrix printer.
 - 2. Printer shall receive English language text from Control Panel in standard ASCII format via RS-232-C connection.
 - 3. Printed information shall include time, date, status, point number, label, and device type identifier.
 - 4. Printer shall have the following features:
 - a. 120 VAC input power
 - b. 180 characters per second printing speed
 - c. 3 kilobytes buffer capacity
 - d. Cartridge type ribbon
 - e. Friction feed for cut forms
 - f. Tractor feed for continuous 9-1/2" wide pin-to-pin fanfold paper
- C. Terminal
 - 1. Desktop terminal (monitor with detachable keyboard) with English language and display of time and date of system events.
 - 2. Monitor shall be tilt/swivel, with 14", green phosphor, non-glare CRT.
 - 3. Displayed information shall include time, date, status, point number, label, and device type identifier.
 - 4. Information on screen shall not scroll off until an acknowledge key is pressed.

5. Terminal shall include composite video output to drive slave monitors.
6. Terminals shall provide and control the following:
 - a. Acknowledgment of alarms, troubles and supervisory conditions
 - b. Alarm silence
 - c. System Reset
 - d. Time and Date
 - e. Alarm, Trouble and Supervisory service conditions summary screens

2.26 ADDRESSABLE TEXTUAL NOTIFICATION APPLIANCE (MESSAGE BOARD)

- A. Textual Notification Appliance is to operate on a compatible Signaling Line Circuit (SLC) and is to provide a high visibility, multi-color LED text message display.
 1. Textual Notification Appliance shall be listed to UL 1638 Visual Signaling Appliances.
 2. Appliance shall be capable of up to thirty two (32) pre-programmed message selections that can be activated in response to pre-defined emergency situations or linked to specific system point status conditions.
 3. Textual Notification Appliance shall be capable of displaying single line emergency instructions. Instructions can show as static, flashing, or scrolling with a variety of appearance/transition options. Instructions shall be capable of displaying using multi-colors to emphasize instructions content.
 4. Textual Notification Appliance shall be capable of providing non-emergency information during non-emergency conditions. Emergency conditions will override non-emergency message/instructions and display emergency instructions.
 5. Textual Notification Appliance shall be capable of scrolling instructions of at least 512 characters in length.
 6. Textual Notification Appliance shall be viewable from a distance of up to 200 feet, wide area viewing (140deg). (Single line 4.7" high message)
 7. Textual Notification Appliance shall be powered by a listed fire alarm power supply providing 24VDC with battery back-up.
 8. Textual Notification Appliance shall be capable of wall or ceiling mounting options.
- B. The contractor shall furnish the necessary accessories required for a complete listed system.

2.27 LOUDSPEAKERS

- A. Weather resistant and constructed of heavy gauge, treated aluminum. and constructed of heavy gauge, treated aluminum.
- B. Able to operate within any ambient temperature environment ranging from 66 degrees C (150°F) to -35 degrees C (-30°F)
- C. Double reentrant type with a 15 watt RMS audio power rated compression driver producing a UL rated 102 dB measured at 15 watts at 10 feet.
- D. Impedance selection via a 7 position switch of 5000, 2500, 1300, 666, 333, 89 & 45.

- E. Power taps shall be available at 2.0, 4.0, 7.5 & 15 watts for the 100 volt line, .9, 1.8, 3.8, 7.5 & 15 watts for the 70 volt line and .48, .94, 1.8, 7.5 & 15 watts for the 25 volt line.
- F. Each power tap shall have a 3dB incremental rating. The frequency response range shall be 400 - 14000 Hz.
- G. Dispersion of 70 degrees.
- H. Furnished with a mounting bracket that allows adjustment on either a vertical or horizontal plane with a single locking pin and include provisions for mounting, banding or strapping.
- I. Wiring terminals shall be fully enclosed and a vandal-resistant adapter cover shall provide connection protection for cable or conduit.
- J. The horn shall be 7.875" W x 8.75" H x 9.313" D (200 x 222 x 237 mm).
- K. The horn shall be finished in gray baked epoxy.

PART 3 - EXECUTION

3.1 GENERAL

- A. Class A circuiting shall be used for initiating circuits.
- B. Class B circuiting shall be used for notification circuits.
- C. Installation shall be done in neat, workmanlike manner in accordance with manufacturer's recommendations.
- D. Smoke detectors shall not be mounted until construction is completed.

3.2 RACEWAYS

- A. Fire Alarm Panel risers shall be in conduit system separate from other building wiring.
- B. Wiring shall be in conduit system separate from other building wiring. See Section 260533 - Raceway and Boxes for Electrical Systems.
- C. Minimum 3/4" steel raceway.
- D. Contractor shall size conduit and boxes by circular mil size of cable in conduit or box.
- E. Surface access to existing alarm initiating circuits in public areas shall be via surface metal raceways (minimum equivalent to 3/4" conduit) and box extensions.
- F. Existing conduit and surface metal raceway that are not 3/4" size may be reused if found to have adequate space for existing and new conductors.

3.3 CONDUCTORS

- A. Cables and wires shall be provided per manufacturer shop drawings.

- B. Conductors shall be color-coded. Coding shall be consistent through out facility.
- C. Green wire shall be used only for equipment ground.
- D. Control Panel power wiring shall be #12 AWG.
- E. Control Panel shall have #12 AWG equipment ground wire.
- F. Where fire alarm circuits enter or leave building, additional transient 75 to 90 V gas tube protection shall be provided for each conductor.
- G. Cable Detector Loops shall be twisted pair with shield jacket. Shield shall be connected to earth ground only at control panel.
- H. Detector wiring shall not be in same conduit with 120/240 VAC wiring or other high current circuits.
- I. T-taps are not allowed for any wiring.
- J. Leave 8" wire tails at each device box and 36" wire tails at Control Panel.
- K. Cable for RS 232-c devices (CRT, PRINTER) shall be two, shielded twisted pair.
- L. Cable for RS 485 devices (Remote Annunciators) shall be shielded-twisted pair for data signal.
- M. Wiring of initiating device circuits shall be #14 AWG minimum.
- N. Wiring of horn and strobe notification circuits shall be #12 AWG minimum.
- O. Fire alarm cable shall be held in place at device box by means of 2-screw connector, (do not use squeeze or crimp type connectors).
- P. Connections shall be made at device terminals, terminal cabinets, etc. Splices are not allowed within junction boxes - splices are only allowed within labeled terminal cabinets.
- Q. Boxes shall be red and labeled "FIRE ALARM SYSTEM" by decal or other approved markings.
- R. Horn and strobe circuits shall have separate conductors, and shall operate independently of each other.
- S. Install surge protection devices securely within a listed metal enclosure adjacent to the electrical panelboard where circuits originate. Conductors between panelboard and surge suppressor are to be as short as is practical to maximize effectiveness of surge protection device.
 - 1. Provide #10 ground conductor from ground bus of panelboard to bond enclosure and all surge protection device ground terminals.
 - 2. Provide small coil in phase conductor wound 5-10 turns in 1" diameter and securely tie-wrapped. Coil is to be located on Load side of surge suppressor in the phase conductor (not neutral or ground conductors)

- T. Adjacent to FACP and near the point of entry to any outdoor devices or outlying building, provide DC surge protection .
 - 1. Provide #10 ground conductor from ground bus of panelboard to bond enclosure and all surge protection device ground terminals.

3.4 DEVICE MOUNTING

- A. Recommended mounting heights, and requirements are as follows:
 - 1. Fire Alarm Control Panels
 - a. Mount control panel so visual indicators and controls at 60" above floor level.
 - 2. Remote Annunciators
 - a. Mount panel so visual indicators and controls at 60" above floor level.
 - b. Install multi-gang box as required by manufacturer, flush or surface mounted.
 - 3. Audio-Visual Devices
 - a. Install flush or semi-flush 6" below finished ceiling or 80" from bottom of device to finished floor.
 - b. No devices protruding 4" or more shall be installed lower than 80".
 - c. Audio/visual devices may be installed on the ceilings in accordance with NFPA 72 - Table 2-A.
 - d. For surface mounting, use manufacture-supplied backboxes and trim plates.
 - e. Mark each device with its circuit number.
 - 4. Manual Stations
 - a. Operable part of manual stations shall be installed not less than 42" and not more than 4-1/2' 54" above finished floor.
 - b. Manual stations shall be in unobstructed locations.
 - c. For surface mounting, use manufacturers supplied backboxes and trim plates
 - d. Mark unit's address on inside and outside of housing.
 - 5. Heat and Smoke Detectors
 - a. Location of detectors shown on plans is schematic only. Detectors must be located according to code requirements.
 - b. Surface mounted detectors shall be installed using back boxes equal to base size. Standard octagon and square boxes are not acceptable.
 - c. Detectors shall be located on the highest part of smooth ceiling so that edge of detector is no closer than 4" from sidewall.
 - d. Ceilings with beams, joists or soffits that exceed 8" in depth require special planning and closer spacing.
 - e. Mount detectors on sidewalls with top of detector no closer than 4" from ceiling and no further away than 12".
 - f. Smoke detectors shall not be installed closer than 3' from air supply diffusers.
 - g. No detectors shall be installed in direct airflow.
 - h. Heat and smoke detectors should be located near center of open area, which they protect.

- i. Mark zone number and ranking of each detector on its base.
- j. For intelligent systems, mark address and loop number on each detector's base.

3.5 IDENTIFICATION LABELS

- A. Junction boxes shall be painted red and labeled "Fire Alarm."
- B. Circuits must be labeled with name of circuit and area being served by circuit.
- C. Labels shall be permanent, and be machine generated. NO HANDWRITTEN OR NON-PERMANENT LABELS SHALL BE ALLOWED.
- D. Labels shall be self-laminating, white/transparent vinyl and be wrapped around cable.
- E. Flag type labels are not allowed.
- F. Labels shall be of adequate size to accommodate circumference of cable being labeled and properly self-laminate over full extent of printed area of label.
- G. Adhesive type labels not permitted except for phase and wire identification.
- H. Wiring color code shall be maintained throughout installation.
- I. Green wire shall be used only for equipment ground.

3.6 MANUFACTURER'S SERVICES

- A. Supervision of installation shall be provided by trained service technician from manufacturer of fire alarm equipment.
- B. Technician shall be US certified and have had minimum of 2 yrs of service experience in fire alarm industry.
- C. Technician's name shall appear on equipment submittals, and letter of certification from fire alarm manufacturer shall be sent to project engineer.
- D. Manufacturer's service technician shall be responsible for following items:
 - 1. Pre-installation visit to job site to review equipment submittals and verify method by which system shall be wired.
 - 2. Make periodic job site visits to verify installation and wiring of system.
 - 3. Upon completion of wiring, final connections shall be made under supervision of technician.
 - 4. At time of final checkout, technician shall give operational instructions to Owner and/or his representative.
 - 5. Job site visits shall be dated and documented in writing and signed by Electrical contractor.
 - 6. Discrepancy shall be noted on document and copy kept in system job folder, which shall be available to project Engineer any time during project.

3.7 TESTING

- A. Manufacturer's authorized representative shall perform complete test of each system and each device and submit written report to Contractor attesting to proper operation of completed system prior to final inspection.
 - 1. Testing of smoke detectors is to be accomplished by introducing simulated smoke into the sampling chamber of the detector. Utilizing magnetic test switches to demonstrate system operation will not be acceptable until all device operations have been demonstrated using smoke.
- B. Contractor shall perform audible notification verification survey and submit a report documenting the ambient and alarm sound levels for each space within the building
 - 1. Sound pressure level shall be measured with sound level meter meeting ANSI S1.4a, Specifications for Sound Level Meters, Type 2 requirements. Levels throughout protected area shall be measured and recorded. The sound level meter shall be set in accordance with ANSI S3.41, American National Standard Audible Evacuation Signal, using the time-weighted characteristic F (FAST). Record the maximum output when the audible emergency evacuation signal is on.
- C. Contractor shall demonstrate system operation, including 100% device test, in presence of Designer. Any deficiencies will be documented by Designer for correction by Contractor.
- D. Contractor shall demonstrate system operation, including 100% device test, in presence of Owner. Owner may elect to participate in Designer demonstration instead of a separate inspection, but this is only at Owner's discretion.
- E. Note that Designer is responsible for signing the NFPA 72 record of completion as the AHJ (per responsibility delegated to the Designer by the NC Office of State Construction). Designer will not sign record of completion until all fire alarm related punch list items have been corrected, device and system operation has been verified, and all documentation is in place. A signed NFPA 72 form is required for final inspection by the NC Office of State Construction.
- F. The NC Office of State Construction will perform additional testing during the project final inspections, up to 100% of the system if deemed necessary by the inspector.
- G. The Contractor will be responsible for supporting all required inspections with appropriate staff and materials to facilitate efficient completion of testing.

3.8 WARRANTY

- A. Warranty completed fire alarm system wiring and equipment to be free from inherent mechanical and electrical defects for a minimum period of 1 yr from the date of final acceptance.
- B. Post warranty period along with company's name and telephone number inside fire alarm panel.
- C. Warranty service for equipment shall be provided by system supplier's factory trained representative.

- D. Warranty shall include parts, labor, and necessary travel.
- E. Occupied facility shall not be without UL and NFPA approved and fully operational fire alarm system for period longer than 2 h. Emergency response shall be provided within 2 h of notification, to Contractor, of failure of system to perform operationally per UL and NFPA standards.
- F. Non-emergency service calls shall be responded to within 24 h of notification to Contractor.
- G. Repairs and/or replacement shall be completed within 72 h of time of notification. Other than emergency, actual repairs and/or replacement shall be provided during normal working hours, Monday through Friday, excluding holidays.
- H. If repair and/or replacement cannot be made within prescribed time, other means and methods of protection shall be provided to ensure safety of building occupants during which time system is not in compliance with standards. This may involve up to and include hiring Owner approved qualified personnel to stand fire watch, at Contractor's expense.

3.9 TRAINING

- A. Contractor shall provide minimum of 4 h system operation training for Owner, Architect/Engineer, and fire department personnel.
- B. Training session shall be at a time to be stipulated by Owner.
- C. Training shall be completed prior to final inspection.

3.10 MAINTENANCE CONTRACT

- A. Equipment manufacturer shall make available to Owner, maintenance contract proposal to provide minimum of 2 inspections and tests per year in compliance with NFPA-72 Codes.

3.11 SPARE PARTS

- A. Contractor shall provide the following spare parts in quantities shown, with a minimum of 1/item:

Quantity	<u>Type of Device Present</u>
10%	Photoelectric smoke detectors
10%	Heat detectors
10%	Smoke and heat detector bases
10%	Monitor Modules
10%	Control Modules
10%	Duct detectors with housing and sample tubes
5%	Isolation Modules
10%	Each alarm notification device type
5%	Manual Stations

INDOOR PRACTICE FACILITY
EAST CAROLINA UNIVERSITY, GREENVILLE, NC
SCO ID# 23-26345-01A
AIM # 1752

2 (ea size)	Fuses
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END OF SECTION 283116

31 10 00 - SITE CLEARING

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. Protecting existing vegetation to remain.
2. Removing existing vegetation.
3. Clearing and grubbing.
4. Removing above- and below-grade site improvements.
5. Disconnecting, capping or sealing, removing site utilities, abandoning site utilities in place.
6. Temporary erosion and sedimentation control.
7. Proper removal of noted manmade structures.

- B. Related Requirements:

1. Section 015000 "Temporary Facilities and Controls" for temporary erosion- and sedimentation-control measures.

1.3 DEFINITIONS

- A. 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.
- B. 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 previously disturbed areas such as urban environments, the surface soil can be subsoil.
- C. Topsoil: Top layer of the soil profile consisting of existing surface topsoil or existing in-place surface soil; the zone where plant roots grow. Also known as "root zone material."
- 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 as indicated on Drawings.
- F. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

1.4 MATERIAL OWNERSHIP

- A. Except for 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.

1.5 INFORMATIONAL SUBMITTALS

- A. Existing Conditions: Documentation of existing trees and plantings, adjoining construction, and site improvements that establishes preconstruction conditions that might be misconstrued as damage caused by site clearing.
 - 1. Use sufficiently detailed photographs or video recordings.
 - 2. Include plans and notations to indicate specific wounds and damage conditions of each tree or other plant designated to remain.

1.6 FIELD 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. Improvements on Adjoining Property: Authority for performing site clearing 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 Architect.
- C. Salvageable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises where indicated.
- D. Utility Locator Service: Notify North Carolina 811 for area where Project is located before site clearing. Private locates also required.
- E. Do not commence site clearing operations until temporary erosion- and sedimentation-control and plant-protection measures are in place, commensurate with tasks desired.
- F. Tree- and Plant-Protection Zones: Protect according to requirements in Section 015639 "Temporary Tree and Plant Protection."
- G. Soil Stripping, Handling, and Stockpiling: Perform only when the soil is dry or slightly moist.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect and maintain benchmarks and survey control points from disturbance during construction.
- B. Verify that trees, shrubs, and other vegetation to remain or to be relocated have been flagged and that protection zones have been identified and enclosed according to requirements in Section 015639 "Temporary Tree and Plant Protection."
- C. 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 authorities having jurisdiction.
- 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 TREE AND PLANT PROTECTION

- A. Protect trees and plants remaining on-site according to requirements in Section 015639 "Temporary Tree and Plant Protection."
- B. Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations according to requirements in Section 015639 "Temporary Tree and Plant Protection."
- C. Clearly mark Buffer Zone boundary. No activity to take place in these areas. Errant trash or debris, including limbs and vegetation, removed during clearing to be disposed of properly, not in buffer.

3.4 EXISTING UTILITIES

- A. 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 not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Owner's written permission.

B. Excavate for and remove underground utilities indicated to be removed.

3.5 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 larger than 1 inches in diameter, obstructions, and debris to a depth of 24 inches below exposed subgrade (as applicable). Obviously in areas where elevation will change, stumps and roots are to be removed.
 3. Use only hand methods or air spade for grubbing within protection zones.
 4. 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.

3.6 TOPSOIL STRIPPING

- A. Remove sod and grass before stripping topsoil.
- B. Strip topsoil to depth of up to 6 inches in a manner to prevent intermingling with underlying subsoil or other waste materials.
1. Remove subsoil and nonsoil materials from topsoil, including clay lumps, gravel, and other objects larger than 1 inches in diameter; trash, debris, weeds, roots, and other waste materials. This may require screening.
- C. Stockpile topsoil from edge of excavations without intermixing with subsoil or other materials. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.
1. Limit height of topsoil stockpiles to reasonable preapproved sizes and location.
 2. Do not stockpile topsoil within protection zones.
 3. Dispose of surplus topsoil. Surplus topsoil is that which exceeds quantity indicated to be stockpiled or reused. This is only to be done near end of grading operation.
 4. Stockpile surplus topsoil to allow for resspreading deeper topsoil.

3.7 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.

3.8 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. Maintain records.
- B. Burning of tree, shrub, vegetation, and other waste and debris is prohibited without permission of Owner and City/County permit.
- C. 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 31 10 00

INDOOR PRACTICE FACILITY
EAST CAROLINA UNIVERSITY, GREENVILLE, NC
SCO ID# 23-26345-01A
AIM # 1752

31 20 00 - EARTH MOVING

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. Subbase course for concrete walks and pavements.
2. Subbase course and base course for asphalt paving.
3. Excavating and backfilling trenches for utilities and pits for buried utility structures.
4. Excavating for removal of existing utilities.

- B. Related Requirements:

1. Section 013200 "Construction Progress Documentation" for recording pre-excavation and earth-moving progress.
2. Section 311000 "Site Clearing" for site stripping, grubbing, stripping topsoil, and removal of above- and below-grade improvements and utilities.
3. Section 312319 "Dewatering" for lowering and disposing of ground water during construction.
4. Section 315000 "Excavation Support and Protection" for shoring, bracing, and sheet piling of excavations.
5. Section 329200 "Turf and Grasses" for finish grading in turf and grass areas, including preparing and placing planting soil for turf areas.

1.3 UNIT PRICES

- A. Rock Measurement: Volume of rock to be removed, measured in original position, but not to exceed the following: Note: Unit prices for rock excavation include replacement with approved materials. No payment will be made for unsuitable material excavation removed prior to field measurement (by section) by the owner or his representative has been evaluated and approved.

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. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.
- F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
 - 1. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Designer. Unauthorized excavation, as well as remedial work directed by Designer, shall be without additional compensation.
 - 2. Excavation, trench, or otherwise expressly called out shall be unclassified.
 - 3. Trench rock, mass rock, unsuitable material (as determined by the designer) are excluded and shall be paid by unit price and 3rd party confirmed quantity.
- G. Fill: Soil materials used to raise existing grades.
- H. 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. Equipment for Footing, Trench, and Pit Excavation: Late-model, track-mounted hydraulic excavator; equipped with a 42-inch-maximum-width, short-tip-radius rock bucket; rated at not less than 138-hp flywheel power with bucket-curling force of not less than 28,700 lbf and stick-crowd force of not less than 18,400 lbf with extra-long reach boom.
 - 2. Equipment for Bulk Excavation: Late-model, track-mounted loader; rated at not less than 230-hp flywheel power and developing a minimum of 47,992-lbf breakout force with a general-purpose bare bucket.
- I. Rock: Rock material in beds, ledges, un-stratified masses, conglomerate deposits, and boulders of rock material 3/4 cu. yd. or more in volume that exceed a standard penetration resistance of 100 blows/2 inches when tested by a geotechnical testing agency, according to ASTM D 1586.

- 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. Subbase Course: Aggregate layer placed between the subgrade and base course for hot-mix asphalt pavement, or aggregate layer placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.
- 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 PREINSTALLATION MEETINGS

- A. Pre-installation Conference: Conduct pre-excavation conference at Project site.
 - 1. Review methods and procedures related to earthmoving, including, but not limited to, the following:
 - a. Personnel and equipment needed to make progress and avoid delays.
 - b. Coordination of Work with utility locator service.
 - c. Coordination of Work and equipment movement with the locations of tree- and plant-protection zones.
 - d. Extent of trenching by hand or with air spade.
 - e. Field quality control.

1.6 ACTION SUBMITTALS

- A. Product Data: For each type of the following manufactured products required:
 - 1. Geogrid.
 - 2. Warning Tapes (all types – literature and sample)
 - 3. Fill Material with specific product material tested by an authorized licensed engineer.
- B. Samples for Verification: For the following products, in sizes indicated below:
 - 1. Geogrid: 12 by 12 inches.
 - 2. Warning Tape: 12 inches long; of each color.
 - 3. Fill Material with specific product material tested by an authorized licensed engineer.

1.7 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency.
- B. Material Test Reports: For each on-site soil material proposed for fill and backfill as follows. Coordinated by Contractor and scheduled with Owner, 3rd party Geotech who shall submit to Designer with recommendations.
 - 1. Classification according to ASTM D 2487.

2. Laboratory compaction curve according to ASTM D 698.

- C. 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.
- D. As Built of the Storm Piping conveyance and Storm Water Detention systems. See Section 31 20 00 Earth Moving, Part 3.20 for additional information.

1.8 QUALITY ASSURANCE

- A. Geogrid Testing Agency Qualifications: Qualified according to ASTM E 329 and ASTM D 3740 for testing indicated.

1.9 FIELD 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, 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 Designer.
- C. Utility Locator Service: Notify "Call Before You Dig" "One Call" for area where Project is located before beginning earth-moving operations. Private locator service is responsibility of Contractor.
- D. Do not commence earth-moving operations until temporary site fencing and erosion- and sedimentation-control measures specified in Section 015000 "Temporary Facilities and Controls" and Section 311000 "Site Clearing" are in place.
- E. 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.
- F. Do not direct vehicle or equipment exhaust towards protection zones.
- G. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

- A. General: Provide borrowed soil materials when sufficient satisfactory soil materials are not available from excavations. ALSO Contractor to be thoroughly familiar with Geotech report, including assessment of onsite soils and to be familiar with local practices relating to decision when to use marginal local material, as well as techniques and engineered enhancements.
- B. Satisfactory Soils: Soil Classification Groups GW, GP, GM, SW, SP, and SM 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, vegetation, and other deleterious matter.
 - 1. Liquid Limit: 50.
 - 2. Plasticity Index: 20.
- C. Unsatisfactory Soils*: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D 2487, or a combination of these groups. (*Some of these soils may be considered marginal or seasonably acceptable depending on factors determined by the geotech, i.e. moisture.)
 - 1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.
- D. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.
- E. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 294/D 2940M 0; with at least 95 percent passing a 1-1/2-inch sieve and not more than 8 percent passing a No. 200 sieve.
- F. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.
- G. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; 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 zero 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 zero to 5 percent passing a No. 4 sieve.
- J. Sand: ASTM C 33/C 33M; fine aggregate.
- K. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

2.2 GEOGRID

- A. Subsurface Geogrid: Integrally formed biaxial geogrid, manufactured for base reinforcement and subgrade improvement applications, made from polypropylene; complying with ASTM D4759-02 and the following, measured per test methods referenced:
 - 1. Index Properties:
 - a. Aperture Dimensions: 1”.
 - b. Minimum Rib Thickness: 0.03”.
 - c. Tensile Strength @ 2% Strain: 280 lbf; ASTM D6637-01.
 - d. Tensile Strength @ 5% Strain: 580 lbf; ASTM D6637-01.
 - e. Ultimate Tensile Strength: 850 lbf; ASTM D6637-01.
 - 2. Junction Efficiency: 93%; GRI-GG2-05.
 - 3. Flexural Stiffness: 750,000; ASTM D5732-01.
 - 4. Aperture Stability: 0.32 deg.
 - 5. Manufactures shall be:
 - a. SYNTEC – Biaxial Geogrid, SBX 11 (Type 1) Minimum Rib Thickness: 0.03”.
 - b. BaseGrid Geogrids – Biaxial Geogrid, BaseGrid 11
 - c. Tensar - Biaxial Geogrid, Tensar BX1200
 - d. Or Approved Equal.

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.

PART 3 - EXECUTION

3.1 PREPARATION

- A. 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.

- B. Protect and maintain erosion and sedimentation controls during earth-moving operations.
- C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

3.2 DEWATERING

- A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.
- B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.
 - 1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.

3.3 EXPLOSIVES

- A. Explosives: **Do not use explosives.**
- B. Explosives: Obtain written permission from Owner and authorities having jurisdiction 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 subgrade elevations regardless of the character of surface and subsurface conditions encountered *(see 3.4B). Unclassified excavated materials may include ripable rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for ripable rock excavation or removal of obstructions.
- B. Classified Excavation: There is Classified Excavation for mass rock, trench rock, and unsuitable soils.

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. Pile Foundations: Stop excavations 6 to 12 inches above bottom of pile cap before piles are placed. After piles have been driven, remove loose and displaced material. Excavate to final grade, leaving solid base to receive concrete pile 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. Do not disturb bottom of excavations intended as bearing surfaces.

B. Excavations at Edges of Tree- and Plant-Protection Zones:

1. Excavate by hand or with an air spade to indicated lines, cross sections, elevations, and subgrades. If excavating by hand, 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, tear, or pulls roots.
2. Cut (use a saw and cut cleanly) and protect roots (recover with soil).

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. Beyond building perimeter, excavate trenches to allow installation top of pipe below frost line.

- B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit unless otherwise indicated.

1. Clearance: 12 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. Trench Bottoms: Excavate trenches 4 inches deeper than bottom of pipe and conduit elevations to allow for bedding course. Hand-excavate deeper for bells of pipe.

1. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

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.

3.8 SUBGRADE INSPECTION

- A. Notify Designer when excavations have reached required subgrade.
- B. If Designer determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
- C. Proof-roll subgrade below building and pavements slabs 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 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. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Designer, and replace with compacted backfill or fill as directed.
- D. Authorized additional excavation and replacement material will be paid for according to Contract provisions for unit prices.
- E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Designer, without additional compensation.

3.9 UNAUTHORIZED EXCAVATION

- A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of 2500 psi, may be used when approved by Designer.
1. Fill unauthorized excavations under other construction, pipe, or conduit as directed by Designer.

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. Do not store within drip line of remaining trees.
 2. Do not commingle strippings, grubbed and duff material, and excavated material from below the surface.

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, bracing, and sheeting.
 - 7. Installing permanent or temporary horizontal bracing on horizontally supported walls.
 - 8. Installation of detection and warning tape. If depth of utility is $\leq 48"$, a combination detection/warning tape may be used at 30" depth. Otherwise, warning tape at 1' above top of pipe and detection tape at 30" below surface.
- 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; fill with concrete to elevation of bottom of footings. Concrete is specified in Section 033000 "Cast-in-Place Concrete."
- D. Trenches under Roadways: Provide 4-inch- thick, concrete-base slab support for piping or conduit less than 30 inches below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of 4 inches of concrete before backfilling or placing roadway subbase course. Concrete is specified in Section 033000 "Cast-in-Place Concrete."
- E. Backfill voids with satisfactory soil while removing shoring and bracing.
- F. Initial Backfill:
 - 1. Soil Backfill: Place and compact initial backfill of subbase material, free of particles larger than 1 inch in any dimension, to a height of 12 inches over the pipe or conduit.
 - a. 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.
 - 2. Controlled Low-Strength Material: Place initial backfill of controlled low-strength material to a height of 12 inches over the pipe or conduit. Coordinate backfilling with utilities testing.
- G. Final Backfill:

1. Soil Backfill: Place and compact final backfill of satisfactory soil to final subgrade elevation.
 2. Controlled Low-Strength Material: Place final backfill of controlled low-strength material to final subgrade elevation.
- H. Warning Tape: Install warning tape directly above utilities, 30 (≤ 12 ") inches below finished grade, except 6 inches below subgrade under pavements and slabs.

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 to required elevations as follows:
1. Under grass and planted areas, use satisfactory soil material.
 2. Under walks and pavements, use satisfactory soil material.
 3. Under steps and ramps, use engineered fill.
 4. Under building slabs, use engineered fill.
 5. Under footings and foundations, use engineered fill.
- 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 2 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. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 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 soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 698:
1. Under structures, building slabs, steps, and pavements, scarify and recompact top 24 inches of existing subgrade and each layer of backfill or fill soil material at 98 percent.
 2. Under walkways, scarify and recompact top 12 inches below subgrade and compact each layer of backfill or fill soil material at 95 percent.

3. Under turf or unpaved areas, scarify and recompact top 12 inches below subgrade and compact each layer of backfill or fill soil material at 88 percent.
4. For utility trenches, compact each layer of initial and final backfill soil material at 90 percent.

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 elevations required to achieve indicated finish elevations, within the following subgrade 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.
- C. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2 inch when tested with a 10-foot straightedge.

3.17 SUBSURFACE DRAINAGE

- A. Subdrainage Pipe: Specified in Section 334600 "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 85 percent of maximum dry unit weight according to ASTM D 698.
- 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 85 percent of maximum dry unit weight according to ASTM D 698.
 2. Place and compact impervious fill over drainage backfill in 6-inch- thick compacted layers to final subgrade.

3.18 SUBBASE AND BASE COURSES UNDER PAVEMENTS AND WALKS

- A. Place subbase course and base course on subgrades free of mud, frost, snow, or ice.

- B. On prepared subgrade, place subbase course and base course under pavements and walks as follows:
 - 1. Install separation geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
 - 2. Place base course material over subbase course under hot-mix asphalt pavement.
 - 3. Shape subbase course and base course to required crown elevations and cross-slope grades.
 - 4. Place subbase course and base course 6 inches or less in compacted thickness in a single layer.
 - 5. Place subbase course and base course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
 - 6. Compact subbase course and base course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D 698.
- C. Pavement Shoulders: Place shoulders along edges of subbase course and base course to prevent lateral movement. Construct shoulders, at least 12 inches wide, of satisfactory soil materials and compact simultaneously with each subbase and base layer to not less than 95 percent of maximum dry unit weight according to ASTM D 698.

3.19 DRAINAGE COURSE UNDER CONCRETE SLABS-ON-GRADE

- A. Place drainage course on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs-on-grade as follows:
 - 1. Install subdrainage geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
 - 2. Place drainage course 6 inches or less in compacted thickness in a single layer.
 - 3. Place drainage course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
 - 4. Compact each layer of drainage course to required cross sections and thicknesses to not less than 95 percent of maximum dry unit weight according to ASTM D 698.

3.20 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:
 - 1. Determine prior to placement of fill that site has been prepared in compliance with requirements.
 - 2. Determine that fill material classification and maximum lift thickness comply with requirements.
 - 3. Determine, during placement and compaction, that in-place density of compacted fill complies with requirements.
- B. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.

- C. Allow testing agency to inspect 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.
- D. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2937, and ASTM D 6938, as applicable. Tests will be performed at the following locations and frequencies:
 - 1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 2,000 sq. ft. or less of paved area or building slab 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.
- F. Contractor will complete camera test on all new storm lines outside the building to include all new/improved storm convenience systems and storm storage systems. Camera Test shall be T.V. Quality/HD and recorded with measured stations, notes, easy to follow locations and orientation of pipes and structures. Digital copy provided to Owner/Owners represented for review and approval. Hard copy provided to owner as a requirement of Project Close out.
- G. As Built all proposed ponds, storage systems (Storm Water, Water Quality, BMP) piping conveyance systems and structures for all permanent storm water facilities.
 - 1. Field document proposed grading (ground shots/proposed topography) for all ponds/storage facilities to extend beyond outside perimeter of facility and or top of bank/dam plus 40 LF. Documents shall provide true field conditions of the entire storage facility and highlighting finish surface, bottom surface, top of pond/storage pipe section, dam section, bottom of pond, water volume capacity and completed storm piping & structures according to regulatory authority's requirements having jurisdiction for these facilities.
 - 2. Replace leaking structures, embankments and piping using new materials and repeat testing until leakage is within allowances specified.
 - 3. Field as built record document with ground shots to establish proposed grading/ topography for all permanent ponds/storage facility including all structures at the storage facility.
 - 4. Coordinate with Section 33 41 00 "Storm Drainage", for additional information.
 - 5. As Built: Sealed survey required prior to acceptance indicating vertical and horizontal locations of the entire storm system.

As Built; Contractor shall provide a field verify record documented conditions of the proposed constructed storm water pond/storage facility. 'As-Built' Record Document(s). Record Documents shall be signed and sealed by a Professional Registered NC Land Surveyor for the storm system including all permanent storm facility/storage facility/water quality ponds (stormwater and water quality systems). 'As-Built' documents shall accurately document the field verified constructed system of the entire system including finish grade ground shots, proposed topography, structures, ancillary structures, pipes, pipe inverts & rims, FES, fittings, material & sizes, stormwater pond/stormwater bmp (pipes and

proposed pond grading ie constructed pond), etc including material and both vertical/horizontal identifications.

The As-Built Document shall be submitted to the Owner/Owners Project Representative for review and Final Approval/Acceptance prior to request for Substantial Completion. If As-Built material is in conflict, represents deficiencies or unacceptable to the Owner and the proposed storm system design. The contractor shall make the field corrections necessary to bring the constructed system in compliance with the Bid Documents per Base Bid requirement. These modifications shall be completed within the time frame of the Base Contract/Substantial Completion schedule.

3.21 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 Designer; 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.

3.22 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.
- B. Transport surplus satisfactory soil to designated storage areas on Owner's property. Stockpile or spread soil as directed by Designer.
 - 1. Remove waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 31 20 00

INDOOR PRACTICE FACILITY
EAST CAROLINA UNIVERSITY, GREENVILLE, NC
SCO ID# 23-26345-01A
AIM # 1752

31 20 20 – EROSION CONTROL

PART 1 – GENERAL

1.1 Related Documents

- A. Drawings and general provisions of the Contract, including the General and Supplementary Conditions apply to this Section.

1.2 Summary

- A. This Section includes soil erosion and sedimentation control shall be provided by the Contractor for all areas of the site that are graded or disturbed by any construction operations and elsewhere as indicated on Drawings or specified herein. Erosion control shall be as specified herein and as may be required by actual conditions and governing authorities.
- B. The Contractor shall have full responsibility for the construction and maintenance of erosion control and sedimentation control facilities as shown on the Drawings and as specified herein.
- C. The Contractor shall provide permanent or temporary ground cover as soon as possible, within 7 working days after disturbing any areas of the site with slopes and not over 14 working days after completion of the rough grading of any specific area. Contractor responsible for monitoring, reporting, and record keeping as dictated by administrative statute relating to erosion control.
- D. Related Sections: The following Sections contain requirements that relate to this Section
 - 1. Site Clearing
 - 2. Earth Moving
 - 3. Drainage
 - 4. Turf and Grasses
- E. Product Handling
 - 1. Deliver seed, fertilizer, and other packaged materials in unopened original packages with labels legible and intact. Seed packages shall bear a guaranteed analysis by a recognized authority.
 - 2. On-site storage of materials shall be kept to a minimum. Wet or damaged seed or other material shall be removed from the project site immediately.

PART 2 – PRODUCTS

2.1 Materials:

- A. Lime:
 - 1. Ground Dolomitic limestone not less than 85% total carbonates and magnesium, ground so that 50% passes 100 mesh sieve and 90% 20 mesh sieve. Coarser material will be acceptable provided the specified rates of application are increased proportionately on the basis of quantities passing No. 100 mesh sieve.
- B. Commercial Fertilizer:
 - 1. A complete plant food containing nitrogen, phosphoric acid and potash in percentages as recommended by the State Department of Agriculture based on analysis of topsoil and soil required herein.
 - 2. Conforming to applicable State fertilizer laws; with availability of plant nutrients conforming to standards of A.O.A.C. uniform in composition, dry, free flowing.

- C. Superphosphate:
 - 1. Granular, dry, free flowing normal superphosphate (18-20% P.O.); deliver in original bags.
- D. Seed:
 - 1. Fresh seed guaranteed 95% pure with a minimum germination rate of 85% within one year of test.
 - 2. P.L.S. (Purity x Germination)/100
 - 3. Tolerances shall be those tabulated in USDA Bulletin No. 480.
 - 4. Variety of grass for temporary grassing shall conform to requirements of Section 02930.
- E. Mulch:
 - 1. Threshed straw of oats, wheat, or rye; free from seed or obnoxious weeds; or clean hay.
- F. Matting:
 - 1. 70% straw fiber (.35 lbs/sq. yrd.) 30% coconut fiber (0.15 lbs/sq. yrd.) netting on both sides, leno woven, 100% biodegradable organic jute fiber, 9.3 lbs./1000 sq. ft.
- G. Wire Staples:
 - 1. 16 gauge, 8" U-shaped steel staples.
- H. Gravel for Stone Filters:
 - 1. Crushed stone so that all stone will pass a 1-1/2" mesh screen and be retained on 3/4" mesh screen.
- I. Silt Filter:
 - 1. Engineering fabric should meet the following performance criteria:
 - a. Tensile strength of 90 lbs and not more than 50% elongation according to ASTM D 4632.
 - b. Mullen burst strength of 190 psi according to ASTM D 3786.
 - c. Trapezoidal tear strength of 35 lbs according to ASTM D 4533.
 - d. Puncture strength of 55 lbs according to ASTM D 4833.
 - e. UV resistance after 500 hours of 70% strength according to ASTM D 4355.
 - f. Sieve opening size of 70% (AOS) according to ASTM D 4751.
 - g. Permittivity of 2.0 sec-1 according to ASTM D 4491.
 - h. Flow rate of 150 gal/min/sf according to ASTM D 4491.
 - i. Fabric shall be non woven polypropylene geotextile.
- J. Rip Rap:
 - 1. Provide rip rap of size and class indicated, where indicated on the Drawings and as approved by the Architect.

PART 3 – EXECUTION

3.1 General:

- A. Existing Structures and Facilities:
 - 1. Existing structures, facilities, and water courses shall be protected from sedimentation.
 - 2. The Contractor shall be responsible for the construction of necessary measures, and all costs shall be at the expense of the Contractor.
 - 3. Items to be protected from sedimentation deposits shall include, but are not limited to, all down stream property, natural waterways, streams, lakes and ponds, catch basins, drainage ditches, road gutters, and natural buffer zones.

4. Control measures such as the erection of silt fences, barriers, dams, or other structures shall begin prior to any land disturbing activity. Additional measures shall be constructed as required during the construction.
5. All facilities installed shall be maintained continuously during construction until the disturbed areas are stabilized.
6. Project shall not be final accepted until NCDENR has issued a final inspection report indicating site is established AND all measures are thusly removed, and/or made to be in their permanent state.

3.2 Protective Measures:

- A. Protective measures shall conform to all State and Local requirements.
- B. The following measures are listed as guide for the protection of existing structures and facilities, and shall be included in the Contractor's expense where applicable. Design and construction of the measures shall be in accordance with all applicable laws, codes, ordinances, rules, and regulations.
- C. Silt Check Fence:
 1. Filter fabric fence shall be a minimum of 32" in width and shall have a minimum of 6 line wires with 12" stay spaces.
 2. Woven filter fabric to be used where silt fence is to remain for a period of more than 30 days.
 3. Steel posts be 5'-0" in height and be of the self-fastener angle steel type.
 4. Prefabricated silt fence is not allowed.
 5. Wash Stone shall be used to bury skirt when silt fence is used adjacent to a channel, creek, or pond.
 6. Turn silt fence up slope at ends.
 7. Fabric use with wire mesh may use 8' center posts.
 8. Silt fencing shall comply with details on drawings.
- D. Berms and Diversion Ditches: These shall be graded channels with a supporting ridge on the lower side constructed across a sloping land surface. Diversion ditches and berms shall be planted in vegetative cover as soon as completed.
- E. Mulching shall be used to prevent erosion and to hold soil and seed in place during the establishment of vegetation. Matting shall be used also where seeding may be easily eroded or disturbed.
- F. Matting: Matting shall be used for temporary stabilization during the establishment of seeded cover on areas such as grassed ditches, channels, long slopes, and steep banks.
- G. Build Berm, Pits, and Gravel Filter as shown on Drawings. Maintain as long as possible during construction to keep erosion and sedimentation to a minimum. When it is necessary to remove berm, pits, and gravel, return area to required profiles and condition.
- H. Temporary Drainage Inlet Protection: provide temporary drainage inlet protection where indicated on Drawings and as approved by the Architect.
- I. Other Measures: Other methods of protecting existing structures and facilities, such as vegetative filter strips, diversions, rip-rap, baffle boards, and ditch checks used for reduction of sediment movement and erosion, may be used at the option of the Contractor when approved by the appropriate State or local authorities.

3.3 Stabilization:

- A. Permanently protect stabilized areas prior to the removal of protective devices.

- B. After the final establishment of permanent stabilization, remove temporary sediment control measures. Re-spread accumulated sediments as specified.
- C. Permanently stabilize all areas disturbed by the removal and re-spreading operations immediately.

3.4 Temporary Seeding:

- A. Variety of seed, rate of application, and time for use of specific variety shall comply with requirements of Section 02930 and plan detail.
- B. Prepare soil by light disking to establish approximate permanent grade.
- C. Remove roots, debris, and stones. After rough grading has been completed, and before topsoil is spread, apply soil conditioning materials as follows:

<u>Material</u>	<u>Application Rate</u> (lbs. Per 1000 sq. ft.)
Lime	100 (Apply from October through May)
Fertilizer	20 (10-10-10)
Superphosphate	15

- D. Thoroughly scarify ground to a depth of 6". Mix materials thoroughly with rototiller in 2 directions at right angles.
- E. Where requested, apply topsoil. Rake topsoil to a uniform grade so that all areas will drain properly. Compact lightly with a cultipacker before distributing grass seed.
- F. Sow seed evenly with a mechanical spreader at the rate required for the specific variety in Section 02930. Roll with a cultipacker to cover seed, and water with a fine spray. Method of seeding and rate may be varied at discretion of Contractor on his own responsibility to establish a smooth, uniformly grassed area.

3.5 Mulching And Matting:

- A. Apply mulch or matting to retain soil and grass. Coordinate with drawings as required.
- B. Mulch areas by spreading a light cover of straw mulch over seeded area at the rate of not less than 85 lbs. per 1000 sq. ft.

END OF SECTION 31 20 20

31 23 19 - DEWATERING

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 construction dewatering.
- B. Related Requirements:
 - 1. Section 312000 "Earth Moving" for excavating, backfilling, site grading, and controlling surface-water runoff and ponding.

1.3 SUBMITTALS

- A. Shop Drawings: For dewatering system, prepared by or under the supervision of a qualified professional engineer.
 - 1. Show arrangement, locations, and details of wells and well points; locations of risers, headers, filters, pumps, power units, and discharge lines; and means of discharge, control of sediment, and disposal of water.
 - 2. Include layouts of piezometers and flow-measuring devices for monitoring performance of dewatering system.
 - 3. Include written plan for dewatering operations including sequence of well and well-point placement coordinated with excavation shoring and bracings and control procedures to be adopted if dewatering problems arise.
- B. Delegated-Design Submittal: For dewatering system indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
- C. Qualification Data: For Installer.
- D. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer that has specialized in design of dewatering systems and dewatering work.
- B. Regulatory Requirements: Comply with governing EPA notification regulations before beginning dewatering. Comply with hauling and disposal regulations of authorities having jurisdiction.

C. Preinstallation 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. Geotechnical report.
 - c. Proposed site clearing and excavations.
 - d. Existing utilities and subsurface conditions.
 - e. Coordination for interruption, shutoff, capping, and continuation of utility services.
 - f. Construction schedule. Verify availability of Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
 - g. Testing and monitoring of dewatering system.

1.5 FIELD CONDITIONS

- A. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of a geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by a geotechnical engineer. Owner is not responsible for interpretations or conclusions drawn from this data.
 1. Make additional test borings and conduct other exploratory operations necessary for dewatering according to the performance requirements.
 2. The geotechnical report is referenced elsewhere in Project Manual.
- B. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.

PART 2 - PRODUCTS

2.1 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. Design dewatering system, including comprehensive engineering analysis by a qualified professional engineer.
 2. Continuously monitor and maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes, prevention of flooding in excavation, and prevention of damage to subgrades and permanent structures.
 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.
- B. Regulatory Requirements: Comply with governing EPA notification regulations before beginning dewatering. Comply with water- and debris-disposal regulations of authorities having jurisdiction.

PART 3 - EXECUTION

3.1 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 or 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.
1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.
- C. Provide temporary grading to facilitate dewatering and control of surface water.
- D. Protect and maintain temporary erosion and sedimentation controls, which are specified in Section 015000 "Temporary Facilities and Controls," Section 311000 "Site Clearing," during dewatering operations.

3.2 INSTALLATION

- A. Install dewatering system utilizing wells, well points, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls.
1. Space well points or wells at intervals required to provide sufficient dewatering.
 2. Use filters or other means to prevent pumping of fine sands or silts from the subsurface.
- B. Place dewatering system into operation to lower water to specified levels before excavating below ground-water level.
- C. Provide sumps, sedimentation tanks, and other flow-control devices as required by authorities having jurisdiction.
- D. Provide stand by equipment on-site, installed and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails.

3.3 OPERATION

- A. Operate system continuously until drains, sewers, and structures have been constructed and fill materials have been placed or until dewatering is no longer required.
- B. Operate system to lower and control ground water to permit excavation, construction of structures, and placement of fill materials on dry subgrades. Drain water-bearing strata above and below bottom of foundations, drains, sewers, and other excavations.
 - 1. Do not permit open-sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.
 - 2. Reduce hydrostatic head in water-bearing strata below subgrade elevations of foundations, drains, sewers, and other excavations.
 - 3. Maintain piezometric water level a minimum of 24 inches below bottom of excavation.
- C. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water and sediment in a manner that avoids inconvenience to others.
- D. Remove dewatering system from Project site on completion of dewatering. Plug or fill well holes with sand or cut off and cap wells a minimum of 36 inches below overlying construction.

3.4 FIELD QUALITY CONTROL

- A. Observation Wells: Provide observation wells or piezometers, take measurements, and maintain at least the minimum number indicated; additional observation wells may be required by authorities having jurisdiction.
 - 1. Observe and record daily elevation of ground water and piezometric water levels in observation wells.
 - 2. Repair or replace, within 24 hours, observation wells that become inactive, damaged, or destroyed. In areas where observation wells are not functioning properly, suspend construction activities until reliable observations can be made. Add or remove water from observation-well risers to demonstrate that observation wells are functioning properly.
 - 3. Fill observation wells, remove piezometers, and fill holes when dewatering is completed.
- B. Survey-Work Benchmarks: Resurvey benchmarks regularly during dewatering and maintain an accurate log of surveyed elevations for comparison with original elevations. Promptly notify Architect if changes in elevations occur or if cracks, sags, or other damage is evident in adjacent construction.
- C. Provide continual observation to ensure that subsurface soils are not being removed by the dewatering operation.

3.5 PROTECTION

- A. Protect and maintain dewatering system during dewatering operations.
- B. Promptly repair damages to adjacent facilities caused by dewatering.

END OF SECTION 31 23 19

32 12 16 - 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 patching.
2. Hot-mix asphalt paving.
3. Hot-mix asphalt overlay.
4. Asphalt traffic-calming devices.
5. 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, unbound-aggregate subbase and base courses, and aggregate pavement shoulders.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site to comply with requirements of Division 1 Section "Project Management and Coordination" Review methods and procedures related to asphalt paving including, but not limited to, the following:

1. Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt (by submittal prior to meeting).
2. Review condition of substrate and preparatory work performed by other trades (proof roll prior to scheduled conference).
3. Review requirements for protecting paving work, including restriction of traffic (and parking) during installation period and for remainder of construction period.
4. Review and finalize construction schedule for paving and related work. Verify availability of materials, paving Installer's personnel, and equipment required to execute the Work without delays.
5. Review inspection and testing requirements, governing regulations, and proposed installation procedures.
6. Review forecasted weather conditions and procedures for coping with unfavorable conditions.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include technical data and tested physical and performance properties.
 - 2. Job-Mix Designs: Certification, by authorities having jurisdiction, of approval of each job mix proposed for the Work.
 - 3. Job-Mix Designs: For each job mix proposed for the Work.
 - 4. Coursing plan (which direction and how asphalt will be applied)
- B. Samples for Verification: For the following product, in manufacturer's standard sizes unless otherwise indicated. Previous examples of existing paving as chosen by Benesch may be viewed in place to demonstrate expectation of finished product.
 - 1. Paving Fabric: Geogrid, 12 by 12 inches, minimum.

1.5 INFORMATIONAL SUBMITTALS

- A. Material Certificates: For each paving material.
- B. Material Test Reports: For each paving material, by a qualified testing agency. (PE (NC) reg.)
- C. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced installer who has completed hot-mix asphalt paving similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.
- B. Manufacturer Qualifications: Engage a company experienced in manufacturing hot-mix asphalt similar to that indicated for this Project and with a record of successful in-service performance.
 - 1. Asphalt Plant Certification
 - a. Plants used for the preparation of bituminous mixtures shall conform to all requirements of NCDOT Standard Specifications for Roads and Structures (SSRS) Subarticle 610-5.
 - b. All asphalt plants shall be currently certified by the NC Department of Transportation for preparation of bituminous concrete pavement mixes as specified herein.
- C. Testing Agency Qualifications: Demonstrate to Engineer's satisfaction, conforming to ASTM D 3666. The independent testing agency shall have the experience and capability to satisfactorily conduct the testing indicated without delaying the Work.
- D. Regulatory Requirements: Conform to applicable standards of authorities having jurisdiction for asphalt paving work on public property.
- E. ALL CERTIFICATIONS MUST BE CURRENT!

- 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 D 3910.
 - 4. Asphalt Base Course: Minimum surface temperature of 45 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 D 692/D 692M, sound; angular crushed stone, crushed gravel, or cured, crushed blast-furnace slag.
- C. Fine Aggregate: ASTM D 1073, 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: ASTM D 242/D 242M, rock or slag dust, hydraulic cement, or other inert material.

2.2 ASPHALT MATERIALS

- A. Asphalt Binder: AASHTO M 320, PG 64-22.
- B. Asphalt Cement: ASTM D 3381/D 3381M for viscosity-graded material.
- C. Cutback Prime Coat: ASTM D 2027, medium-curing cutback asphalt, MC-30 or MC-70.
- D. Emulsified Asphalt Prime Coat: ASTM D 977 emulsified asphalt, or ASTM D 2397 cationic emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.
- E. Tack Coat: ASTM D 977 emulsified asphalt, or ASTM D 2397 cationic emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.
- F. Fog Seal: ASTM D 977 emulsified asphalt, or ASTM D 2397 cationic emulsified asphalt, slow setting, factory diluted in water, of suitable grade and consistency for application.

G. Water: Potable.

H. Undersealing Asphalt: ASTM D 3141/D 3141M; 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 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: ASTM D 1073, 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 D 6690, Type I, hot-applied, single-component, polymer-modified bituminous sealant.
- F. GEOGRID – Tensar BX 1200 or equal, Tenax MX 330
- G. No more than 20% RAP permitted in mix design without a custom asphalt design based on proposed materials.

2.4 MIXES

- A. Hot-Mix Asphalt: Dense-graded, hot-laid, hot-mix asphalt plant mixes approved by authorities having jurisdiction; designed according to procedures in AI MS-2, "Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types"; and complying with the following requirements:
 - 1. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
 - 2. Surface Course: NCDOT Type S9.5B complying with Section 610.
 - 3. Base Course: NCDOT Type I-19.0C complying with Section 610.
- B. Emulsified-Asphalt Slurry: ASTM D 3910, Type 1.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that subgrade is dry and in suitable condition to begin paving.

- 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, install geogrid, or fill as directed.
 - 4. Proceed with paving only after unsatisfactory conditions have been corrected.

3.2 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. 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 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 Patch Material: Partially fill excavated pavements with hot-mix asphalt base mix and, while still hot, compact. Cover asphalt base course with compacted, hot-mix surface layer finished flush with adjacent surfaces.

3.3 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.

3.4 SURFACE PREPARATION

- A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.
- B. Herbicide Treatment: Apply herbicide according to 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. 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.
 - 3. Shall only be utilized when stone base will be allowed to sit for prolonged period and in climate weather is predicted.
- D. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd.
 - 1. Material to be used shall be CRS1.
 - 2. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
 - 3. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.5 PLACING HOT-MIX ASPHALT

- 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 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 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.

3.6 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 according to 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.
- B. Joints shall be consistently smooth and even in appearance and shall be sealed similarly to the center of paving courses with little or no visible aggregate exposed. Example of an acceptable joint and a joint that is not acceptable:



3.7 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: 96 percent of reference laboratory density according to ASTM D 6927, but not less than 94 percent or greater than 100 percent.
 - 2. Average Density: 92 percent of reference maximum theoretical density according to ASTM D 2041, 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. Surfaces shall be smooth.
- 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.

3.8 ASPHALT TRAFFIC-CALMING DEVICES

- A. Construct hot-mix asphalt speed bumps, humps, and tables over compacted pavement surfaces. Apply a tack coat unless pavement surface is still tacky and free from dust. Spread mix at a minimum temperature of 250 deg F.
 - 1. Tack Coat Application: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd.
 - 2. Asphalt Mix: Same as pavement surface-course mix.
 - 3. Before installation, mill pavement that will be in contact with bottom of traffic-calming device. Mill to a depth of 1 inch from top of pavement to a clean, rough profile.
- B. Place and compact hot-mix asphalt to cross section indicated, 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.

3.9 INSTALLATION TOLERANCES

- A. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:
 - 1. Base 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 a surface smoothness within the following tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas:
 - 1. Base 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.
 - 4. Visually inspection of asphalt shall be smooth, sealed with very little to no visible aggregate exposed on surface.
- C. Asphalt Traffic-Calming Devices: Compact and form asphalt to produce the contour indicated and within a tolerance of plus or minus 1/8 inch of height indicated above pavement surface.

3.10 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 according to ASTM D 3910 and allow to cure.
 - 1. Roll slurry seal to remove ridges and provide a uniform, smooth surface.

3.11 FIELD QUALITY CONTROL

- A. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549.
- B. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.
- C. Non-Conforming: Raw material will not be accepted.
- D. Damage Material: Finish product scared, crushed, deformed, broken, cracked, joint/seams separation or otherwise damaged will not be accepted.
- E. Asphalt Traffic-Calming Devices: Finished height of traffic-calming devices above pavement will be measured for compliance with tolerances.
- F. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement according to ASTM D 979.
 - 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 according to ASTM D 2041, and compacted according to job-mix specifications.
 - 2. In-place density of compacted pavement will be determined by testing core samples according to ASTM D 1188 or ASTM D 2726.
 - 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 according to ASTM D 2950 and correlated with ASTM D 1188 or ASTM D 2726.
- G. Replace and compact hot-mix asphalt where core tests were taken.
- H. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements. Owner/Owner's Representative/Designer shall review and give directive on course of action to follow.
- I. The contractor shall provide certified test results for paving density to the Owner/Owner's Representative/Designer.
- J. Where the designer and owner deem it necessary, due to failure of end product (paving) to successfully meet previous testing requirements, the contractor shall provide additional certified testing results at the contractor's expense.
- K. The owner may at his/her election utilize a third party testing firm to verify any and all results. The cost of this verification shall be borne by the owner and is not to be confused with Item I., nor H., where cost belongs to the contractor.

3.12 PROTECTION AND PREVENT DAMAGE

- A. Asphalt that cracks after placement (during the care of the contractor) will be replaced prior to Substantial Completion.
- B. Remove and replace asphalt pavement that is broken, cracked, damaged, or defective or that does not comply with requirements in this Section.
- C. Protect asphalt from damage. Exclude traffic from pavement for at least 15 days after placement. When construction traffic is permitted, maintain pavement as clean as possible by removing surface stains and spillage of materials as they occur. The contractor shall clean, repair, or replace, as required, surfaces damaged during the course of the work at no additional expense to the Owner.
- D. Maintain asphalt pavement free of stains, discoloration, dirt, and other foreign material. Sweep asphalt pavement not more than two days before date scheduled for Substantial Completion inspections.

3.13 WASTE HANDLING

- A. General: Handle asphalt-paving waste according to approved waste management plan required in Section 017419 "Construction Waste Management and Disposal."

END OF SECTION 32 12 16

SECTION 321293.1 – SYNTHETIC GRASS SURFACING

PART 1 - GENERAL

1.1 SCOPE OF WORK

- A. This specification is for synthetic turf for a multisport Indoor Performance Facility to be located at East Carolina University. Scope of work to include all labor, material, equipment, transportation and services to install complete new vertical draining rubber and sand in-filled synthetic turf surfacing system for both the indoor and outdoor practice fields.
- B. It is the intent that the bidding general contractor employ one of the sports field manufacturers (see B.2) and a qualified sport field contractor to coordinate the installation of the synthetic turf. It is the general contractor's contract responsibility to furnish all labor, materials testing, tools and equipment necessary to install, in place, all synthetic turf as indicated on the drawings and specified herein.
 - 1. Turf Systems: Hybrid Slit Film/Monofilament Turf System – 2.25 inch pile height with SBR Rubber and Sand Infill.
 - 2. Approved Manufacturers Sport Turf manufacturers:
 - a. Shaw Sports Turf
 - b. Field Turf
 - c. Astro Turf
 - d. Sprinturf
 - e. Hellas
 - 3. The installation of all new materials shall be performed in strict accordance with the manufacturer's written instructions and in accordance with approved shop drawings.
 - 4. The Sports Field Contractor shall be responsible for the turf base and final grade. Sports Field Contractor Installer shall be a single source responsible for both sub-grade and turf.
 - 5. Bidding contractor must submit solicited pricing sheers for all turf systems for owner review.
 - 6. Additional requirements can be found within this specification/
- C. PRICING PACKAGE
 - 1. Base Bid – Provide a 2.25" synthetic turf field system as defined in specifications installed on an aggregate base with shock pad and associated drainage.
- D. Provide equipment and materials, and do work necessary to construct the synthetic field system, as indicated on the Drawings and as specified. Work shall include but shall not be limited to:

1. Base Construction
 - a. Subgrade will be delivered by the building general contractor within ± 0.1 of the finished subgrade.
 - b. Excavation, trenching, grading, backfilling, compaction to achieve subgrade as needed.
 - c. Laser grading
 - d. Disposal of spoil materials off site.
 - e. Grade elevation verification of Finish Subgrade and acceptance prior to gravel install.
2. Panel and Collector Drainage System Filter Fabric
 - a. Gravel drainage trench fill material.
 - b. Panel drain pipe, collector pipe and fittings
 - c. Drainage Stone Base
 - d. Clean outs and inline structures/manholes
 - e. Grade elevation certification of finished stone base installation
3. Curbing
 - a. Installation of perimeter curb/nailer system.
 - b. Installation of concrete curb edge
4. Synthetic Turf Field
 - a. Rubber and Sand Infill material
 - b. Related finish work.
5. Asbuilt Drawings
 - a. Complete set of construction as built in CAD.

1.2 RELATED WORK

- A. Review all Construction Documents for the following work-related items to be included in the project.

1.3 REFERENCES

- A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive requirement shall govern.
 1. Drawings and the general provisions of the contract, including General and Supplementary Conditions and other Division I Specification Sections, apply to this section.
 2. Installation shall comply with rules and/or regulations for field play set forth by the NCAA where applicable. Contractor to provide shop drawing striping plans for all fields prior to construction to ensure compliance.
 3. American Society for Testing and Materials (ASTM): Latest standard test methods for the products used for the synthetic turf product system, RCRA testing approved by the EPA, And, European Committee for Standardization of International Playing Surfaces EN 1177 for Head injury Criteria.
 - a. Rubber Property – Compression Test (D 395)
 - b. Pile Yarn Floor Covering Construction 9D 418)

- c. Breaking Load (Strength) and Elongation of Yarn by the Single-Strand Method (D 2256)
- d. Mass Per Unit Area (Weight) of Woven Fabric (D 3776)
- e. Hydraulic Bursting Strength of Knitted Goods and Non-woven Fabrics: Diaphragm Bursting Strength Tester Method (D 3786)
- f. Water Permeability of Geotextiles (D 4533)
- g. Trapezoid Tearing Strength of Geotextiles (Grab Method) (D 4632)
- h. Break Load and Elongation of Geotextiles, Geomembranes, & Related Products (D 4833)
- i. Index Puncture Resistance of Geotextiles, Geomembranes,, & Related products (D 4833)
- j. Shock Absorbing Properties of Playing Surface Systems and Materials (F355, F1936)
- k. Corrugated Polyethylene (PE) Tubing and Fittings (F 405)
- l. Subsurface Installation for Agricultural Drainage or Water Table Control 9 F 449)
- m. Corrugated Polyethylene Tubing and Fittings (F 667)
- n. Wheel Chair Accessibility – (F1951-0)
- o. Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (D 1557)
- p. Testing for Water Permeability of Synthetic Turf Systems and Permeable Bases (F1551)
- q. Additional Testing Required as per Section 2.1 for Synthetic Turf Product Requirements.

1.4 SUBMITTALS

- A. Provide any perimeter edge / sideline drain detail / any sub drainage details, concrete curb border and turf nailer details, and sub-base recommendations as detailed and recommended by the manufacturer that vary from the details/specifications provided. All details shall be CAD drawn at a scale 1"=20 or larger. All recommendations for approval by the Owner/Engineer/Architect
- B. Two (2) 12" x 12" sample of proposed synthetic turf carpet, physical color samples of all color inlays requested, and one (1) 12" x 12" boxed turf sample including infill representative of finished synthetic turf system.
- C. Main and Inlay Seams: One sample of both sewn and glued inlays per vendors/manufacturers instructions including written specifications.
- D. One (1) 12"x12" sample of Geotextile fabric.
- E. One (1) full width sample of panel drain 24" long
- F. All drainage gravel written specifications.
- G. Signed public welfare and safety affidavit of heavy metal and containment free synthetic turf system

- H. Digital .pdf copies of all third-party ASTM product data and testing documents stated in the specifications section demonstrating that proposed system meets or exceed all specified requirements Submit to Owner for approval. All testing shall be paid for by the Contractor.
- I. List of all company litigation in the last 10 years pertaining to synthetic turf construction. Includes litigation history for all associated subcontractors.
- J. Affidavit signed by an authorized representative of the Synthetic Turf Manufacturer attesting that the Sports Field Contractor is accepted and certified by the STM.
- K. Copy of standard eight (8) year warranty against workmanship and materials on the proposed synthetic turf.
- L. Prior to the beginning of installation, the manufacturer/installer of the synthetic turf shall inspect the sub base, nailer and supply a Certificate of Subbase Acceptance for the purpose of obtaining manufacturer's warranty for the finished synthetic playing surface. Any discrepancies, other issues or if none are found this should be noted in the statement. This accepted certification will be added to all warranty information for validation purposes. All information to be reviewed by the Owner/Engineer/Architect. Items to include;
 - 1. Permeability Rates
 - 2. Grade
 - 3. Compaction
 - 4. Statement of Suitability for turf installation
 - 5. Signed by the base contractor, turf manufacturer and turf installer.
 - 6. All testing shall be performed by a certified third party independent lab and paid for by the Contractor.
- M. Submit a list of all material providers, including relevant contact information.
- N. Provide both a delivery and installation schedule.
- O. Provide a list and contact information of all subcontractors.
- P. Submit written statement signed by general contractor, synthetic turf manufacturer and installer that all drawings and specifications are in compliance with warranty requirements and are appropriate for the project at hand.
- Q. Subgrade, gravel drainage layer and field surface grades to verified by a North Carolina licensed surveyor.
- R. The turf manufacturer shall submit a signed statement for the safety of their product regarding lead, heavy metals and other chemicals used in manufacturing of the product.
- S. Submit all compaction test results of the subgrade and gravel layer to conform with drawings and specification requirements.

- T. Prior to Final Acceptance, the Contractor shall submit to the Owner three (3) hard copies and one (1) digital .pdf copy of Maintenance Manuals, which will include all necessary instructions for the proper care and preventative maintenance of the synthetic turf system, including painting and striping.
- U. All required submittals listed within this specification. Please refer to each section for specific requirements.

1.5 SHOP DRAWINGS

- A. Shop drawings shall be prepared and contain all pertinent information regarding installation. These drawings shall be submitted to the Owner for approval prior to the manufacturing and shipment of materials.
- B. Submit drawings for;
 - 1. Seaming plan
 - 2. Manufacture installation details
 - 3. Details that may deviate from plan documents.

1.6 QUALITY ASSURANCE AND WARRANTY

- A. Manufacturer/Installer's Experience;
 - 1. The Sports Field Base Contractor/Installer must have installed and/or provided a minimum of five (5) full size synthetic turf football fields in the last three (3) years. The Contractor shall employ only qualified, experienced supervisors and technicians skilled in the installation of this system.
 - 2. Any Sport Turf Manufactures that have not been approved and wish to seek approval for comparable products must meet the requirement of having supplied a minimum of seven (7) Division 1A (FBS) NCAA Full Size Football Field installs in the last five (5) years on University/College campus sites in the United States. The manufacturer must also submit the following items
 - a. Product samples
 - b. Product specifications
 - c. Product performance data
 - d. Proof of local representation
 - e. Proof of post installation experience
 - f. Five (5) References
 - g. List and description of the seven (7) full size FBS NCAA Division 1 Football Fields on University/College Campus sites in the United States in the last five (5) years.
- B. Hold Harmless Clause

1. The turf manufacture and sport field contractor shall indemnify the University and design team consultants from any potential patent and/or trademark infringements, litigation and or trade secret issues identified during the bid and construction process.

C. Warranty

1. The Contractor shall submit its Manufacturer's Warranty that guarantees the usability and playability of the synthetic turf system for its intended uses for a minimum eight (8) year period commencing with the date of Final Acceptance. The warranty coverage shall not be prorated nor limited to the amount of the usage. The warranty submitted must have the following characteristics:
 - a. Must provide full coverage for eight (8) years from the date of Final Acceptance.
 - b. Must warrant materials and workmanship.
 - c. Must warrant that the materials installed meet or exceed the product specifications.
 - d. Must have a provision to repair or replace such portions of the installed materials that are no longer serviceable to maintain a serviceable and playable surface.
 - e. Must be a warranty from a single source covering workmanship and all self-manufactured or procured materials.
 - f. Guarantee the availability of replacement material for the synthetic turf system installed for the full warranty period.
 - g. The Sports Field Contractor may be required, upon the request of the Owner, to provide a list of three (3) clients for which they have completed after-the-sale warranty work.
 - h. Any issues with type of shoe requirements for multi-sport play must be stated in the Warranty.
 - i. The 8-year warranty must also be supported by a 3rd party insured warranty from an A-rated domestic insurance carrier. The value of the policy shall be no less than \$5,000,000 per occurrence, no deductibles allowed, with a total annual policy aggregate of \$10,000,000 renewed per each year of use. Only true 3rd party policies will be accepted. Companies submitting policies that are actually letters of credit or not truly a 3rd party insurance policy will not be accepted. Submit three (3) copies of the actual insurance policy.
 - j. The 8-year warranty shall cover the following designated uses and associated wear characteristics for each sport use below
 - 1) NCAA Football
 - 2) Lacrosse
 - 3) Sport Camps
 - 4) General Recreation
 - 5) Special Events
 - 6) Pneumatic tire vehicle access
 - 7) Maintenance in accordance with manufacture recommendations.

D. Maintenance

1. The Contractor shall supply the Owner with a written maintenance manual for proper care of the finished product. The maintenance manual shall specify any use limitations for the field (e.g. heavy vehicle traffic, etc.)

E. System Performance Characteristics

1. G-Max (shock attenuation) must test below 125 at installation.
2. The various Gmax Values should not vary each year by more than 10% above or below the average at time of installation for any individual drop.
3. Lifecycle Gmax Values: The maximum Gmax Value throughout the warranted lifecycle of the synthetic turf playing surface is not to exceed 125G which matches the Brock Powerbase Pro 125G warranty.
4. The depth of the infill material shall be measured at each test location
5. All testing shall be performed by a certified third party independent lab and paid for by the Contractor.
6. After the Contractor installs the system, he must guarantee that the field will meet the following performance criteria;
 - a. Permeability (to ASTM D4491). The system shall allow a minimum percolation rate of 30 inches per hour.
 - b. Relative Abrasiveness (to ASTM F 1015). The system has an Abrasiveness Index of 20.2
 - c. Shock Absorbency (to ASTM F355, ASTM F 1936) Less than 125 G-Max for 8-year warranty.
 - d. Flammability (to ASTM D 2859)

1.7 COMPLETION AND ACCEPTANCE

- A. Punch list shall be scheduled at least 10 days before the Substantial Completion Date.
- B. Owner shall be notified of the Punch list date 10 days before planned occurrence in writing.
- C. All items to be installed and in working order prior to Punch List request.
- D. After Punch List items are corrected, the contractor shall notify the owner for "Substantial Completion" 10 days prior.

1.8 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

PART 2 - PRODUCTS

2.1 SYNTHETIC TURF PRODUCT

- A. Base Bid product to be a rubber and sand infilled 2.25" fiber slit-film/monofilament synthetic synthetic grass system. Provide all ASTM/EIN/EPA tests as applicable with the turf submittal.

<u>Turf Requirements:</u>	<u>Description</u>	<u>Tests</u>
Turf Type:	Dual Fiber (Slit Tape/Mono Hybrid)	
Base Turf Color	Field Green	
Pile Height	2.25" min.	ASTM D 5823
Pile Yarn	UV Resistant Polyethylene	
Slit Tape Fiber	XP Blade + or Equal	
Mono Fiber Type	Ridged	
Face/Pile Weight	50 oz per SY Min.	ASTM D 5848
Primary Backing	8 oz/SY Min.	ASTM D 5848
Primary Backing UV Stabilizer	1000 hours of QUV A testing	
Secondary Backing	20 oz/SY Min.	ASTM D 5848
Total Carpet Weight	78 oz/SY Min.	ASTM D 5848
Machine Gauge	1/2" to 3/4" centers	ASTM D 5793
Single Needle Tufting	Required for 1/2" stitch gauge to prevent corn rows	
Tuft Bind	Min. 8lbs without infill, 10lbs with infill	ASTM D 1335
Grab Strength	> 200 lbs avg.	ASTM D 5034
Grab Tear Width	> 200 lbs avg.	ASTM D 5034
Pill Burn Test	Pass	ASTM D 2859
Shock/Drainage Pad	Brock Power Base Gen 2 Pro	ASTM F 355
Infill Mix	70% Sand 30% Black SBR	
Infill Rubber Granule Comp	Black SBR Rubber	
Infill Rubber Granule Shape	Spherical, Moderate, Angular	EN 14955
Infill Rubber Granule Spec. Gravity	1.1 min to 1.2 max	ASTM D 297
Infill Rubber Ash Content	Between 5% and 15%	ASTM D 297
Infill Rubber Sieve Analysis	10 / 20 Mesh (2.0mm - 0.85mm)	ASTM D 5644
Infill Sand Granule Shape	Semi-rounded to rounded angularity	ASTM F 1632
Infill Sand Sieve Analysis	20 / 40 Mesh (0.85mm - 0.425 mm)	ASTM E 1632
Infill per SF	Min. 7 lbs per SF (may be higher per manuf. requirements)	
Fabric Width	15'-0	ASTM D 5793
Yard Denier Slit Film	5,000 Min.	ASTM D 1577
Yard Denier Mono	10,000 Min.	ASTM D 1577
Breaking Strength	18 lbs/sf	ASTM D 2256
Yarn Melting Point	246 digress	ASTM D 789
Fiber Reveal	Per Manuf. Standards	
Turf with Infill Permeability	20 inches per hour	ASTM D 4491
Wheel Chair Accessibility	Accessibility	ASTM F 1951
HIC Head Injury Criteria	HIC Testing	EN 1177
GMAX Testing	GMAX	ASTM F 355
Fiber Lead Testing	Lead Content Testing in the Fiber	ASTM F 2765

- B. The Secondary Backing of high-grade polyurethane shall be applied to the Primary Backing. The tuft bind shall be a minimum average of 8 lbs. without infill and 10 lbs. with infill.
- C. Tuft products with permeable backing do not require perforations.
- D. All perforations shall be unobstructed.
- E. Tuft products with a coated or non-drain thru backing must include perforations in the backing.
- F. All turf carpet and infill material shall be provided by a single source and documented accordingly.
- G. All inlaid lines will be tufted in the factory to the extent practical. All widths of lines per NCAA rules.
- H. All seams shall be flat, tight, and permanent with no separation or fraying.
- I. Carpet rolls shall be 15-foot widths.
- J. The finished surface shall function as a grass field with similar natural playing grass field characteristics.
- K. The use of all conventional athletic shoes shall be allowed and identified in the warranty specifications.
- L. All components and their installation method shall be designed and manufactured for use on outdoor athletic fields. The materials as hereinafter specified should be able to withstand full climatic exposure in all climates, be resistant to insect infestation, rot, fungus, mildew, ultraviolet light and heat degradation, and shall have the basic characteristics of flow-through drainage, allowing free movement of surface runoff through the synthetic turf fabric where such water may flow to the existing base and into the field drainage system.
- M. The finished playing surface shall appear as mowed grass with no irregularities and shall afford excellent traction for conventional athletic shoes of all types. The finished surface shall resist abrasion and cutting from normal use.
- N. Sew seam turf as recommended by the synthetic turf manufacturer.
- O. Glue seams as recommended by the synthetic turf manufacturer.

2.2 INFILL

- A. Infill should be a combination of 30% SBR Rubber and 70% Sand.
 - 1. Infill Rubber Granule Comp SBR (Ambient or Cryogenic)
 - 2. Infill Rubber Granule Shape Spherical, Moderate, Angular
 - 3. Infill Rubber Spec. Gravity 1.1 min to 1.2 max

- | | | |
|----|------------------------------|------------------------------------|
| 4. | Infill Rubber Ash Content | Between 5% and 15% |
| 5. | Infill Rubber Sieve Analysis | 10/20 Mesh (2.0mm-0.85mm) |
| 6. | Infill Sand Granule Shape | Semi-rounded to rounded angularity |
| 7. | Infill Sand Sieve Analysis | 20/40 Mesh *0.85mm – 0.425 mm) |

2.3 GEOTEXTILE

- A. Geotextile Filter Fabric for the Subgrade and Collector Drainage: Non-woven polypropylene geotextile fabric shall be chemically and biologically inert. The subgrade shall be covered in its entirety with a geotextile fabric meeting the following specifications. The geotextile shall be woven from high-tenacity long-chain synthetic polymers composed of at least 95 percent by weight of polyolefins or polyesters and pass a minimum of 135 gpm. They shall form a stable network such that the filaments or yarns retain their dimensional stability relative to each other, including selvages
- B. Geotextile for the subgrade shall have minimums:
1. Mass/Weight of 4.5 oz /yd²
 2. Flow rate 135 gal/min/ft²
 3. Permivity 1.8 cm/sec
 4. Tensile Strength 120 lbs
 5. Elongation 50%
 6. Trapezoid Tear Strength 40lbs
 7. Apparent Opening Size 50 US Sieve
 8. Geotextile for the stone base shall be approved by the Drainage Pad manufacturer to confirm compatibility.
- C. Provide geotextile on field subgrade, top of finished stone layer and collector drainage trenches.
- D. Secure geotextile to subgrade with staples as recommended by the manufacturer.

2.4 DRAINAGE PIPE, PANEL DRAIN AND COLLECTOR PIPE.

- A. Drainage Pipe: A network of perforated HDPE highway grade drainage pipe (1" x 12" flat panel pipe) shall be installed under an 8" layer of free draining base aggregate. The drainage pipe and perimeter collector lines will be sized and installed per manufacturer recommendations.
- B. Perforated pipe shall be double wall high-density polyethylene pipe (HDPE) and shall conform to all associated AASHTO requirements.
- C. HDPE Perforated pipe shall Class have 2 slotted perforations in accordance with associated AASHTO requirements.
- D. Solid wall pipe shall be high-density polyethylene pipe (HDPE) and shall conform to associated AASHTO requirements.

- E. Underdrain panel Drains and Fittings shall be 1" x 12" wide flat panel composite pipe
 - 1. Advandeg 12" width
 - 2. Multiflow 12" width
 - 3. Approved Equal
- F. The panel drain core shall have a minimum in-plane flow rate of 170 gpm/ft width at 3600 psf and a hydraulic gradient of 1.0, per ASTM D-4716. The core shall have a minimum compressive strength of 7,500 psf.
- G. Corrugated panel drain shall conform to the requirements for Class B Geocomposite as defined in ASTM D7001-06.
- H. Provide panel drain complete with all fittings such as bends, reducers, adapters, couplings, collars, and joint materials. All fittings shall be supplied by the same manufacturer as the panel drain.
- I. Inline structures only are to be used for collector drains. Risers with fittings are not allowed.
- J. Collector basins/cleanouts to be Nyloplast or approved equal with solid grates.

2.5 STONE BASE COURSE FOR OUTDOOR FIELD

- A. Stone Base Course: The following gradation of stone is typical and recommended specification. The synthetic turf base contractor is required to focus on achieving the planarity, porosity and compaction requirements to provide a sound crushed stone base for synthetic turf installation. The free-draining base aggregate base layer shall consist of a consistent depth of open graded material. Base drainage aggregate used must achieve a 95% minimum overall compaction rate. Material shall conform to the AASHTO #57 #8 classification. The stone base shall conform to the turf vendor's standard specifications subject to the Engineer's approval and meet the following requirements using ASTM Method C136: the open graded aggregate material shall conform to the following criteria:

B.

AASHTO #8 Choker Stone	
Sieve Size	% Passing by Weight
1/2"	100
3/8"	85-100
No. 4	10-30
No. 8	0-10
No. 16	0-5
No. 100	0-3
No. 200	0-2

AASHTO #57 Free Draining Base Stone	
Sieve Size	% Passing by Weight
1-1/2"	100
3/4"	95-100
1/2"	25-60
No. 4	0-10
No. 8	0-5

- C. All stone shall be angular. Rounded or river stone is not acceptable.
- D. In no instance, shall multiple quarry sources be used within a single playing field area. Bridging Characteristics:
- | | |
|---|--|
| <p>a) 3< D50 base <6</p> <div style="border-top: 1px solid black; width: 100%; margin: 0 20px;"></div> <p> D50 top</p> <p> stone</p> | <p>b) D85 top <2</p> <div style="border-top: 1px solid black; width: 100%; margin: 0 20px;"></div> <p> D15 base</p> <p> stone</p> |
|---|--|
- E. All stone shall be angular. Rounded will not be acceptable.
- F. The stone material shall be AASHTO#57 and #8. Material must be clean. Subject to architectural approval, local or regional stone specifications that meet compaction and porosity requirements are permitted.
- G. In no instance, shall multiple quarry sources be used within a single playing field area.

- H. Permeability for base stone shall be greater than 40"/hr. 3rd Party Testing Required. (ASTM F 1551-6)
- I. Permeability for combined stone sections shall be greater than 30"/hr. 3rd Party Testing Required. (ASTM F 1551-6)

2.6 COMPOSITE NAILER

- A. A composite synthetic 2" x 4", TREX, PolyTuf HDPE or equivalent nailing strip shall be used.

2.7 EARTHMOVING MATERIALS.

- A. Refer to Earthmoving specifications for subgrade and site work.
- B. Refer to Geotechnical report for suitable soil specifications and structural fill requirements.

PART 3 - EXECUTION

3.1 GENERAL

- A. The installation shall be performed in full compliance with approved shop drawings.
- B. Only factory-trained technicians skilled in the installation of synthetic turf systems shall undertake the placement of the system.
- C. The surface to receive the synthetic turf shall be inspected and certified by the manufacturer as ready for installation of the synthetic turf system and must be perfectly clean as installation commences and shall be maintained in that condition throughout the process.
- D. The turf system shall be fibrillated only after the infill material is installed with a machine specifically designed to do so. All contractors shall be familiar and understand all drawings and specifications for the work prior to beginning construction.
- E. All work shall be protected from inclement weather conditions.
- F. Verification of Conditions: Examine areas and conditions under which all work of this Section is being performed. Do not proceed with any work until unsatisfactory conditions have been corrected. Commencement of work implies acceptance of all areas and conditions.
- G. Site shall be secure to limit unauthorized personnel access and measures taken to protect all workers.
- H. Unanticipated Conditions: Notify the Engineer immediately upon finding evidence of previous structures, filled materials that penetrate below designated excavation levels, or other conditions

which are not shown or which cannot be reasonably assumed from existing surveys and geotechnical reports. Secure the Engineer's instruction before proceeding with further work in such areas.

- I. The Project Superintendent shall thoroughly inspect all materials delivered to the site both for quality and quantity to assure that the entire installation shall have sufficient material to maintain proper mixing ratios.

3.2 INSTALLATION LIMITATIONS.

- A. Installation shall not proceed when: Ambient air temperature is below 50 degrees F. material temperature is below 50 degrees F. and when rain is falling or pending, unless acceptable to qualified installers.
- B. Site conditions exist, or are pending, that will be unsuitable for the installation of the system.

3.3 SUBGRADE AND EARTHMOVING

- A. Establish required lines, levels, contours and datum. Contractor responsible for work shall coordinate and ensure that the final grades of subgrade, stone base and playing surface meet the established design requirements.
- B. Maintain all benchmarks and other elevation control points. Re-establish, if disturbed or destroyed, at no additional cost to the Owner.
- C. Locate all utilities before grading. Coordinate with the Owner.
- D. If groundwater levels are sufficiently high, provide pumps in sumps as required maintaining groundwater at a minimum depth of two feet below excavation bottom at all times. Maintain dry conditions until completion and acceptance of the base, prior to synthetic turf placement.
- E. Monitor groundwater during construction
- F. Prevent surface water from infiltrating and damaging the subgrade and stone base.
- G. There shall be no ponding on site at anytime.
- H. For all excavation requirements procedures refer to geotechnical report and Earthmoving specification.
- I. For all structural fill requirements and procedures refer to geotechnical report and Earthmoving specification.

3.4 SUBGRADE SLOPES AND FINAL GRADES

- A. Final subgrades shall conform to the lines and grades shown on the drawings. The measured grades shall not deviate more than 0.04 feet from the planned grades and not vary more than 0.04 feet in 25 feet in any direction. Laser grading is required.
- B. Subgrade shall mirror the final finish elevation of the field surface in regards to slope except where noted on the drawings.
- C. All surfaces shall be graded to drain to drainage structures with no ponding. Grading tolerances given above do not relieve the Contractor from this requirement.
- D. All subgrade grades shown on the drawings shall be completed by the Contractor and inspected. If survey is required for finish grades all testing and special inspections shall be by the contractor
- E. The aggregate subbase will need to be inspected and accepted by the Engineer and Synthetic Turf Installer prior to synthetic turf installation.
- F. Playing Field Subgrade elevation verification: A certified survey by a State licensed land surveyor shall be performed at 25-foot centers for each field to verify grade and elevation of the subgrade. The survey shall indicate spot elevations and tenth of foot contours.

3.5 SUBSURFACE DRAINAGE

- A. All subsurface laterals shall be designed by contractor's engineer, and installed per manufacture recommendations.
- B. Only perform trenching, drainage pipe installation and backfilling operations that can be completed in one day. Exposed trenches that collapse due to rain or other occurrences shall be widened and filled as specified or refilled with subgrade materials, compacted, and retrenched.
- C. Lay perforated collector pipe in accordance with pipe manufacturer's recommendations. Provide collars and couplings as required for installation of this line and for connection with panel drains.
- D. Lateral drain lines size to be determined by manufacture recommendations
- E. Laterals shall be buried in a pea gravel like materials
- F. Laterals shall have a minimum of 3" of clean materials below the pipe, above subgrade materials.
- G. Lateral lines shall NOT, be covered by a geotextile fabric. If geotextile is required by permitting, it shall only be on sides, and bottom of lateral line trench. Covering of top of lateral drainage trench shall not be permitted.

- H. Connect panel drains to collector/header piping using panel drain manufacturer provided fittings, per manufacturer instructions and as shown on drawings.
- I. All panel drains shall be attached to form a continuous drain. Refer to manufacture specifications regarding connection procedures and requirements for panel drain field connections.
- J. Collector drains shall be installed per the slopes designed by the contractors' engineer. Pipes shall be installed, connected and fully mudded into any and all catch basins, or drop boxes designed.
- K. All pipes shall be installed per slopes and grades shown on contractors approved plans, shop drawings, and permitted drawings.
- L. Remove all spoils associated with trenching offsite at contractor's expense.

3.6 TURF NAILER

- A. A composite synthetic 2" x 4", TREX, PolyTuf HDPE or equivalent nailing strip shall be used.
- B. Specifications and shop drawings for nailer and anchors shall be submitted Synthetic Turf Manufacturer (STM) for review and approval prior to contractor installation.
- C.

3.7 PREPARATION

- A. Remove welded-in shipping spreaders installed at factory. Restore exposed finish by grinding, filling, and dressing, as required to make repaired area smooth, flush, and invisible on exposed faces.
- B. Drill and tap doors and frames to receive nontemplated, mortised, and surface-mounted door hardware.
- C. After installation of the concrete curbing the contractor shall install the nailer, prior to final placement of the top stone rock for synthetic turf base.
- D. Nailer shall be installed using concrete anchors as specified by the Synthetic Turf Manufacturer (STM)
- E. Nailer shall be anchored at both end of board, and every 2' along entire length of product installed.
- F. Nailer shall be installed to an approved dimension below grade, as specified by the synthetic turf carpet supplier. Contractor shall verify finish grade of nailer with turf contractor.

- G. Any anchors that do not fully drive into concrete shall be removed and new anchor installed adjacent on either side of the previous anchor that failed to install fully

3.8 CONCRETE CURBING

- A. Clean existing concrete surfaces thoroughly before placing abutting fresh concrete.
- B. Concrete curbing for synthetic turf shall be per plan details. Finish shall be medium broom.
- C. Concrete curbing shall have appropriate control, expansion and construction joints installed per details.
- D. All curbing adjacent to walls and buildings shall have expansion joints.

3.9 GEOTEXTILE FABRIC

- A. The geotextile shall be laid smooth without wrinkles or folds on the prepared subgrade in the direction of construction traffic.
- B. Adjacent geotextile rolls shall be overlapped. Overlaps shall be in the direction as shown on the plans and in accordance with the manufacturer's requirements. The lateral seam shall have a minimum overlap of 24"
- C. Dimensions to be a minimum width of 10' and minimum continuous length of 150'
- D. Attached to subgrade per manufacture specifications/recommendation.

3.10 SUBGRADE ESTABLISHMENT

- A. The subgrade shall be excavated to create a positive slope towards the subsurface drainpipes at greater than .5% for the outdoor field.
- B. No work shall be completed in this section until subgrade is 100% completed and accepted by the Civil Engineer and Owner or their representative.
- C. Following rough grading of the subgrade, the exposed soil shall be moisture conditioned to near the optimum moisture content and compacted to at least 90 percent relative compaction (modified proctor) to produce a firm non-yielding surface.
- D. Subgrade after compaction and inspection shall be covered with an approved geotextile fabric between all drain line locations. Fabric shall be non-woven, and be approved.
- E. Loaded trucks shall not be permitted to drive over fabric surface until the base aggregate has been placed accordingly.

- F. All aggregate layers to compacted to a minimum 95% of maximum dry density compaction rates.

3.11 SITE PREPARATION

- A. The Contractor shall strip all debris and organic matter from areas to be graded for the synthetic turf base.
- B. All drain line spoils shall be removed from subgrade and all subgrade areas shall be rolled and compacted to 90% and compaction test results submitted to Synthetic Turf Contractor, Owner and Civil Engineer for approval and for the records.

3.12 COMPACTED FILL

- A. Place and compact approved fill material in accordance with the specifications and drawings.
- B. No fill shall be compacted during periods of rain or on ground that is saturated or has standing water. Soil that has been over-saturated by rain or any other means shall not be used until the moisture content is within limits required by the Owner and Engineer

3.13 PERMEABLE BASE AND TOP STONE

- A. The specified base stone shall be carefully placed and compacted over the subgrade and/or drainpipe to the grades and elevations shown on the drawings. If the thickness of the planned base stone exceeds 6 inches, the stone shall be placed in horizontal layers not to exceed 6 inches and each layer proof rolled to 95 percent relative compaction (modified proctor) with vibratory smooth drum roller. Testing shall be done using the nuclear method.
- B. Moisture Content of the stone shall be 4% - 7% of dry weight to ensure no migration of fines during transport and installation. Installation of base stone shall not be permitted during periods of heavy rainfall or moisture. Segregation of fines during transport and stockpiling. will not be acceptable. Field specialty contractor is to apply water during construction to keep proper moisture content. In case of inclement weather contractor is to protect stone already on site and in place to ensure fines do not wash out of materials. This means covering all work with visquine and sandbags or other means to keep visquine in place during weather.
- C. Each layer of materials shall be uniformly spread and not move more than 10' from location of import onto site. Any rock materials that are seen to have been worked more than once with equipment shall be removed.
- D. Base stone for the synthetic field shall be placed to a 6" compacted thickness. Unless otherwise indicated on drawings.

- E. Top stone for the synthetic turf field to be 2" compacted depth. Approval of the subgrade fill materials shall be completed and tested for compaction prior to any work being done in this area.
- F. Finished surface shall be proof rolled with a vibratory smooth double drum roller to provide a non-yielding, smooth, flat surface. Compaction must be to 95%-modified proctor. Modified proctor testing per current ASTM standards is required. Submit testing procedure to geotechnical engineer for approval.
- G. Final crushed rock base grades shall conform to the lines and grades shown on the drawings. The measured grades shall not deviate more than 0.04 feet from the planned grades and not vary more than 0.04 feet in 25 feet in any direction. Laser grading is required.
- H. The top surface of the base stone shall be flat from the centerline toward the sideline as shown on the drawings.
- I. All base stone grades shown on the drawings shall be completed by the Contractor and inspected by the Civil Engineer and synthetic turf representative prior to commencing with the subsequent work items.
- J. Both base stone and finish stone is subject to Testing for Water Permeability of Synthetic Turf Systems and Permeable Bases (ASTM F1551) at six (6) locations on the outdoor field.

3.14 PERMEABILITY REQUIREMENTS

- A. All systems collectively shall drain vertically a minimum of 30" rain per hour with no signs of visible ponding.

3.15 SYNTHETIC TURF

- A. Synthetic turf shall be loose laid across the field, stretched, and attached to the perimeter edge detail. Turf shall be of sufficient length to permit full cross-field installation.
- B. Turf panels shall either be glued or sewn together.
- C. Glued Seams: Panels glued together at the seams using the latest state of the art procedures approve by the manufacturer. Seams shall be adhered using reinforcing tape and high-grade adhesive approved by the manufacturer. All seams shall be transverse to the field direction; i.e., run perpendicularly across the field. Seams shall be flat, tight, and permanent with no separation or fraying.
- D. Sewn Seams: Utilizing standard state of the art sewing procedures, each roll shall be attached to the next. Each seam will be stitched using cord as approved by the manufacturer. When all of the rolls of the playing surface have been installed, the sideline areas may be installed at right angles to the playing field turf

3.16 REPAIR MATERIALS, GROOMER AND SWEEPER

- A. Upon Final Acceptance, the turf Contractor shall provide to the Owner the Following items in the minimum quantities specified:
- B. 1 Super Sack (3,000 lbs) of SBR Rubber Infill
- C. 1 Super Sack (3,000 lbs) of Sand Infill
- D. 500 SF of attic stock of base field green turf.
- E. 200 LF of seaming tape and epoxy
- F. **Supply one (1) REDEXIM VERTI TOP 1800 with Vacuum Attachment.** Prior to ordering confirm that this machine is acceptable to the selected sport field manufacturer's specifications and recommendations for turf maintenance and warranty requirements.
- G. Provide specifications for type of field utility vehicle tires allowed on the field. Includes this provision in the warranty.

3.17 MAINTENANCE TRAINING

- A. The Sports Field Manufacturer will be responsible for training the Owners selected personnel regarding the maintenance and upkeep of the field upon completion. The Sports Field Contractor is responsible for scheduling this event and obtaining written confirmation and acceptance of the scheduled time from the owner.

3.18 REQUIRED PERFORMANCE G-MAX AND HIC TESTING

- A. At Final Acceptance and 1 year after, 3 years after, 5 years after, 7 years after and 8 years after the Final Acceptance date, the Sports Field Manufacturer shall, as specified, hire an independent testing laboratory to perform G-max testing 9ASTM 355, 1936 method, and HIC EN 1177 testing at a minimum of 8 locations per field, including heavy wear areas to verify that the chock attenuation properties of the field meet the requirements set forth in this specification.
- B. The Owner reserves the right to have the field tested for shock attenuation at its own cost at anytime it deems necessary. If at anytime the G-max ranges reach unacceptable levels, it is the responsibility of the Sports Field Contractor to bring the field back into the required ranges at no cost to the Owner.
- C. At any time, should the Sports Field Contractor fail to provide an independent third party Gmax test that confirms an average G-max value of 125G or lower, then the Sports Field Contractor will be solely responsible for the remove and dispose of the existing field surface, and the full installation of a new synthetic turf playing surface that meets all the specifications of the original bid documents and is independently tested to be safe by the original Gmax-Shock Attenuation requires as listed within this section.

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- D. Submit three (3) copies of the test report findings to the Owner at the completion of each test.

END SECTION 32 18 23.19

32 13 13 - 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. This Section includes exterior cement concrete pavement for the following:
 - 1. Parking lots (where applicable).
 - 2. Curbs and gutters.
 - 3. Walkways.
 - 4. Slabs (if applicable).
- B. Related Sections include the following:
 - 1. Division 31 Section "Earth Moving" for subgrade preparation, grading, and subbase course.
 - 2. Division 32 Section "Concrete Paving Joint Sealants" for joint sealants of joints in concrete pavement and at isolation joints of concrete pavement with adjacent construction.

1.3 DEFINITIONS

- A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash and other pozzolans, and ground granulated blast-furnace slag.

1.4 SUBMITTALS

- A. Product Data: For each type of manufactured material and product indicated.
- B. Design Mixtures: For each concrete pavement mixture. Include alternate mixture designs when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
- C. Qualification Data: For testing agency.
- D. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated, based on comprehensive testing of current materials:
 - 1. Aggregates. Include service record data indicating absence of deleterious expansion of concrete due to alkali-aggregate reactivity.

- E. Material Certificates: Signed by manufacturers certifying that each of the following materials complies with requirements:
 - 1. Cementitious materials.
 - 2. Steel reinforcement and reinforcement accessories.
 - 3. Fiber reinforcement.
 - 4. Admixtures.
 - 5. Curing compounds.
 - 6. Applied finish materials.
 - 7. Bonding agent or epoxy adhesive.
 - 8. Joint fillers.
- F. Field quality-control test reports.
- G. Minutes of preinstallation conference.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Manufacturer of ready-mixed concrete products who complies with ASTM C 94/C 94M requirements for production facilities and equipment.
 - 1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."
- B. Testing Agency Qualifications: An independent agency qualified according to ASTM C 1077 and ASTM E 329 for testing indicated, as documented according to ASTM E 548.
 - 1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-01 or an equivalent certification program.
- C. ACI Publications: Comply with ACI 301, "Specification for Structural Concrete," unless modified by requirements in the Contract Documents.
- D. Concrete Testing Service: Engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixtures.
- E. Mockups: Cast mockups of full-size sections of concrete pavement to demonstrate typical joints, surface finish, texture, color, and standard of workmanship.
 - 1. Build mockups in the location and of the size indicated or, if not indicated, as directed by Architect.
 - 2. Notify Architect seven days in advance of dates and times when mockups will be constructed.
 - 3. Obtain Architect's approval of mockups before starting construction.
 - 4. Maintain approved mockups during construction in an undisturbed condition as a standard for judging the completed pavement.
 - 5. Demolish and remove approved mockups from the site when directed by Architect.
 - 6. Approved mockups may become part of the completed Work if undisturbed at time of Beneficial Occupancy.

- F. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 01 Section "Project Management and Coordination."

1. Before submitting design mixtures, review concrete pavement mixture design and examine procedures for ensuring quality of concrete materials and concrete pavement construction practices. Require representatives, including the following, of each entity directly concerned with concrete pavement, to attend conference:
 - a. Contractor's superintendent.
 - b. Independent testing agency responsible for concrete design mixtures.
 - c. Ready-mix concrete producer.
 - d. Concrete pavement subcontractor.

1.6 PROJECT CONDITIONS

- A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products specified.

2.2 FORMS

- A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, smooth exposed surfaces.
1. Use flexible or curved forms for curves with a radius 100 feet or less.
 2. Use forms free from warp and of sufficient strength when staked to hold the specified alignment during concrete placing and finishing operations.
- B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.

2.3 STEEL REINFORCEMENT

- A. Plain-Steel Welded Wire Reinforcement: ASTM A 185, fabricated from as-drawn steel wire into flat sheets.
- B. Deformed-Steel Welded Wire Reinforcement: ASTM A 497, flat sheet.

- C. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420); deformed.
- D. Joint Dowel Bars: Plain steel bars, ASTM A 615/A 615M, Grade 60 (Grade 420). Cut bars true to length with ends square and free of burrs.
- E. 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, and as follows:
 - 1. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.

2.4 CONCRETE MATERIALS

- A. Cementitious Material: Use one of the following cementitious materials, of the same type, brand, and source throughout the Project:
 - 1. Portland Cement: ASTM C 150, Type I gray. Supplement with the following:
 - a. Fly Ash: ASTM C 618, Class F.
- B. Normal-Weight Aggregates: ASTM C 33, Class 4S coarse aggregate, uniformly graded. Provide aggregates from a single source with documented service record data of at least 10 years' satisfactory service in similar pavement applications and service conditions using similar aggregates and cementitious materials.
 - 1. Maximum Coarse-Aggregate Size: 3/4 inch nominal.
 - 2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
 - 3. Do not use fine or coarse aggregates that contain substances that cause spalling.
 - 4. Local aggregates not complying with ASTM C 33 that have been shown to produce concrete of adequate strength and durability by special tests or actual service may be used when acceptable to Architect.
- C. Water: ASTM C 94/C 94M.
- D. Air-Entraining Admixture: ASTM C 260.
- E. Chemical Admixtures: Provide 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 C 494/C 494M, Type A.
 - 2. Retarding Admixture: ASTM C 494/C 494M, Type B.
 - 3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
 - 4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
 - 5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
 - 6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

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2.5 FIBER REINFORCEMENT

- A. Synthetic Fiber: Monofilament or fibrillated polypropylene fibers engineered and designed for use in concrete pavement, complying with ASTM C 1116, Type III, 1/2 to 1-1/2 inches long.

1. Products:

a. Monofilament Fibers:

- 1) Axim Concrete Technologies; Fibrasol IIP.
- 2) Euclid Chemical Company (The); Fiberstrand 100.
- 3) FORTA Corporation; Forta Mono.
- 4) Grace, W. R. & Co.--Conn.; Grace MicroFiber.
- 5) Metalcrete Industries; Polystrand 1000.
- 6) SI Concrete Systems; Fibermix Stealth.
- 7) Or product equal to the above.

b. Fibrillated Fibers:

- 1) Axim Concrete Technologies; Fibrasol F.
- 2) FORTA Corporation; Forta.
- 3) Euclid Chemical Company (The); Fiberstrand F.
- 4) Grace, W. R. & Co.--Conn.; Grace Fibers.
- 5) SI Concrete Systems; Fibermesh.
- 6) Or product equal to the above.

2.6 CURING MATERIALS

- A. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. dry.
- B. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.
- C. Water: Potable.
- D. Evaporation Retarder: Waterborne, monomolecular film forming; manufactured for application to fresh concrete.

1. Products:

- a. Axim Concrete Technologies; Cimfilm.
- b. Burke by Edeco; BurkeFilm.
- c. ChemMasters; Spray-Film.
- d. Conspec Marketing & Manufacturing Co., Inc.; Aquafilm.
- e. Dayton Superior Corporation; Sure Film.
- f. Euclid Chemical Company (The); Eucobar.
- g. Kaufman Products, Inc.; Vapor Aid.
- h. Lambert Corporation; Lambco Skin.
- i. L&M Construction Chemicals, Inc.; E-Con.
- j. MBT Protection and Repair, ChemRex Inc.; Confilm.
- k. Meadows, W. R., Inc.; Sealtight Evapre.
- l. Metalcrete Industries; Waterhold.

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- m. Nox-Crete Products Group, Kinsman Corporation; Monofilm.
 - n. Sika Corporation, Inc.; SikaFilm.
 - o. Symons Corporation; Finishing Aid.
 - p. Vexcon Chemicals, Inc.; Certi-Vex EnvioAssist.
 - q. Or product equal to the above.
- E. Clear Waterborne Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B.
 - 1. Products:
 - a. Anti-Hydro International, Inc.; AH Curing Compound #2 DR WB.
 - b. Burke by Edoko; Aqua Resin Cure.
 - c. ChemMasters; Safe-Cure Clear.
 - d. Conspec Marketing & Manufacturing Co., Inc.; W.B. Resin Cure.
 - e. Dayton Superior Corporation; Day Chem Rez Cure (J-11-W).
 - f. Euclid Chemical Company (The); Kurez DR VOX.
 - g. Kaufman Products, Inc.; Thinfilm 420.
 - h. Lambert Corporation; Aqua Kure-Clear.
 - i. L&M Construction Chemicals, Inc.; L&M Cure R.
 - j. Meadows, W. R., Inc.; 1100 Clear.
 - k. Nox-Crete Products Group, Kinsman Corporation; Resin Cure E.
 - l. Symons Corporation; Resi-Chem Clear.
 - m. Tamms Industries Inc.; Horncure WB 30.
 - n. Unitex; Hydro Cure 309.
 - o. Vexcon Chemicals, Inc.; Certi-Vex Enviocure 100.
 - p. Or product equal to the above.
- F. White Waterborne Membrane-Forming Curing Compound: ASTM C 309, Type 2, Class B.
 - 1. Products:
 - a. Anti-Hydro International, Inc.; AH Curing Compound #2 WP WB.
 - b. Burke by Edoco; Resin Emulsion White.
 - c. ChemMasters; Safe-Cure 2000.
 - d. Conspec Marketing & Manufacturing Co., Inc.; W.B. Resin Cure.
 - e. Dayton Superior Corporation; Day-Chem White Pigmented Cure (J-10-W).
 - f. Euclid Chemical Company (The); Kurez VOX White Pigmented.
 - g. Kaufman Products, Inc.; Thinfilm 450.
 - h. Lambert Corporation; Aqua Kure-White.
 - i. L&M Construction Chemicals, Inc.; L&M Cure R-2.
 - j. Meadows, W. R., Inc.; 1200-White.
 - k. Symons Corporation; Resi-Chem White.
 - l. Tamms Industries, Inc.; Horncure 200-W.
 - m. Unitex; Hydro White.
 - n. Vexcon Chemicals, Inc.; Certi-Vex Enviocure White 100.
 - o. Or product equal to the above.

2.7 RELATED MATERIALS

- A. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber.

- B. Bonding Agent: ASTM C 1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

2.8 PAVEMENT MARKINGS

- A. Pavement-Marking Paint: Alkyd-resin type, lead and chromate free, ready mixed, complying with FS TT-P-115, Type I or AASHTO M 248, Type N.

2.9 CONCRETE MIXTURES

- A. Prepare design mixtures, proportioned according to ACI 301, for each type and strength of normal-weight concrete determined by either laboratory trial mixes or field experience.
 - 1. Use a qualified independent testing agency for preparing and reporting proposed concrete mixture designs for the trial batch method.
- B. Proportion mixtures to provide normal-weight concrete with the following properties:
 - 1. Compressive Strength (28 Days): 3,400 -4,000 psi (20.7 MPa). (Varies – see plans)
 - 2. Maximum Water-Cementitious Materials Ratio at Point of Placement: 0.50.
 - 3. Slump Limit: 4 inches (100 mm), plus or minus 1 inch.
- 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: 6 percent plus or minus 1.5 percent for 3/4-inch nominal maximum aggregate size
- D. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.
- E. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.
 - 1. Use water-reducing admixture, high-range, water-reducing admixture, high-range, water-reducing and retarding admixture, plasticizing and retarding 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.
- F. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 requirements.
 - 1. Fly Ash or Pozzolan: 25 percent.
 - 2. Ground Granulated Blast-Furnace Slag: 50 percent.
 - 3. Combined Fly Ash or Pozzolan, and Ground Granulated Blast-Furnace Slag: 50 percent, with fly ash or pozzolan not exceeding 25 percent.
- G. Synthetic Fiber: Uniformly disperse in concrete mix at manufacturer's recommended rate, but not less than 1.0 lb/cu. yd..

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2.10 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Furnish batch certificates for each batch discharged and used in the Work.
 - 1. When air temperature is between 85 deg F 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.

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 pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding.
 - 1. Completely proof-roll subbase in one direction and repeat in perpendicular 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. Subbase with soft spots and areas of pumping or rutting exceeding depth of 1/4 inch require correction according to requirements in Division 31 Section "Earth Moving."
- C. Proceed with concrete pavement operations only after nonconforming conditions have been corrected and subgrade is ready to receive pavement.

3.2 PREPARATION

- A. Remove loose material from compacted subbase surface immediately before placing concrete.
- B. Check completed formwork and screeds for grade and alignment to following tolerances:
 - 1. Top of Forms: Not more than 1/8 inch in 10 feet.
 - 2. Vertical Face on Longitudinal Axis: Not more than 1/4 inch in 10 feet.

3.3 EDGE FORMS AND SCREED CONSTRUCTION

- A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides for pavement 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. Check completed formwork and screeds for grade and alignment to following tolerances:
 - 1. Top of Forms: Not more than 1/8 inch in 10 feet.
 - 2. Vertical Face on Longitudinal Axis: Not more than 1/4 inch in 10 feet.

- C. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.4 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. *Welded wire reinforcement is required in ALL flatwork, such as slabs, sidewalks, etc. See plans.

3.5 JOINTS

- A. General: Form construction, isolation, and contraction joints and tool edgings 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 pavement, place transverse joints to align with previously placed joints, unless otherwise indicated.
- B. Construction Joints: Set construction joints at side and end terminations of pavement and at locations where pavement operations are stopped for more than one-half hour unless pavement terminates at isolation joints.
 - 1. Continue steel reinforcement across construction joints, unless otherwise indicated. Do not continue reinforcement through sides of pavement strips, unless otherwise indicated.
 - 2. Provide tie bars at sides of pavement 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 asphalt-coat 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, walks, 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. Protect top edge of joint filler during concrete placement 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 pavement:
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. Eliminate groover marks on concrete surfaces.
 2. Doweled Contraction Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt coat one-half of dowel length to prevent concrete bonding to one side of joint.
 3. Sawed Joints: Minimum 3/4 inch deep x 1/4 inch wide all allowed.
- E. Edging: Tool edges of pavement, gutters, curbs, and joints in concrete after initial floating with an edging tool to a 1/4-inch radius. Repeat tooling of edges after applying surface finishes. Eliminate tool marks on concrete surfaces.

3.6 CONCRETE PLACEMENT

- A. Inspection: Before placing concrete, inspect and complete formwork installation, steel reinforcement, and items to be embedded or cast in. Notify other trades to permit installation of their work.
- B. Remove snow, ice, or frost from subbase surface and 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.
- F. Do not add water to fresh concrete after testing.
- G. 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.
- H. 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 reinforcement, dowels, and joint devices.
- I. Place concrete in two operations; strike off initial pour for entire width of placement and to the required depth below finish surface. Lay welded wire fabric or fabricated bar mats immediately in final position. Place top layer of concrete, strike off, and screed.
 1. Remove and replace concrete that has been placed for more than 15 minutes without being covered by top layer, or use bonding agent if approved by Architect.
- J. Screed pavement surfaces with a straightedge and strike off.
- K. Commence initial floating using bull floats or darbies to impart an open textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.
- L. Curbs and Gutters: When automatic machine placement is used for curb and gutter placement, submit revised mix design and laboratory test results that meet or exceed requirements. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing as specified for formed concrete. If results are not approved, remove and replace with formed concrete.
- M. Slip-Form Pavers: When automatic machine placement is used for pavement, submit revised mix design and laboratory test results that meet or exceed requirements. Produce pavement to required thickness, lines, grades, finish, and jointing as required for formed pavement.
 1. Compact subbase and prepare subgrade of sufficient width to prevent displacement of paver machine during operations.
- N. When adjoining pavement lanes are placed in separate pours, do not operate equipment on concrete until pavement has attained 85 percent of its 28-day compressive strength.
- O. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
 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 mix designs.
- P. Hot-Weather 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 to 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.

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 bleed-water 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.
 4. Final Tooling: Toll edges of paving, gutters, curbs, and joints formed in fresh concrete with a jointing tool to the following radius. Repeat tooling of edges and joints after applying surface finishes. Eliminate tool marks on concrete surfaces.
 - a. Radius: 1/4 inch.

3.8 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. Moist 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-inch lap over adjacent absorptive covers.
2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, 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 during 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. Splotchy, inconsistent splash/spray patterns of compound with not be accepted.

3.9 PAVEMENT TOLERANCES

A. Comply with tolerances of ACI 117 and as follows:

1. Elevation: 1/4 inch.
2. Thickness: Plus 3/8 inch, minus 1/4 inch.
3. Surface: Gap below 10-foot- long, unlevelled straightedge not to exceed 1/4 inch. (assuming no ponded water)
4. Lateral Alignment and Spacing of Tie Bars and Dowels: 1 inch.
5. Vertical Alignment of Tie Bars and Dowels: 1/4 inch.
6. Alignment of Tie-Bar End Relative to Line Perpendicular to Pavement Edge: 1/2 inch.
7. Alignment of Dowel-Bar End Relative to Line Perpendicular to Pavement Edge: Length of dowel 1/4 inch per 12 inches.
8. Joint Spacing: 3 inches.
9. Contraction Joint Depth: Plus 1/4 inch, no minus.
10. Joint Width: Plus 1/8 inch, no minus.
11. Contractor will be required to remove and replace sidewalk constructed without positive drainage (i.e. bird baths) at contractor's expense.

3.10 PAVEMENT MARKING

- A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Architect.
- B. Allow concrete pavement to cure for 28 days and be dry before starting pavement marking, except as indicted by paint manufacturer.
- 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 mils.

3.11 FIELD QUALITY CONTROL

- A. Testing Agency: Contractor will engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports. Cost for the work will be billed against the geotechnical testing allowance with approval from the Architect.
- B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:
 - 1. Testing Frequency: Testing will be conducted randomly as directed by Architect.
 - 2. Slump: ASTM C 143/C 143M; testing will be conducted randomly as directed by Architect.
 - 3. Air Content: ASTM C 231, pressure method; testing will be conducted randomly as directed by Architect.
 - 4. Concrete Temperature: ASTM C 1064; testing will be conducted randomly as directed by Architect.
 - 5. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
 - 6. Compressive-Strength Tests: ASTM C 39/C 39M; test 1 specimen at 7 days and 2 specimens at 28 days.
 - a. A compressive-strength test shall be the average compressive strength from 2 specimens obtained from same composite sample and tested at 28 days.
- C. Strength of each concrete mix will be satisfactory if average of any 3 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. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced and additional work with specified requirements.
- G. Remove and replace concrete pavement where test results indicate that it does not comply with specified requirements.

3.12 REPAIRS AND PROTECTION

- A. Concrete that cracks after placement (during the care of the contractor) will be replaced prior to Substantial Completion.
- B. Remove and replace concrete pavement that is broken, cracked, damaged, or defective or that does not comply with requirements in this Section.
- C. Drill test cores, where directed by Architect, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory pavement areas with Portland cement concrete bonded to pavement with epoxy adhesive.
- D. Protect concrete from damage. Exclude traffic from pavement for at least 14 days after placement. When construction traffic is permitted, maintain pavement as clean as possible by removing surface stains and spillage of materials as they occur.
- E. Protection from damage: The Contractor shall adequately and fully protect all parts of the work against damage until completed and accepted by the Owner for maintenance. Damages shall be properly repaired by the Contractor at no additional expense to the Owner.
- F. Temporary barricades: Throughout the duration of the Contract, the Contractor shall provide temporary barricades, conforming with the latest edition of U.S. Department of Transportation's "Manual on Uniform Traffic Control Devices for Streets and Highways," properly lighted, to keep traffic off the current portion of the work.
- G. Protection of adjacent surfaces: The Contractor shall protect exposed surfaces to the work from physical damage resulting from construction activities, and from becoming stained during application of paving materials. The Contractor shall clean, repair, or replace, as required, surfaces damaged during the course of the work at no additional expense to the Owner.
- H. Protection from graffiti: Newly poured concrete roads, streets, curbs, or sidewalks shall be protected AND guarded from graffiti from passersby until the concrete has sufficiently cured to resist such molestation. Failure to prevent graffiti, or other such vandalism, shall result in the new concrete having to be removed and replaced. This requirement shall mandate the Contractor to take the necessary steps in preventing such incidents including, but not limited, to guarding the project after normal working hours.
- I. Maintain concrete pavement free of stains, discoloration, dirt, and other foreign material. Sweep concrete pavement not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION 32 13 13

32 13 73 - CONCRETE PAVING JOINT SEALANTS

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. Cold-applied joint sealants.
 - 2. Hot-applied joint sealants.
- B. Related Sections:
 - 1. Division 32 Section "Asphalt Paving" for constructing joints between concrete and asphalt pavement.
 - 2. Division 32 Section "Concrete Paving" for constructing joints in concrete pavement.

1.3 PRECONSTRUCTION TESTING

- A. Preconstruction Compatibility and Adhesion Testing: Submit to joint-sealant manufacturers, for testing indicated below, Samples of materials that will contact or affect joint sealants.
 - 1. Use manufacturer's standard test method to determine whether priming and other specific joint-preparation techniques are required to obtain rapid, optimum adhesion of joint sealants to joint substrates.
 - 2. Submit no fewer than eight pieces of each type of material, including joint substrates, shims, joint-sealant backings, secondary seals, and miscellaneous materials.
 - 3. Schedule sufficient time for testing and analyzing results to prevent delaying the Work.
 - 4. For materials failing tests, obtain joint-sealant manufacturer's written instructions for corrective measures including use of specially formulated primers.
 - 5. **Testing will not be required if joint-sealant manufacturers submit joint-preparation data that are based on previous testing, not older than 24 months, of sealant products for compatibility with and adhesion to joint substrates and other materials matching those submitted.**

1.4 SUBMITTALS

- A. Product Data: For each joint-sealant product indicated.
- B. Contractor's Proposed Joint Layout: Contractor shall submit a Joint Layout Plan based on the proposed Site Development Plans. The Joint Layout Plan shall address the various types of proposed joints.

C.

- D. Samples for Verification: For each kind and color of joint sealant required, provide Samples with joint sealants in 1/2-inch- wide joints formed between two 6-inch- long strips of material matching the appearance of exposed surfaces adjacent to joint sealants.
- E. Pavement-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, where applicable.
- F. Qualification Data: For qualified Installer.
- G. Product Certificates: For each type of joint sealant and accessory, from manufacturer.
- H. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for joint sealants.
- I. Preconstruction Compatibility and Adhesion Test Reports: From joint-sealant manufacturer, indicating the following:
 - 1. Materials forming joint substrates and joint-sealant backings have been tested for compatibility with and adhesion to joint sealants.
 - 2. Interpretation of test results and written recommendations for primers and substrate preparation needed for adhesion.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
- B. Source Limitations: Obtain each type of joint sealant from single source from single manufacturer.
- C. Product Testing: Test joint sealants using a qualified testing agency.
 - 1. Testing Agency Qualifications: An independent testing agency qualified according to ASTM C 1021 to conduct the testing indicated.
- D. Preinstallation Conference: Conduct conference at Project site.

1.6 PROJECT 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 MATERIALS

- A. Compatibility: Provide joint sealants, backing 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.
- B. Colors of Exposed Joint Sealants: As selected by Architect from manufacturer's full range.

2.2 COLD-APPLIED JOINT SEALANTS

- A. Single-Component, Self-Leveling, Silicone Joint Sealant for Concrete: ASTM D 5893, Type SL.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Crafco Inc., an ERGON company; RoadSaver Silicone SL.
 - b. Dow Corning Corporation; 890-SL.
 - c. Pecora Corporation; 300 SL.

2.3 HOT-APPLIED JOINT SEALANTS

- A. Hot-Applied, Single-Component Joint Sealant for Concrete: ASTM D 3406.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Crafco Inc., an ERGON company; Superseal 444/777.
 - b. W.R. Meadows Sealtight; #1190
 - c. Designer approved equal.

2.4 JOINT-SEALANT BACKER MATERIALS

- A. General: Provide joint-sealant backer materials that are nonstaining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are 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 D 5249, Type 1, of diameter and density required to control sealant depth and prevent bottom-side adhesion of sealant.

- C. Round Backer Rods for Cold-Applied Joint Sealants: ASTM D 5249, Type 3, of diameter and density required to control joint-sealant depth and prevent bottom-side adhesion of sealant.
- D. Backer Strips for Cold- and Hot-Applied Joint Sealants: ASTM D 5249; Type 2; of thickness and width required to control joint-sealant depth, prevent bottom-side adhesion of sealant, and fill remainder of joint opening under sealant.

2.5 PRIMERS

- A. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine joints indicated 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: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions.
- 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.
- C. Ensure joints are reasonably consistent depth and thickness prior to installing sealant, and straight!

3.3 INSTALLATION OF JOINT SEALANTS

- A. General: 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 C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.
- C. Install joint-sealant backings of kind indicated 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 backings.
 2. Do not stretch, twist, puncture, or tear joint-sealant backings.
 3. Remove absorbent joint-sealant backings that have become wet before sealant application and replace them with dry materials.
- D. Install joint sealants using proven techniques that comply with the following and at the same time backings are installed:
1. Place joint sealants so they directly contact and fully wet 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. Tooling of Nonsag Joint Sealants: Immediately after joint-sealant application and before skinning or curing begins, tool sealants according to the following requirements to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint:
1. Remove excess joint sealant from surfaces adjacent to joints.
 2. Use tooling agents that are approved in writing by joint-sealant manufacturer and that do not discolor sealants or adjacent surfaces.
- F. Provide joint configuration to comply with joint-sealant manufacturer's written instructions unless otherwise indicated.

3.4 CLEANING

- A. Clean off excess joint sealant or sealant smears adjacent to joints as the Work progresses, by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.5 PROTECTION

- A. 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.

3.6 PAVEMENT-JOINT-SEALANT SCHEDULE

- A. Joint-Sealant Application: Joints within cement concrete pavement.
1. Joint Location:
 - a. Expansion and isolation joints in cast-in-place concrete pavement.
 - b. Contraction joints in cast-in-place concrete slabs.
 - c. Other joints as indicated.
 2. Silicone Joint Sealant for Concrete: Single component, self-leveling.

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3. Hot-Applied Joint Sealant for Concrete: Single component.
4. Joint-Sealant Color: As selected by Architect from manufacturer's full range.

END OF SECTION 32 13 73

32 14 00 - UNIT 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. Concrete pavers set in aggregate setting beds on ridged subsurface.
 - 2. Cast-in-place concrete edge restraints.
- B. Related Sections:
 - 1. Division 32 Section "Concrete Paving" for concrete base under unit pavers.

1.3 PRECONSTRUCTION TESTING

- A. Preconstruction Adhesion and Compatibility Testing: Submit to latex-additive manufacturer, for testing as indicated below, samples of paving materials that will contact or affect mortar and grout that contain latex additives.
 - 1. Use manufacturer's standard test methods to determine whether mortar, grout and joint materials will obtain optimum adhesion with, and will be nonstaining to, installed pavers and other materials constituting paver installation.

1.4 SUBMITTALS

- A. Product Data: For materials other than water and aggregates.
- B. Product Data: For the following:
 - 1. Pavers.
 - 2. Setting Bed Material.
- C. Sieve Analyses: For aggregate setting-bed materials, according to ASTM C 136, ASTM C 33.
- D. Samples for Initial Selection: For the following:
 - 1. Each type of unit paver indicated.
 - 2. Joint materials involving color selection.
 - 3. Bedding material.

E. Samples for Verification:

1. Full-size units of each type of unit paver indicated. Assemble no fewer than five Samples of each type of unit.
2. Joint materials.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain each type of unit paver, joint material, and setting material from single source with resources to provide materials and products of consistent quality in appearance and physical properties.
- B. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
 1. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
- C. Preinstallation Conference: Conduct conference at Project site. Coordinate with Owner.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Store pavers on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied.
- B. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.
- C. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.
- D. Store liquids in tightly closed containers protected from freezing.

1.7 PROJECT CONDITIONS

- A. Cold-Weather Protection: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen subgrade or setting beds. Remove and replace unit paver work damaged by frost or freezing.

PART 2 - PRODUCTS

2.1 CONCRETE PAVERS

- A. Regional Materials: Provide concrete pavers that have been manufactured within 600 miles of project site from aggregates and cement that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles of project site.

- B. Concrete Pavers: Solid interlocking paving units complying with ASTM C 936 and resistant to freezing and thawing when tested according to ASTM C 67, made from normal-weight aggregates.
1. 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:
 - a. Licensee of Symrah Licensing Inc. that markets unit pavers in Project location.
 - b. Licensee of Uni-Group U.S.A. that markets unit pavers in Project location.
 - c. Capitol Ornamental Concrete Specialties, Inc.
 - d. Cemex.
 - e. Hanover Architectural Products, Inc.
 - f. Hastings Pavement Co., Inc.
 - g. Nicolock.
 - h. Oldcastle Architectural Products.
 - i. Sunny Brook Pressed Concrete Co.
 - j. Wassau Tile, Inc.; Terra-Paving Div.
 - k. Metromont Materials Corp.
 - l. Gorla Enterprises
 2. Thickness: 80 mm.
 3. Face Size and Shape: 3-7/8-inch x 7 7/8-inches (Nominal 4"x8") rectangle paver for field and soldier course.
4" x 8" paver for soldier course banding where shown.
 4. Color:
Field, Traditional Red Concrete paver, as selected by Architect from manufacturer's full range. Final Selection by Owner.
Soldier Course, Dark Red Concrete paver, (a tone darker than field) as selected by Architect from manufacturer's full range. Final Selection by Owner.

2.2 ACCESSORIES

- A. Compressible Foam Filler: Preformed strips complying with ASTM D 1056, Grade 2A1.

2.3 AGGREGATE SETTING-BED ON CONCRETE LEVELING COURSE

- A. Graded Aggregate for Subbase: Sound, crushed stone or gravel complying with as specified in section 32 13 13, concrete paving.
- B. Concrete Leveling Course: See Section 32 13 13 and 31 20 00 for additional requirements.
- C. Sand for Leveling Course: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C 33 for fine aggregate, with 200 sieve material limited to 1% and 100 sieve material limited to 10%.

- D. Sand for Joints: Fine, sharp, washed, natural sand or crushed stone with 100 percent passing No. 16 (1.18-mm) sieve and no more than 10 percent passing No. 200 (0.075-mm) sieve for light duty paving applications.
- E. Separation 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. Survivability: Class 2, AASHTO M 288.
 - 2. Apparent Opening Size: No. 60 (0.250-mm) sieve, maximum; ASTM D 4751.
 - 3. Permittivity: 0.02 per second, minimum; ASTM D 4491.
 - 4. UV Stability: 50 percent after 500 hours' exposure, ASTM D 4355.
- F. Drainage Geotextile: Nonwoven needle-punched geotextile fabric, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
 - 1. Survivability: Class 2, AASHTO M 288.
 - 2. Apparent Opening Size: No. 40 (0.425-mm) sieve, maximum; ASTM D 4751.
 - 3. Permittivity: 0.5 per second, minimum; ASTM D 4491.
 - 4. UV Stability: 50 percent after 500 hours' exposure, ASTM D 4355.
- G. Herbicide: Commercial chemical for weed control, registered with the EPA. Provide in granular, liquid, or wettable powder form.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas indicated to receive paving, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.

3.2 PREPARATION

- A. Remove substances from concrete substrates that could impair bond, including curing and sealing compounds, form oil, and laitance.
- B. Sweep concrete substrates to remove dirt, dust, debris, and loose particles.
- C. Proof-roll prepared subgrade according to requirements in Division 31 Section "Earth Moving" to identify soft pockets and areas of excess yielding. Proceed with unit paver installation only after deficient subgrades have been corrected and are ready to receive subbase and base course for unit pavers.

3.3 INSTALLATION, GENERAL

- A. Do not use unit pavers with chips, cracks, voids, discolorations, or other defects that might be visible or cause staining in finished work.
- B. Mix pavers from several pallets or cubes, as they are placed, to produce a uniform blend of colors and textures.
- C. Cut unit pavers with motor-driven wet masonry saw equipment to provide clean, sharp, unchipped edges. Cut units to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible. Hammer cutting is not acceptable. 3"x3" minimum nominal size of field cut paver.
- D. Joint Pattern: As indicated.
- E. Tolerances: Do not exceed 1/32-inch (0.8-mm) unit-to-unit offset from flush (lippage) nor 1/8 inch in 10 feet (3 mm in 3 m) from level, or indicated slope, for finished surface of paving.
- F. Expansion and Control Joints: Provide for sealant-filled joints at locations and widths indicated. Provide compressible foam filler as backing for sealant-filled joints. Install joint filler before setting pavers. Sealant materials and installation are specified in Division 07 Section "Joint Sealants."
- G. Provide edge restraints as indicated. Install edge restraints before placing unit pavers.
 - 1. Install job-built concrete edge restraints to comply with requirements in Division 03 Section "Cast-in-Place Concrete."

3.4 AGGREGATE SETTING-BED ON CONCRETE SUB SURFACE APPLICATIONS

- A. Compact soil subgrade uniformly to at least 95 percent of ASTM D 698 laboratory density.
- B. Proof-roll prepared subgrade to identify soft pockets and areas of excess yielding. 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.
- C. Install concrete subbase in accordance with Division 32 section "Concrete Paving".
- D. Place drainage geotextile over concrete base, overlapping ends and edges at least 12 inches (300 mm).
- E. Install sand leveling course and screed to a thickness of 1 to 1-1/2 inches (25 to 38 mm), taking care that moisture content remains constant and density is loose and uniform until pavers are set and compacted.
- F. Treat leveling course with herbicide to inhibit growth of grass and weeds.
- G. Set pavers with a minimum joint width of 1/16 inch (1.5 mm) and a maximum of 1/8 inch (3 mm), being careful not to disturb leveling base. If pavers have spacer bars, place pavers hand tight against spacer bars. Use string lines to keep straight lines. Fill gaps between units that exceed 1/4 inch with pieces cut to fit from full-size unit pavers.

1. When installation is performed with mechanical equipment, use only unit pavers with spacer bars on sides of each unit.
- H. Vibrate pavers into leveling course with a low-amplitude plate vibrator capable of a 3500- to 5000-lbf (16- to 22-kN) compaction force at 80 to 90 Hz. Use vibrator with neoprene mat on face of plate or other means as needed to prevent cracking and chipping of pavers. Perform at least three passes across paving with vibrator.
 1. Compact pavers when there is sufficient surface to accommodate operation of vibrator, leaving at least 36 inches (900 mm) of uncompacted pavers adjacent to temporary edges.
 2. Before ending each day's work, compact installed concrete pavers except for 36-inch (900 mm) width of uncompacted pavers adjacent to temporary edges (laying faces).
 3. As work progresses to perimeter of installation, compact installed pavers that are adjacent to permanent edges unless they are within 36 inches (90 mm) of laying face.
 4. Before ending each day's work and when rain interrupts work, cover pavers that have not been compacted and cover leveling course on which pavers have not been placed with nonstaining plastic sheets to protect them from rain.
- I. Spread dry sand and fill joints immediately after vibrating pavers into leveling course. Vibrate pavers and add sand until joints are completely filled, then remove excess sand. Leave a slight surplus of sand on the surface for joint filling.
- J. Do not allow traffic on installed pavers until sand has been vibrated into joints.
- K. Repeat joint-filling process 2 more times in the next 30 days later.

3.5 REPAIRING AND CLEANING

- A. Remove and replace unit pavers that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment and with no evidence of replacement.
- B. Cleaning: Remove excess grout from exposed paver surfaces; wash and scrub clean.
 1. Remove temporary protective coating as recommended by coating manufacturer and as acceptable to paver and grout manufacturers.
 2. Do not allow protective coating to enter floor drains. Trap, collect, and remove coating material.

END OF SECTION

32 17 23 - 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 painted markings applied to asphalt and concrete pavement.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site. **This conference shall be a part of pre-construction for paving.**
 - 1. Review methods and procedures related to marking pavement including, but not limited to, the following:
 - a. Pavement aging period before application of pavement markings.
 - b. Review requirements for protecting pavement markings, including restriction of traffic during installation period.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include technical data and tested physical and performance properties.
- B. Shop Drawings: For pavement markings.
 - 1. Indicate and confirm pavement markings, colors, lane separations, defined parking spaces, and dimensions to adjacent work (Contractor may use details and plan as basis).
 - 2. Indicate, with international symbol of accessibility, spaces allocated for people with disabilities.
- C. Samples: For each exposed product and for each color and texture specified; on rigid backing, 8 inches square.

1.5 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of NCDOT for pavement-marking work.

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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Benjamin Moore & Co.
 - 2. Color Wheel Paints & Coatings.
 - 3. Columbia Paint & Coatings.
 - 4. Conco Paints.
 - 5. Coronado Paint; Benjamin Moore Company.
 - 6. Diamond Vogel Paints.
 - 7. Ennis Traffic Safety Solutions, Inc.
 - 8. General Paint.
 - 9. McCormick Paints.
 - 10. Miller Paint Co.
 - 11. Parker Paint; Comex Group.
 - 12. PPG Industries.
 - 13. Rohm and Haas Company.
 - 14. Scott Paint.
 - 15. Sherwin-Williams Company (The).

2.2 PAVEMENT-MARKING PAINT

- A. Glass Beads: AASHTO M 247, Type 1 made of 100 percent recycled glass.
 - 1. Roundness: Minimum 75 percent true spheres by weight.
- B. Pavement-Marking Paint: Alkyd-resin type, lead and chromate free, ready mixed, complying with AASHTO M 248, Type N; colors complying with FS TT-P-1952.
 - 1. Color: White, Yellow, Blue, Green (Specify).
- C. Pavement-Marking Paint: MPI #32, alkyd traffic-marking paint.
 - 1. Color: White, Yellow, Blue, Green.
- D. Pavement-Marking Paint: Latex, waterborne emulsion, lead and chromate free, ready mixed, complying with FS TT-P-1952, Type II, with drying time of less than 45 minutes.
 - 1. Color: White, Yellow, Blue.
- E. Pavement-Marking Paint: MPI #97, latex traffic-marking paint.
 - 1. Color: White, Yellow, Blue.

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3.1 EXAMINATION

- A. Verify that pavement is dry and in suitable condition to begin pavement marking according to 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 paving to age for a minimum of 2 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 mils.
 - 1. Apply graphic symbols and lettering with paint-resistant, die-cut stencils, firmly secured to pavement. Mask an extended area beyond edges of each stencil to prevent paint application beyond the stencil. Apply paint so that it cannot run beneath the stencil.
 - 2. Broadcast glass beads uniformly into wet markings at a rate of 6 lb/gal..

3.3 PROTECTING AND CLEANING

- A. Protect pavement markings from damage and wear during the 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 32 17 23

32 31 13 - 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Steel Chain Link Fence with 'Black' Polymer Coated Finish.
 - 2. Galvanized Steel Framework with 'Black' Polymer Coated Finish.
 - 3. Galvanized Steel Hardware with 'Black' Polymer Coated Finish.
- B. Related Sections: The following Sections contain requirements that relate to this Section:
 - 1. Division 2 Section "Earthwork" for footing excavation filling and grading work.
 - 2. Division 3 Section "Cast in Place Concrete" for footings.

1.3 SUBMITTALS

- A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product data in the form of manufacturer's technical data, specifications, and installation instructions for fence and gate posts, fabric, gates, foul poles, windscreens, fan protection system, and accessories
- C. Shop drawings showing location of fence, gates, each post, foul poles, windscreen, fan protection system, and details of post installation, extension arms, gate swing, hardware, and accessories.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced Installer who has at least three years' experience and has completed at least five chain link fence projects with same material and of

similar scope to that indicated for this project with a successful construction record of in-service performance.

- B. Single-Source Responsibility: Obtain chain link fences and gates, including accessories, fittings, and fastenings, from a single source. Below is a list of approved manufactures for the color coated fence.
1. Merchant Metals-Color Bond II System
 2. Master Halco
 3. Ameristar
 4. Approved equal

1.5 PROJECT CONDITIONS

- A. Field Measurements: Verify layout information for fences and gates shown on the Drawings in relation to the property survey and existing structures. Verify dimensions by field measurements.

PART 2 - PRODUCTS

2.1 FABRIC

- A. Selvage: Knuckled on both selvages.
- B. Steel Chain-Link Fence Fabric: Fabricated in one-piece widths for fencing 12 feet and less in height to comply with Chain Link Fence Manufacturers Institute (CLFMI) "Product Manual" and with requirements indicated below:
1. Mesh and Wire Size: 2-inch mesh, 0.192-inch diameter (Finished Gauge: 6).
 2. Polymer-Coated Fabric: Class 2a consisting of polymer coating extruded and adhered to zinc-coated steel wire. Core wire size to be 9 gauge with an 6 guage finish. Color; 'Black' Polymer Coated Finish.
 3. Coat selvage ends of fabric that is metallic coated before the weaving process with manufacturer's standard clear protective coating.

2.2 FRAMING

- A. Round member sizes are given in actual outside diameter (OD) to the nearest thousandth of inches. Round fence posts and rails are often referred to in ASTM standard specifications by nominal pipe sizes (NPS) or the equivalent trade sizes in inches. Round members shall have same finish coating as fabric. The following indicates these equivalents all measured in inches:

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Actual OD	NPS Size	Trade Size
1.315	1	1-3/8
1.660	1-1/4	1-5/8
1.900	1-1/2	2
2.375	2	2-1/2
2.875	2-1/2	3
3.500	3	3-1/2
4.000	3-1/2	4
6.625	6	6-5/8
8.625	8	8-5/8

1. Type I (LCX) Framework for color coated fence shall be coated with 3 mil minimum polyester resin over galvanized steel ASTM F-1043, Group 1c with a minimum yield strength of 55,000 psi. Protective coating per ASTM F-1043, external coating type B Zinc with organic overcoat, 0.9 ounces per square foot Zinc coating with chromatic conversion coating and verifiable polymer film.
- B. Type I Round Posts: Standard weight (schedule 40) galvanized-steel pipe conforming to ASTM F 1083, according to heavy industrial requirements of ASTM F 669, Group IA, with minimum yield strength of 25,000 psi, not less than 1.8 oz. of zinc per sq. ft. Round members shall have same finish coating as fabric. Type A coating inside and outside according to ASTM F 1234, as determined by ASTM A 90, and weights per foot as follows:

Actual OD	Weight (lb/ft)	NPS Size
1.315	1.68	1
1.660	2.27	1-1/4
1.900	2.72	1-1/2
2.375	3.65	2
2.875	5.79	2-1/2
3.500	7.58	3
4.000	9.11	3-1/2
6.625	8.97	6
8.625	28.55	8

- C. Top Rail: Manufacturer's longest lengths (17 to 21 feet) with swaged-end or expansion-type coupling, approximately 6 inches long for joining. Provide rail ends or other means for attaching top rail securely to each gate corner, pull, and end post. All top rail shall have same finish coating as fabric.

1. Top Rail for Color Coated fence: 1.660-inch O.D. Type II DQ 40 pipe (0.111" wall thickness, 1.83 lb/ft).

- D. Steel posts for fabric heights up to 6 feet:

1. Round Line or Intermediate Posts for Color Coated fence: 2.375-inch OD Type II DQ 40 pipe (0.130" wall thickness, 3.12 lb/ft).
 2. Round End, Corner, and Pull Posts for Color Coated fence: 2.875-inch OD Type II DQ 40 pipe (0.160" wall thickness, 4.64 lb/ft).
- E. Steel posts for fabric heights over 6 feet:
1. Round Line or Intermediate Posts for Color Coated fence: 2.375-inch OD Type II DQ 40 pipe (0.130" wall thickness, 3.12 lb/ft).
 2. Round End, Corner, and Pull Posts for Color Coated fence: 2.875-inch OD Type II DQ 40 pipe (0.160" wall thickness, 4.64 lb/ft).
 3. Round Gate Posts for Color Coated fence: 4.00-inch OD Type II DQ 40 pipe (0.160" wall thickness, 4.973 lb/ft).
- F. Swing Gate Posts: Furnish posts to support single gate leaf, or one leaf of a double-gate installation, according to ASTM F 900, sized as follows for steel pipe posts. Gate members shall have same finish coating as fabric
1. Steel posts for fabric height of 6 feet or less and gate leaf width:
 - a. Up to and Including 4 Feet: 2.875-inch OD pipe weighing at least 4.64 lb per ft. Fabric for Color Coated fence as specified above.
 - b. Over 4 to 10 Feet: 4.000-inch OD pipe weighing at least 8.65 lb per ft. Fabric for Color Coated fence as specified above.
- G. Polymer Coating finish over framework:
1. Color: 'Black' Polymer-Coating to match fabric finish, complying with ASTM F934.

2.3 FITTINGS AND ACCESSORIES

- A. Material: Comply with ASTM F 626. Mill-finished aluminum or galvanized iron or steel to suit manufacturer's standards.
1. Steel and Iron: Unless specified otherwise, hot-dip galvanize pressed steel or cast-iron fence fittings and accessories with at least 1.2 oz. zinc per sq. ft. as determined by ASTM A 90.
 2. Color Coated Fence: Provide polymer coating, 6 mils minimum, over hot dipped galvanized pressed steel.
- B. Post and Line Caps: Provide weathertight closure cap for each post. Provide line post caps with loop to receive tension wire or top rail.

1. Color Coated Fence: Provide polymer coating, 6 mils minimum, over hot dipped galvanized pressed steel.
- C. Post Brace Assembly: Manufacturer's standard adjustable brace. Use material specified below for brace, and truss to line posts with 3/8-inch-diameter rod and adjustable tightener. Provide manufacturer's standard galvanized-steel, cast-iron or cast-aluminum cap for each end.
 1. Round Steel: 1.660-inch OD Type I steel pipe.
 2. Color Coated Fence: Provide polymer coating, 6 mils minimum, over hot dipped galvanized pressed steel.
- D. Bottom and Center Rail: Same material as top rail unless indicated otherwise. Provide manufacturer's standard galvanized-steel, cast-iron or cast-aluminum cap for each end.
 1. Color Coated Fence: Same material as Color Coated top rail.
- E. Tension or Stretcher Bars: Hot-dip galvanized steel with a minimum length 2 inches less than the full height of fabric, a minimum cross section of 3/16 inch by 3/4 inch, and a minimum of 1.2 oz. of zinc coating per sq. ft. Provide one bar for each gate and end post, and two for each corner and pull post, except where fabric is integrally woven into the post.
 1. Color Coated Fence: Provide polymer coating, 6 mils minimum, over hot dipped galvanized pressed steel.
- F. Tension and Brace Bands: 3/4-inch-wide minimum hot-dip galvanized steel with a minimum of 1.2 oz. of zinc coating per sq. ft.
 1. Color Coated Fence: Provide polymer coating, 6 mils minimum, over hot dipped galvanized pressed steel.
 2. Tension Bands: 0.074 inch thick (14 gage) minimum.
 3. Brace Bands: 0.105 inch thick (12 gage) minimum.
- G. Tension Wire: 0.177-inch-diameter metallic-coated steel marcelled tension wire conforming to ASTM A 824 with finish to match fabric.
 1. Coating Type II zinc in the following class as determined by ASTM A 90.
 - a. Class 2, with a minimum coating weight of 1.20 oz. per sq. ft. of uncoated wire surface.
 2. Color Coated Fence: Provide polymer coating, 6 mils minimum, over hot dipped galvanized pressed steel.
- H. Tie Wires: 0.106-inch-diameter (12-gage) galvanized steel with a minimum of 0.80 oz. per sq. ft. of zinc coating according to ASTM A 641, Class 3 or 0.148-inch-diameter (9-gage) aluminum wire alloy 1350-H19 or equal, to match fabric wire.

1. Color Coated Fence: Provide polymer coating, 6 mils minimum, over hot dipped galvanized pressed steel.

I. Polymer Coating finish over fittings and accessories:

1. Color: 'Black' Polymer-Coating to match fabric finish, complying with ASTM F934.

2.4 CONCRETE

- A. Concrete: Provide concrete consisting of portland cement per ASTM C 150, aggregates per ASTM C 33, and potable water. Mix materials to obtain concrete with a minimum 28-day compressive strength of 3000 psi. Use at least four sacks of cement per cu. yd., 1-inch maximum size aggregate, 3-inch maximum slump.
- B. Packaged Concrete Mix: Mix dry-packaged normal-weight concrete conforming to ASTM C 387 with clean water to obtain a 2- to 3-inch slump.

2.5 GATES

- A. Fabricate perimeter frames of gates from same material and finish as fence framework. Assemble gate frames by welding. Provide horizontal and vertical members to ensure proper gate operation and attachment of fabric, hardware, and accessories. Space frame members maximum of 8 feet apart unless otherwise indicated.
 1. Fabric: Same as for fence unless otherwise indicated. Secure fabric at vertical edges with tension bars and bands and to top and bottom of frame with tie wires.
 2. Bracing: Install diagonal cross-bracing consisting of 5/16-inch-diameter adjustable-length truss rods on gates to ensure frame rigidity without sag or twist.
 3. Color Coated Fence: Fabric, bracing, framing, fittings, and accessories same as for Color Coated fence specified herein.
- C. Swing Gates: Comply with ASTM F 900.
 1. Steel: Gates up to 8 feet wide:
 - a. Up to 6 Feet High: Fabricate perimeter frames of 1.660-inch minimum OD Type I steel pipe or 1-1/2-inch-square galvanized-steel tubing weighing 1.84 lb per sq. ft.
 - b. Over 6 Feet High: Fabricate perimeter frames of 1.90-inch minimum OD Type I steel pipe or 2-inch-square galvanized-steel tubing weighing 2.52 lb per sq. ft.
 - c. Color Coated Fence: Shall match materials and finish of fence.
 2. Gate Hardware: Provide galvanized hardware and accessories for each gate according to the following:

- a. Hinges: Size and material to suit gate size, non-lift-off type, offset to permit 180-degree gate opening. Provide 1-1/2 pair of hinges for each leaf over 6-foot nominal height.
 - b. Latch: Forked type and plunger-bar type to permit operation from either side of gate, with padlock eye as an integral part of latch.
 - c. Keeper: Provide a keeper for vehicle gates that automatically engages gate leaf and holds it in the open position until manually released.
 - d. Gate Stops: Provide gate stops for double gates consisting of mushroom-type flush plate with anchors, set in concrete, and designed to engage a center drop rod or plunger bar. Include a locking device and padlock eyes as an integral part of the latch, permitting both gate leaves to be locked with a single padlock.
 - e. Color Coated Fence: All hardware shall match materials and finish of other fence.
- D. Polymer Coating finish over gate system and accessories:
- 1. Color: 'Black' Polymer-Coating to match fabric finish, complying with ASTM F934.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Install fence to comply with ASTM F 567. Do not begin installation and erection before final grading is completed, unless otherwise permitted.
- 1. Apply fabric to outside of framework.
- B. Excavation: Drill or hand-excavate (using post-hole digger) holes for posts to diameters and spacings indicated, in firm, undisturbed or compacted soil.
- 1. If not indicated on Drawings, excavate holes for each post to minimum diameter recommended by fence manufacturer, but not less than four times the largest cross section of post.
 - 1. Unless otherwise indicated, excavate hole depths approximately 3 inches lower than post bottom, with bottom of posts set not less than 36 inches below finish grade surface.
 - 2. Coordinate excavation with turf contractor.
- C. Setting Posts: Center and align posts in holes 3 inches above bottom of excavation. Space a maximum of 10 feet o.c., unless otherwise indicated.
- 1. Protect portion of posts above ground from concrete splatter. Place concrete around posts and vibrate or tamp for consolidation. Check each post for vertical and top alignment, and hold in position during placement and finishing operations.

- a. Unless otherwise indicated, maintain concrete footings 2 inches below finished grade.
3. Coordinate excavation with turf contractor.
 - a. Provide and install any sleeving required to sequence work with concrete curb installation.
 - b. Sleeved footing installation will occur separately from fence post installation and requires additional re-mobilization.
- D. Top Rails: Run rail continuously through line post caps, bending to radius for curved runs and at other posts terminating into rail end attached to posts or post caps fabricated to receive rail. Provide expansion couplings as recommended by fencing manufacturer.
- E. Center Rails: Install center rails in one piece between posts and flush with post on fabric side, using rail ends and special offset fittings where necessary.
- F. Brace Assemblies: Install braces at end and gate posts and at both sides of corner and pull posts. Locate horizontal braces at midheight of fabric on fences with top rail and at two thirds fabric height on fences without top rail. Install so posts are plumb when diagonal rod is under proper tension.
- G. Bottom Tension Wire: Install tension wire within 6 inches of bottom of fabric before stretching fabric and tie to each post with not less than same gauge and type of wire. Pull wire taut, without sags. Fasten fabric to tension wire with 0.120-inch-diameter (11-gage) hog rings of same material and finish as fabric wire, spaced a maximum of 24 inches o.c.
- H. Fabric: Leave approximately 1/2 inch between finish grade and bottom selvage unless otherwise indicated. Pull fabric taut and tie to posts, rails, and tension wires. Install fabric on security side of fence, and anchor to framework so that fabric remains under tension after pulling force is released.
- I. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts with tension bands spaced not over 15 inches o.c.
- J. Tie Wires: Use wire of proper length to secure fabric firmly to posts and rails. Bend ends of wire to minimize hazard to persons or clothing.
 1. Maximum Spacing: Tie fabric to line posts 12 inches o.c. and to rails and braces 24 inches o.c.
- K. Fasteners: Install nuts for tension bands and carriage bolts on the side of the fence opposite the fabric side. Peen ends of bolts or score threads to prevent removal of nuts for added security.
- L. Netting Ties: Fasten safety netting to tension cable and fence top rail with cable ties at at 12" o/c.

3.2 GATE INSTALLATION

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- A. install gates plumb, level, and secure for full opening without interference. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary. Install gates according to manufacturer's instructions, plumb, level, and secure.

3.3 ADJUSTING

- A. Gates: After repeated operation of completed installation equivalent to 3 days' use by normal traffic, re-adjust gates and controls for optimum operating condition and safety. Lubricate and clean exposed surfaces.

3.4 WARRANTY

- A. Color Coated Fence: Shall have a 15 year minimum warranty against failure due to rust or corrosion.

END OF SECTION 32 31 13

TURF AND GRASSES

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. Seeding.
 - 2. Hydroseeding.
 - 3. Sodding.
 - 4. Turf renovation.
 - 5. Erosion-control material(s).
- B. Related Sections:
 - 1. Division 31 Section "Site Clearing" for topsoil stripping and stockpiling.
 - 2. Division 31 Section "Earth Moving" for excavation, filling and backfilling and rough grading.
 - 3. Division 32 Section "Plants" for border edgings.

1.3 DEFINITIONS

- A. Finish Grade: Elevation of finished surface of planting soil.
- B. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
- C. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.
- D. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
- E. Planting Soil: Also known as root zone material; standardized topsoil; existing, native surface topsoil; existing, modified in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
- F. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill before planting soil is placed.

- G. Subsoil: All soil beneath the topsoil layer of the soil profile and typified by the lack of organic matter and soil organisms.
- H. 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.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
 - 1. Pesticides and Herbicides: Include product label and manufacturer's application instructions specific to this Project.
- B. Certification of sod and grass seed: From sod and seed vendor for each grass-seed 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 and seed mixture. Include identification of source botanical and common name and name and telephone number of supplier.
 - 1. Seed and Sod shall be 419 Tifton Bermuda. Original Certified Tag shall accompany the material.
- D. Qualification Data: For qualified Landscape Installer.
- E. Product Certificates: For soil amendments and fertilizers, from manufacturer.
- F. Material test reports from qualified independent testing agency indicating and interpreting test results relative to compliance of the following materials with requirements indicated.
 - 1. Analysis of existing surface soil and/or imported topsoil. Testing shall be requested 15 working days prior to delivery of topsoil to the work site. Deficiencies in the topsoil shall be corrected by the contractor. Retesting cost shall be at the Contractor's expense.
 - 2. Provide randomly selected cores in non-athletic field areas of the site.
 - 3. State on sampling the variety of seed to be installed.
 - 4. Provide pH, organic content and recommendations on additives required to establish satisfactory pH for planting.
- G. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of turf during a calendar year. Submit before expiration of required initial maintenance periods.

1.5 QUALITY ASSURANCE

- A. Sod Grower: Grower shall have a minimum of 10 years experience in certified Bermuda production.
- B. Installer Qualifications: Engage a Contractor with at least 5 years experience who has completed a minimum of 20 projects similar in material, design, size, and scope to that indicated for this project and with a record of successful sod establishment.

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1. Personnel Certifications: Installer's field supervisor shall have certification in one of the following categories from the Professional Land care Network:
 - a. Certified Turfgrass Professional, designated CTP (Sports Field Manager).
 - b. Certified Field Builder
- C. Pesticide Applicator: State licensed, commercial.
- D. 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 Professional Landcare Network or the American Nursery and Landscape Association.
 2. Experience: Five years' experience in turf installation in addition to requirements in Division 01 Section "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 Professional Landcare Network:
 - a. Certified Landscape Technician - Exterior, with installation and maintenance specialty area(s), designated CLT-Exterior.
 5. Maintenance Proximity: Not more than two hours' normal travel time from Installer's place of business to Project site.
 6. Pesticide Applicator: State licensed, commercial.
- E. Soil-Testing Laboratory Qualifications: An independent laboratory or university laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.
- F. Soil Analysis: For each unamended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; deleterious material; pH; and mineral and plant-nutrient content of the soil.
 1. Testing methods and written recommendations shall comply with USDA's Handbook No. 60.
 2. The soil-testing laboratory shall oversee soil sampling, with depth, location, and number of samples to be taken per instructions from Architect. A minimum of three representative samples shall be taken from varied locations for each soil to be used or amended for planting purposes.
 3. Report suitability of tested soil for turf growth.
 - a. Based on the test results, recommendations for soil treatments and soil amendments to be incorporated. Recommendations in weight per 1000 sq. ft. (92.9 sq. m) or volume per cu. yd. (0.76 cu. m) for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
 - b. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.

- c. Other amendments, such as sand or organic mulch, may be required to provide proper root zone material.

G. Pre installation Conference: Conduct conference at Project site.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. All sod transported by open truck shall be adequately covered to prevent windburn, drying out or any other wind damage to the sod. Any sod not placed within 48 hours of harvesting shall be rejected and removed from the site immediately at the expense of the Contractor.
- B. Any of the delivered Certified Tifton Bermuda 419 Sod which is damaged through any action or inaction of the Contractor shall be replaced. The cost for re-supplied and replaced sod (directly due to the Contractor's negligence) shall be paid for by the Contractor directly.
- C. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, as applicable.
- D. 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 fertilizers, lime, and soil amendments with appropriate certificates.

1.7 PROJECT 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.

Seed Planting:

- 1. Spring Planting: March 15 – May 15.
- 2. Fall Planting: September 1 – November 1.

Sod Planting:

- 1. Spring/Fall Planting: May 15 – November 1
- 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. Irrigation System: S and Sod shall only be installed after a fully operational and tested irrigation system has been installed. The Contractor has the option to provide temporary power and pumping to meet planting requirements.

1.8 MAINTENANCE SERVICE

- A. Initial Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after each area is planted and continue until acceptable turf is established but for not less than the following periods:
 - 1. Sod or Seeded Turf: Until turf is sufficiently established at Final Acceptance.
 - a. If turf is not established by the end of growing season, contractor care will be required to extend into the next growing season by the contractor at the Owner/Owner's Representative discretion. Continuous care will continue until such time as grass is permanently established as vigorous and viable stand (as also determined by Owner/Owner's Representative).

PART 2 - PRODUCTS

2.1 SOD

- A. The sod shall be a nursery grown sand based Certified Tifton Bermuda grass which shall be purchased by the Sod Contractor and delivered by the sod farm to the project site for unloading by the Sod Contractor. It shall be machine cut sod at a uniform thickness of ½" -3/4" excluding top growth and thatch. The sod farm's sand material base shall be a soil medium that is compatible with the installed playing field root zone. The sod farm's sand soil medium shall be a free draining material acceptable to the Owner in particle size and soil characteristics.
- B. Provide sod samples from the proposed sod farm supplier. Samples shall be submitted by the sod farm to the Contractor for testing and approval (with reports issued to both the Owner and the Architect) prior to the acceptance of the sod farm.
- C. Sod shall be locally sand grown Certified Tifton Bermuda grass, machine cut and taken up in commercial size (big) rolls 42 inches wide by 75 feet long. The sod shall be sufficiently thick to secure a dense stand of live grass. The sod shall be live, fresh, and uninjured at the time of planting. It shall have a soil mat of sufficient and consistent thickness of ½" below the thatch layer adhering firmly to the roots to withstand all necessary handling. The sod shall be 18-24 months old, cut fresh and installed immediately, do not store sod on transfer pallets.
- D. Sod farm harvesting procedures shall be so that uniformity of the cut is obtained. Edges shall be cut at 90-degree angles using constant sharp blades. The thickness and width shall be kept to strict dimensions. The Contractor shall protect sod against the drying and breaking of rolled strips at the site.
- E. The sod shall be subject to review and approval by the Architect and the Owner prior to being cut at the Sod Farm and once again before it is installed on the playing field. The Architect shall have the right to take samples of the sod from the selected sod supply field and submit them for DNA genetic identification and verification. The Architect shall have the right to test the delivered sod at the project site to insure consistency with the DNA genetic identification benchmarks.
- F. Each roll of the Certified Tifton Bermuda grass, sod shall be free of noxious weeds and other objectionable plants and shall not contain thatch quantities and substances injurious to growth.
- G. See plan for limits of planting. Sod all disturbed areas unless otherwise noted.

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2.2 SEED

- A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances. Seed shall be delivered to the site in sealed standard size containers, showing weight, analysis, name of vendor and germination test. Seed which has become wet, moldy or otherwise damaged will not be accepted. New varieties will be considered for review.
- B. Seed Species: Seed of grass species as follows, with not less than 95 percent germination, not less than 85 percent pure seed, and not more than 0.5 percent weed seed:
 - 1. Seed Type 1 - Balanced Mix of 2 Bermuda varieties.
For general lawn areas,
98% 419 Tifton Common Bermuda, drought resistant
2% Annual Rye Grass, started grass.

2.3 INORGANIC SOIL AMENDMENTS

- A. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
 - 1. Class: T, with a minimum of 99 percent passing through No. 8 (2.36-mm) sieve and a minimum of 75 percent passing through No. 60 (0.25-mm) sieve.
 - 2. Provide lime in form of ground dolomitic limestone.

2.4 ORGANIC SOIL AMENDMENTS

- A. Compost: 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 sieve; soluble salt content of 5 to 10 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.
- B. 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, and material harmful to plant growth.

2.5 FERTILIZERS

- A. Bonemeal: Commercial, raw or steamed, finely ground; a minimum of 4 percent nitrogen and 20 percent phosphoric acid.
- B. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.
- C. 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. (0.45 kg/92.9 sq. m) of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight minimum or as required by soil testing laboratory.

D. 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 minimum or as required by soil testing laboratory.

2.6 PLANTING SOILS

A. Planting Soil, re-use surface soil stockpiled from onsite striping, with pH range of 5.5 to 7, a minimum of 2 percent organic material content; free of stones 3/4 inch or larger in any dimension and other extraneous materials harmful to plant growth. Mix topsoil with the following soil amendments and fertilizers in the following quantities to produce planting soil:

1. Weight of Lime per 1000 Sq. Ft. (92.9 Sq. m): 50 lbs/ac.
2. Weight of Superphosphate per 1000 Sq. Ft. (92.9 Sq. m): 500 lbs/ac.
3. Weight of Commercial Fertilizer per 1000 Sq. Ft. (92.9 Sq. m): 1,000 lbs/ac.
4. Amend soils in accordance with soil testing report recommendations.

B. Topsoil shall contain the following specified percentages of constituents:

1. Maximum 25% clay, (red clay, well pulverised); clay shall be sterile.
2. Minimum 15% well-rotted organic material, sawdust, leaf mold or other approved partially decomposed organic matter.
3. Maximum 60% coarse clean sandy loam free of rock, plants, roots and other debris.
4. Topsoil Source: Re-use surface soil and re-condition soil as necessary on the site per plans and specifications as necessary to provide topsoils to depths indicated. Topsoil shall be clean sandy loam free of roots, plants, sods, stones, clay lumps, and other extraneous materials harmful to plant growth.

2.7 MULCHES

A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.

B. 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.

C. Nonasphaltic Tackifier: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application; nontoxic and free of plant-growth or germination inhibitors

2.8 PESTICIDES

A. General: Pesticide, registered and approved by 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 Non-Selective): 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 Non-Selective): Effective for controlling weed growth that has already germinated.

2.9 EROSION-CONTROL MATERIALS

- A. Erosion-Control Blankets: Unless otherwise specified, biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh. Include manufacturer's recommended steel wire staples, 6 inches (150 mm) long. Submit for approval.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to be planted for compliance with requirements and other conditions affecting performance.
 - 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. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.
 - 3. Suspend soil spreading, grading, and tilling 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 and which is too dusty.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. If contamination by foreign or deleterious material, including gravel, or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

3.2 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
 - 1. Protect adjacent and adjoining areas from hydroseeding and hydromulching overspray.
 - 2. Protect grade stakes set by others until directed to remove them.
- 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.

3.3 TURF AREA PREPARATION

- A. Limit turf subgrade preparation to areas to be planted.

- B. Newly Graded Subgrades: Loosen subgrade to a minimum depth of 6 inches (200 mm). Remove stones larger than 3/4 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
 - 1. Apply superphosphate fertilizer directly to subgrade before loosening.
 - 2. Spread soil, apply soil amendments and fertilizer on surface, and thoroughly blend planting soil.
 - a. Delay mixing fertilizer with planting soil if planting will not proceed within a few days.
 - b. Mix lime with dry soil before mixing fertilizer.
 - 3. Spread planting soil to a depth of 6 inches (200 mm) but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
 - a. Spread approximately 1/2 the thickness of planting soil over loosened subgrade. Mix thoroughly into top 4 inches (100 mm) of subgrade. Spread remainder of planting soil.
 - b. Reduce elevation of planting soil to allow for soil thickness of sod.
- C. Unchanged Subgrades: If turf is to be planted in areas unaltered or undisturbed by excavating, grading, or surface-soil stripping operations, prepare surface soil as follows:
 - 1. Remove existing grass, vegetation, and turf. Do not mix into surface soil.
 - 2. Loosen surface soil to a depth of at least 4 inches (200 mm). Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top 4 inches (150 mm) of soil. Till soil to a homogeneous mixture of fine texture.
 - a. Apply superphosphate fertilizer directly to surface soil before loosening.
 - 3. Remove stones larger than 3/4 inch (25 mm) in any dimension and sticks, roots, trash, and other extraneous matter.
 - 4. Legally dispose of waste material, including grass, vegetation, and turf, off Owner's property.
- D. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus 1/2 inch (13 mm) of finish elevation. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit finish grading to areas that can be planted in the immediate future.
- E. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.
- F. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.4 PREPARATION FOR EROSION-CONTROL MATERIALS

- A. Prepare area as specified in "Turf Area Preparation" Article.

- B. For erosion-control blanket or mesh, install from top of slope, working downward, and as recommended by material manufacturer for site conditions. Fasten as recommended by material manufacturer.
- C. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

3.5 SEEDING

- A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph (8 km/h). Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
 - 1. Do not use wet seed or seed that is moldy or otherwise damaged.
 - 2. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.
- B. Sow seed at a total rate of 3-4 lb/1,000 sq. ft..
- C. Rake seed lightly into top 1/8 inch (3 mm) of soil, roll lightly, and water with fine spray.
- D. Protect seeded areas with slopes exceeding 1:3 with erosion-control blankets installed and stapled according to manufacturer's written instructions.
- E. Protect seeded areas with slopes not exceeding 1:6 by spreading straw mulch. Spread uniformly at a minimum rate of 2 tons/acre (42 kg/92.9 sq. m) to form a continuous blanket 1 inch (76 mm) in loose thickness over seeded areas. Spread by hand, blower, or other suitable equipment.

3.6 HYDROSEEDING

- A. Hydroseeding: Mix specified seed, fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.
 - 1. Mix slurry with fiber-mulch manufacturer's recommended tackifier.
 - 2. Apply slurry uniformly to all areas to be seeded in a one-step process. Apply slurry at a rate so that mulch component is deposited at not less than 1500-lb/acre (15.6-kb/92.9 sq. m) dry weight, and seed component is deposited at not less than the specified seed-sowing rate.

3.7 TURF RENOVATION

- A. Renovate existing turf.
- B. Remove sod and vegetation from diseased or unsatisfactory turf areas; do not bury in soil.
- C. Remove topsoil containing foreign materials such as oil drippings, fuel spills, stones, gravel, and other construction materials resulting from Contractor's operations, and replace with new planting soil.

- D. Mow, dethatch, core aerate, and rake existing turf.
- E. Remove weeds before seeding. Where weeds are extensive, apply selective herbicides as required. Do not use pre-emergence herbicides.
- F. Remove waste and foreign materials, including weeds, soil cores, grass, vegetation, and turf, and legally dispose of them off Owner's property.
- G. Till stripped, bare, and compacted areas thoroughly to a soil depth of 6 inches (150 mm).
- H. Apply soil amendments and initial fertilizers required for establishing new turf and mix thoroughly into top 6 inches of existing soil. Install new planting soil to fill low spots and meet finish grades.
- I. Apply seed and protect with straw mulch as required for new turf.
- J. Water newly planted areas and keep moist until new turf is established.

3.8 TURF MAINTENANCE

- A. 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 re-mulch to produce a uniformly smooth turf.
 - 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 (100 mm).
 - 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 (25 mm) per week unless rainfall precipitation is adequate.
- C. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than 1/3 of grass height. Remove no more than 1/3 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 Bermuda blend grasses to a height of 2 to 2 1/4 inches.
- D. Turf Post Fertilization: Apply fertilizer after initial mowing and when grass is dry.

1. Use fertilizer that will provide actual nitrogen of at least 1 lb/1000 sq. ft. (0.45 kg/92.9 sq. m) to turf area.

3.9 SATISFACTORY TURF

- A. Turf installations shall meet the following criteria as determined by Architect:
 1. Satisfactory Seeded Turf: At Substantial Completion, a healthy, dense, 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 3 by 3 inches.
 2. Debris, Gravel and rocks are not visible in the turf.
- B. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.

3.10 PESTICIDE APPLICATION

- A. Apply pesticides and other chemical products and biological control agents in accordance with 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 Non-Selective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written recommendations.

3.11 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. 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.
- C. Remove nondegradable erosion-control measures after grass establishment period.

END OF SECTION 32 92 00

32 93 00 – ORNAMENTAL PLANTS

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. Plants.
 - 2. Planting soils.
- B. Related Sections:
 - 1. Division 31 Section "Site Clearing" for protection of existing trees and plantings, topsoil stripping and stockpiling, and site clearing.
 - 2. Division 31 Section "Earth Moving" for excavation, filling, and rough grading and for subsurface aggregate drainage and drainage backfill materials.
 - 3. Division 32 Section "Turf and Grasses" for turf (lawn) and meadow planting, hydroseeding, and erosion-control materials.

1.3 DEFINITIONS

- A. Backfill: The earth used to replace or the act of replacing earth in an excavation.
- B. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown, with ball size not less than diameter and depth recommended by ANSI Z60.1 for type and size of plant required; wrapped with burlap, tied, rigidly supported, and drum laced with twine with the root flare visible at the surface of the ball as recommended by ANSI Z60.1.
- C. Container-Grown Stock: Healthy, vigorous, well-rooted plants grown in a container, with a well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for type and size of plant required.
- D. Duff Layer: The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.
- E. Finish Grade: Elevation of finished surface of planting soil.
- F. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
- G. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and

molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

- H. Pests: Living organisms that occur where they are not desired, or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
- I. Planting Area: Areas to be planted.
- J. Planting Soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
- K. Plant; Plants; Plant Material: These terms refer to vegetation in general, including trees, shrubs, vines, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.
- L. 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.
- M. Stem Girdling Roots: Roots that encircle the stems (trunks) of trees below the soil surface.
- 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: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.
- P. 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.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated, including soils.
 - 1. Plant Materials: Include quantities, sizes, quality, and sources for plant materials.
 - 2. Pesticides and Herbicides: Include product label and manufacturer's application instructions specific to the Project.
 - 3. Plant Photographs: Include color photographs in digital format of each required species and size of plant material as it will be furnished to the Project. Take photographs from an angle depicting the true size, condition and special characteristic 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, the best quality plant, and the worst quality plant to be furnished. Identify each photograph with the full scientific name of the plant, plant size, and name of the growing nursery.
 - a. Plants must be in situ from source and representative of all units delivered to site or
 - b. Designer may elect to inspect tagged material at nursery.

- B. Qualification Data: For qualified 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.

1.5 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 of either the Professional Landcare Network or the American Nursery and Landscape Association and shall be a registered NC Landscape Contractor (provide license number).
 - 2. Experience: Five years' experience in landscape installation in addition to requirements in Division 01 Section "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 Professional Landcare Network:
 - a. Certified Landscape Technician - Exterior, with installation, maintenance specialty area(s), designated CLT-Exterior.
 - b. Certified Ornamental Landscape Professional, designated COLP.
 - 5. Pesticide Applicator: State licensed, commercial (provide number and designations).
- B. Soil-Testing Laboratory Qualifications: An independent or university laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.
- C. Soil Analysis: For each unamended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; sodium absorption ratio; deleterious material; pH; and mineral and plant-nutrient content of the soil.
 - 1. Testing methods and written recommendations shall comply with USDA's Handbook No. 60.
 - 2. The soil-testing laboratory shall oversee soil sampling; with depth, location, and number of samples to be taken per instructions from Architect. A minimum of three representative samples shall be taken from varied locations for each soil to be used or amended for planting purposes.
 - 3. Report suitability of tested soil for plant growth.
 - a. Based upon the test results, state recommendations for soil treatments and soil amendments to be incorporated. State recommendations in weight per 1000 sq. ft. (92.9 sq. m) or volume per cu. yd. (0.76 cu. m) for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
 - b. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.

- D. 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 will be made by Architect, who will tag plants at their place of growth before they are prepared for transplanting.
- E. 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 (150 mm) above the root flare for trees up to 4-inch (100-mm) caliper size, and 12 inches (300 mm) above the root flare for larger sizes.
 - 2. Other Plants: Measure with stems, petioles, and foliage in their normal position.
- F. Plant Material Observation: 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. Architect retains right to observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and to reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.
 - 1. Notify Architect of sources of planting materials (14) fourteen days in advance of delivery to site.
- G. Preinstallation Conference: Conduct conference at Project site.

1.6 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 conformance 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 fertilizers and soil amendments with appropriate certificates.
- C. 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.
- D. Handle planting stock by root ball.
- E. Store bulbs, corms, and tubers in a dry place at 60 to 65 deg F (16 to 18 deg C) until planting.

- F. 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. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
 - 2. Do not remove container-grown stock from containers before time of planting.
 - 3. 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.
 - 4. Plants to be installed within 72 hours of delivery to site.

1.7 PROJECT 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. Interruption of Existing Services or Utilities: Do not interrupt services or utilities to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary services or utilities according to requirements indicated:
 - 1. Notify Architect and Owner no fewer than seven days in advance of proposed interruption of each service or utility.
 - 2. Do not proceed with interruption of services or utilities without Architect's and Owner's written permission.
- C. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion.
- D. 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.
- E. Coordination with Turf Areas (Lawns): Plant trees, shrubs, and other plants after finish grades are established and before planting turf areas unless otherwise indicated.
 - 1. When planting trees, shrubs, and other plants after planting turf areas, protect turf areas, and promptly repair damage caused by planting operations.

1.8 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, eg. damage or shock and "die back," except for defects resulting from abuse, must be demonstrated by contractor or acknowledged

by owner, lack of adequate maintenance, or neglect by Owner, or incidents that are beyond Contractor's control as deemed appropriate by designer.

- b. Structural failures including plantings falling or blowing over.
- 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.
- 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 will be 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.

1.9 MAINTENANCE SERVICE

- A. Initial Maintenance Service for Trees and Shrubs: Provide maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after plants are installed and continue until Beneficial Occupancy (acceptance of landscape).
- B. Initial Maintenance Service for Ground Cover and Other Plants: Provide maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after plants are installed and continue until Beneficial Occupancy (acceptance of landscape).

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 Schedule or Plant Legend shown 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 (19 mm) in diameter; or with stem girdling roots will be rejected.
 - 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.
 - 3. Plant Selection shall be obtained from a source in Plant Hardiness Zone 8, unless pre-authorized and approved by the Owner prior to purchasing. Plant Zones are defined on

the U.S. Department of Agriculture Plant Hardiness Zone Map. Selection of Plant Material shall be subject to the approval the Owner/

- 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 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 shall begin at root flare according to ANSI Z60.1. Root flare shall be visible before planting.
- D. Labeling: Label at least one 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 as shown on Drawings.
- E. If formal arrangements or consecutive order of plants is shown 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 ORGANIC SOIL AMENDMENTS

- A. Compost: 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 **1/2-inch (13-mm)** sieve; soluble salt content of 5 to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
 - 1. Organic Matter Content: 50 percent of dry weight.
 - 2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.
- B. Sphagnum Peat: Partially decomposed sphagnum peat moss, finely divided or granular texture, with a pH range of 3.4 to 4.8.
- C. Wood Derivatives: Decomposed, nitrogen-treated sawdust, ground bark, or wood waste; of uniform texture and free of chips, stones, sticks, soil, or toxic materials.
- D. 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. Bonemeal: Commercial, raw or steamed, finely ground; a minimum of 4 percent nitrogen and 20 percent phosphoric acid.

- B. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.
- C. 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. (0.45 kg/92.9 sq. m) of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
 - 2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.
- D. 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 soil-testing laboratory.

2.4 PLANTING SOILS

- A. Planting Soil: ASTM D 5268 topsoil, with pH range of 5.5 to 7, a minimum of 4 percent organic material content; free of stones 1/2 inch (12.5 mm) or larger in any dimension and other extraneous materials harmful to plant growth. Mix ASTM D 5268 topsoil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
 - 1. Ratio of Loose Compost to Topsoil by Volume: 1:3 or 33%.
 - 2. Ratio of Loose Sphagnum Peat to Topsoil by Volume: 33%.
 - 3. Weight of Superphosphate per 1000 Sq. Ft. (92.9 Sq. m): 30%.
 - 4. Weight of Commercial Fertilizer per 1000 Sq. Ft. (92.9 Sq. m): per loose directions.

2.5 MULCHES

- A. 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 (25-mm) 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. Double Hammered Shredded Mulch, minimum thickness 3"-4" thickness.

2.6 PESTICIDES

- A. General: Pesticide registered and approved by 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 Non-Selective): 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 Non-Selective): Effective for controlling weed growth that has already germinated.

2.7 MISCELLANEOUS PRODUCTS

- A. Wood Pressure-Preservative Treatment: AWPAC2, with waterborne preservative for soil and freshwater use, acceptable to authorities having jurisdiction, and containing no arsenic; including ammoniacal copper arsenate, ammoniacal copper zinc arsenate, and chromated copper arsenate.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive plants for compliance with requirements and conditions affecting installation and performance.
 - 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. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.
 - 3. Suspend soil spreading, grading, and tilling 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 and which is too dusty.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. 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 Architect and replace with new planting soil.

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 Architect's acceptance of layout before excavating or planting. Make minor adjustments as required.
- D. Lay out plants at locations directed by Architect. Stake locations of individual trees and shrubs and outline areas for multiple plantings.

3.3 PLANTING AREA ESTABLISHMENT

- A. Loosen subgrade of planting areas to a minimum depth of 6 inches (150 mm). Remove stones larger than 1 inch (25 mm) in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
 - 1. Apply superphosphate fertilizer directly to subgrade before loosening.
 - 2. Spread topsoil, apply soil amendments and fertilizer on surface, and thoroughly blend planting soil.
 - a. Delay mixing fertilizer with planting soil if planting will not proceed within a few days.
 - 3. Spread planting soil to a depth of 6 inches (150 mm) but not less than required to meet finish grades after natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
 - a. Spread approximately one-half the thickness of planting soil over loosened subgrade. Mix thoroughly into top 4 inches (100 mm) of subgrade. Spread remainder of planting soil.
- B. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.
- C. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.4 EXCAVATION FOR TREES AND SHRUBS

- A. Planting Pits and Trenches: Excavate circular planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are not acceptable. 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.
 - 1. Excavate approximately three times as wide as ball diameter for balled and burlapped container-grown stock.
 - 2. Excavate at least 12 inches (300 mm) wider than root spread and deep enough to accommodate vertical roots for bare-root stock.
 - 3. Do not excavate deeper than depth of the root ball, measured from the root flare to the bottom of the root ball.
 - 4. 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.
 - 5. Maintain required angles of repose of adjacent materials as shown on the Drawings. Do not excavate subgrades of adjacent paving, structures, hardscapes, or other new or existing improvements.
 - 6. Maintain supervision of excavations during working hours.
 - 7. Keep excavations covered or otherwise protected after working hours.
 - 8. If drain tile is shown on Drawings or required under planting areas, excavate to top of porous backfill over tile.
- B. Subsoil and topsoil removed from excavations may be used as planting soil, if properly amended.

- C. Obstructions: Notify Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.
 - 1. Hardpan Layer: Drill 6-inch- (150-mm-) diameter holes, 24 inches (600 mm) apart, into free-draining strata or to a depth of 10 feet (3 m), whichever is less, and backfill with free-draining material.
- D. Drainage: Notify 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. Before 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. Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.
- C. Set balled and burlapped stock plumb and in center of planting pit or trench with root flare 1 inch (25 mm) above adjacent finish grades.
 - 1. Use planting soil Insert drawing designation 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. Continue backfilling process. Water again after placing and tamping final layer of soil.
- D. Set container-grown stock plumb and in center of planting pit or trench with root flare 1 inch (25 mm) above adjacent finish grades.
 - 1. Use planting 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. Continue backfilling process. Water again after placing and tamping final layer of soil.
- E. 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.
- F. NOTE: Staking recommended although decision is contractor's to make. Blown over trees and damaged root balls belong to contractor during warranty. See detail.

3.6 MECHANIZED TREE SPADE PLANTING

- A. Trees may be planted with an approved mechanized tree spade at the designated locations. Do not use tree spade to move trees larger than the maximum size allowed for a similar field-grown, balled-and-burlapped root-ball diameter according to ANSI Z60.1, or larger than the manufacturer's maximum size recommendation for the tree spade being used, whichever is smaller.
- B. When extracting the tree, center the trunk within the tree spade and move tree with a solid ball of earth.
- C. Cut exposed roots cleanly during transplanting operations.
- D. Use the same tree spade to excavate the planting hole as was used to extract and transport the tree.
- E. Plant trees as shown on Drawings, following procedures in "Tree, Shrub, and Vine Planting" Article.
- F. Where possible, orient the tree in the same direction as in its original location.

3.7 GROUND COVER AND PLANT PLANTING

- A. Set out and space ground cover and plants other than trees, shrubs, and vines as indicated 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 will minimally disturb 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.

3.8 PLANTING AREA MULCHING

- A. Mulch backfilled surfaces of planting areas and other areas indicated.

3.9 PLANT MAINTENANCE

- A. Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, adjusting and repairing tree-stabilization devices, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings. Spray or treat as required to keep trees and shrubs free of insects and disease.
- 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 whenever possible to minimize the use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.

3.10 PESTICIDE APPLICATION

- A. Apply pesticides and other chemical products and biological control agents in accordance with 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. Pre-Emergent Herbicides (Selective and Non-Selective): Apply to tree, shrub, and ground-cover areas in accordance with manufacturer's written recommendations. Do not apply to seeded areas.
- C. Post-Emergent Herbicides (Selective and Non-Selective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written recommendations.

3.11 CLEANUP AND PROTECTION

- A. During planting, keep adjacent paving and construction clean and work area in an orderly condition.
- B. 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.
- C. 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.

3.12 DISPOSAL

- A. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.

END OF SECTION 32 93 00

33 41 00 - STORM UTILITY DRAINAGE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including the General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes drainage systems outside the building. Systems include the following:
 - 1. Storm drainage pipe and fittings.
 - 2. Catch Basins
 - 3. Curb Inlets
 - 4. Pipe Outlets
 - 5. Clean outs.
 - 6. Manholes
 - 7. Storm water detention structures
 - 8. Concrete
- B. Related Sections: The following Sections contain requirements that relate to this Section.
 - 1. Division 31 Section "Earth Moving" for excavation and backfilling.
 - 2. Division 3 Section "Cast-in-Place Concrete" for cast-in-place concrete structures.

1.3 DEFINITIONS

- A. Drainage Piping: System of sewer pipe, fittings, and appurtenances for gravity flow of storm drainage.
- B. RCP: Reinforced Concrete Pipe
- C. PVC: Polyvinyl chloride plastic
- D. HDPE: High Density Polyethylene Pipe

1.4 PERFORMANCE REQUIREMENTS

- A. A.Gravity-Flow, Non-pressure, Drainage-Piping Pressure Ratings: 10-foot head of water (30kPa) Pipe joints shall be at least silt tight, unless otherwise specified.

1.5 SUBMITTALS

- A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product Data: For each type of product indicated.
- C. Shop Drawings: For the Following:

1. Piping, Manholes, Catch Basins, Storm Water Inlets, and Storm Water Detention Structures: Include plans, elevations, sections, details, frames, covers, and grates.

- D. Coordination Drawings: Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from storm drainage system piping. Indicate interface and spatial relationship between manholes, piping, and proximate structures.
- E. Reports and calculations for design mixes for each class of cast-in-place concrete.
- F. Inspection and test reports specified in the "Field Quality Control" Article.
- A. As Built of the Storm Drainage system completion. See Section 33 41 00 Storm Utility Drainage, Piping, Part 3.13 for additional information.
- B. Construction Compliance Certificate Letter certifying the Underground Storm Water Detention System meets the requirements of the contract.

1.6 QUALITY ASSURANCE

- A. Environmental Agency Compliance: Comply with regulations pertaining to storm drainage systems.
- B. Utility Compliance: Comply with regulations pertaining to storm drainage systems. Include standards of water and other utilities where appropriate.
- C. Product Options: Drawings indicate sizes, profiles, connections, and dimensional requirements of system components and are based on specific manufacturer types indicated. Other manufacturers' products with equal performance characteristics may be considered. Refer to Division 1 Section "Product Substitutions Prior to Bid."

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Do not store plastic structures in direct sunlight.
- B. Do not store plastic pipe or fittings in direct sunlight.
- C. Protect pipe, pipe fittings, and seals from dirt and damage.
- D. Handle precast concrete manholes and other structures according to manufacturer's rigging instructions.

1.8 PROJECT CONDITIONS

- A. Site Information: Perform site survey, research public utility records, and verify existing utility locations.
- B. Locate existing structures and piping to be closed and abandoned.
- C. 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 Architect not less than two days in advance of proposed utility interruptions.
 2. Do not proceed with utility interruptions without Architect's written permission.

1.9 PROJECT RECORD DOCUMENTS

- A. Contractor shall be responsible for preparing and submitting “As-Built” drawings by a registered North Carolina Surveyor for all storm water piping systems in the project area including work installed for this contract and existing storm water piping system.

1.10 SEQUENCING AND SCHEDULING

- A. Coordinate with other utility work.

PART 2 - PRODUCTS

2.1 PIPES AND FITTINGS

- A. Reinforced-Concrete Pipe and Fittings: ASTM C 76, Class III, Wall B, for gasketed joints.
 - 1. Gaskets: Butyl mastic compression joints.
 - 2. Watertight – Gravity Joints: Watertight O-Ring Gasket pipe joints.
- B. PVC Pipe and fittings: According to the following:
 - 1. PVC pipe and fittings, NPS 10 and smaller: ASTM D 3034, SDR 35, for solvent-cemented or gasketed joints. PVC Shall be allowed only where indicated on plans.
- C. Corrugated HDPE Drainage Tubing and Fittings: AASHTO M 294, TYPE S, with smooth waterway for coupling joints.
 - 1. Soil tight Couplings: AASHTO M 294, corrugated, matching tube and fittings to form soil tight joints.
 - 2. Soil tight Couplings: HDPE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with tube and fittings to form silttight joints.

2.2 MANHOLES

- A. Heavy-Traffic Precast Circular Concrete Manholes: ASTM C 913; designed according to ASTM C 890 for A-16, heavy-traffic, structural loading; of depth, shape, and dimensions indicated, with provision for rubber gasketed joints. Concrete manholes used shall have pipe penetrations and gasket connections fabricated in the factory, see NCDOT standard detail # 840.52 for additional information. All openings around pipes shall be securely mortared in and watertight. Adhere to all NCDOT Specifications.
 - 1. Ballast: Increase thickness of one or more precast concrete sections or add concrete to structure, as required to prevent flotation.
 - 2. Gaskets: Joint sealants shall meet the requirements of AASHTO M198, type B.
 - 3. Grade Rings: Include two or three reinforced-concrete rings of 6 to 9-inch total thickness, that match 24-inch-diameter frame and cover. Grade rings to be used to raise grate to grade. Brick or block may be substituted to raise grate to grade.
 - 4. Steps: Manufactured from deformed, 1/2-inch steel reinforcement rod complying with ASTM A 615 and encased in polypropylene complying with ASTM D 4101. Include pattern designed to prevent lateral slippage off step. Cast or anchor into sidewalls with steps at 12 To 14-inch intervals. Omit steps for manholes less than 36 inches deep.
 - 5. Base Section: 6-inch minimum thickness for floor slab and 5-inch minimum thickness for walls and base riser section, and separate base slab or base section with integral floor.

6. Riser Sections: 5-inch minimum thickness, and lengths to provide depth indicated.
7. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated, and top of cone of size that matches grade rings.
8. Joint Sealant: ASTM C 990, bitumen or butyl rubber.
9. All manhole openings shall be installed to minimize surface water intrusion through the lid and positioned not to impede mowing. In grassed areas, the opening shall be at or above surrounding grade with a continuous gradual slope down from the opening to accommodate a 72" mowing deck. In paved areas, the opening shall be 1" above the surrounding grade with a continuous gradual slope down from the opening; maximum slope is 1/3" per foot.
10. Outside of manhole shall be coated with bituminous material, to prevent infiltration, prior to placing in ground. Section joints shall be coated once placed in final position prior to backfill.
11. Entire manhole structure shall be rated for continuous vehicle traffic loading per North Carolina Department of Transportation (NCDOT) standards.
12. Smooth channels shall be made at the manhole invert to convey storm water through manholes. These channels shall be made using grout that has been shaped and formed. The space between the grout channel and the manhole walls shall be filled with grout that is shaped to promote drainage back into the channel. The use of brick is allowed in constructing this grout shelf but is not allowed elsewhere in manhole construction.

Manhole Diameter	Diameter of Largest Pipe	Min. Required
4' Manhole	18"	-
5' Manhole	30"	21"
6' Manhole	-	36"

- B. Manhole Frames and Covers: ASTM A 536, Grade 60-40-18, ductile-iron castings designed for heavy-duty service. Include 24-inch ID by 7 to 9-inch riser with 4-inch (100-mm) minimum width flange, and 26-inch diameter cover. Include indented top design with lettering "STORM SEWER" or 'SANITARY SEWER' cast into cover to be coordinate with Owner. Ring and cover shall comply with local standards and construction details.

2.3 CATCH BASIN/DROP INLET/STORM STRUCTURES

- A. Heavy-Traffic, Precast Concrete Storm Structures: ASTM C 913, precast, reinforced concrete; designed according to ASTM C 890 for A-16, heavy-traffic, structural loading; of depth, shape, and dimensions indicated, with provision for rubber gasketed joints. Adhere to all NCDOT Specifications.
1. Gaskets: Joint sealant shall meet requirements of AASHTO M198, type B.
 2. Grade Brick: Use 2 or 3 courses of concrete brick to raise the grate to grade. Mortar joints between brick to be 3/8 to 5/8" thick. Both brick faces to be mortared in and water tight.
 3. Riser Sections: 5-inch minimum thickness and lengths to provide depth indicated.
 4. Joint Sealant: ASTM C 990, bitumen or butyl rubber.
 5. Gaskets: Joint sealant shall meet requirements of AASHTO M198, type B.
 6. Steps: Manufactured from deformed, 1/2-inch steel reinforcement rod complying with ASTM A 615/A 615M and encased in polypropylene complying with ASTM D 4101. Include pattern designed to prevent lateral slippage off step. Cast or anchor into

sidewalls with steps at 12 to 14 inch intervals. Omit steps for manholes less than 36 inches deep.

7. Storm structure inverts/cut out shall be cast into the pre-cast structures from the manufacture's facility as an integral process of pre-casting the structures. With Owner/Owner's Representative permission, they may be skillfully saw cut into the structures on site. Do not hammer/break to create cut outs. Maintain the integrity of the structure, do not impact the corners of the boxes. Any blemished, errors or compromises to the structures shall be the contractor's responsibility to remove and replace.
8. A maximum gap from pipe to inside edge of invert/cut out opening shall be $\pm 2"$. All openings around the pipes shall be securely mortared in and watertight. Maintain a minimum of 5" from pipe invert/cut out to inside edge of the storm structure wall.
9. Size boxes accordingly to connect piping to side/end panels storm boxes, do not cut corners of boxes. Storm Structure Wall Thickness 6" minimum (full width), Width/Length Structure Dimension 30" minimum. Waffle Boxes **are not permitted**. Precast concrete boxes with full thickness and reinforcement rated at NCDOT H20 are required, see NCDOT standard detail # 840.46 for minimum requirements. Ratio of pipe diameter to storm box size & dimension are subject to NCDOT standard details.

- B. Frames and Grates: ASTM A 536, Grade 60-40-18, ductile iron designed for heavy-duty service. Provide grate and frame conforming to jurisdictional requirements and as indicated on drawings.

2.4 STORMWATER INLETS

- A. Combination Inlets: Made with vertical curb and horizontal gutter openings, of materials and dimensions according to utility standards. Include heavy-duty frames and grates.
- B. Frames and Grates: Heavy-duty frames and grates according to utility standards.
- C. Storm water inlet grates shall be ADA compliant and bicycle-safe. "Bicycle-safe" means that bicyclists can ride "smoothly" and safely over the grates when traveling across the grates from any direction at attainable speeds. Grates where bicycle tires "drop-in" or "get stuck" are not considered safe.

2.5 SPECIAL PIPE COUPLINGS AND FITTINGS

- A. Gasket-Type Pipe Couplings: Rubber or elastomeric compression gasket, made to match the outside diameter of smaller pipe and inside diameter or hub of adjoining larger pipe, for non-pressure joints.
 1. Gaskets for Concrete Pipe: Butyl Mastic
 2. Gaskets for Plastic Pipe: ASTM F 477, elastomeric seal.
 3. Gaskets for Dissimilar Pipes: Compatible with pipe materials being joined.

2.6 OUTFALLS

- A. Performed, reinforced concrete flared end sections.
- B. Riprap: Broken stone, irregular size and shape, graded stone according to NSSGA's "Quarried Stone for Erosion and Sediment Control."
 1. class as indicated on drawings.

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2.7 CONCRETE

- A. General: Cast-in-place concrete according to ACI 318, ACI 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 (27.6 MPa) minimum, or as indicated, with 0.45 maximum water-cementitious ratio.
 - 1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
 - 2. Reinforcement Bars: ASTM A 615, Grade 60, deformed steel.
- C. Structure Channels and Benches: Factory or field formed from concrete. Portland cement design mix, 4000 psi minimum, with 0.45 maximum water-cementitious ratio.
 - 1. Include channels and benches in manholes.
 - a. 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.
 - 1) Invert Slope: As indicated.
 - b. Benches: Concrete, sloped to drain into channel.
 - 1) Slope: 8 percent.
 - 2. Include channels in catch basins.
 - a. 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.
 - 1) Invert Slope: As indicated.
- D. Ballast and Pipe Supports: Portland cement design mix, 3000 minimum, with 0.58 maximum water-cementitious ratio.
 - 1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
 - 2. Reinforcement Bars: ASTM A 615, Grade 60, deformed steel.

2.8 CLEANOUTS

- A. PVC Cleanouts: Cast Iron body with PVC riser and threaded plug, flush square counter sunk cap. Provide convex shape concrete collar with a minimum of 6" perimeter between cleanout body and adjacent surface, tapered from adjacent surface up to cleanout body. Include PVC sewer pipe fitting and riser to clean out of same material as sewer piping.

2.9 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
 - 1. Gray-Iron Backwater Valves, Cleanouts, and Drains:
 - a. Josam Co.
 - b. BarryCraft
 - c. McWane, Inc.; Tyler Pipe; Wade Div.
 - d. MIFAB
 - e. Smith: Jay R. Smith Mfg. Co.
 - f. Watts Industries, Inc.: Ancon Drain Div.
 - g. Watts Industries, Inc. Enpoco, Inc. Div.

- h. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.
- 2. PVC Backwater Valves and Cleanouts:
 - a. Canplas, Inc.
 - b. IPS Corp.
 - c. NDS, Inc.
 - d. Plastic Oddities, Inc.
 - e. Sioux Chief Manufacturing Co., Inc.
- 3. Stormwater Drainage Systems, Inc.
 - a. Advanced Drainage Systems, Inc.
 - b. Cultec, Inc.
 - c. Hancor, Inc.
 - d. Infiltrator Systems, Inc.
 - e. PSA, Inc.
 - f. Poly Drain #610 wire trash bucket.
- 4. Plastic Cleanouts:
 - a. Canplas LLC.
 - b. IPS Corporation.
 - c. NDS Inc.
 - d. Plastic Oddities; a division of Diverse Corporate Technologies, Inc.
 - e. Sioux Chief Manufacturing Company, Inc.
 - f. Zurn Light Commercial Products Operation; Zurn Plumbing Products Group.

Description: PVC body with PVC threaded plug. Include PVC sewer pipe fitting and riser to clean out of same material as sewer piping.

2.10 STORM WATER DETENTION STRUCTURES

- A. See plans for layout, materials and details.

The Contractor shall provide a complete Underground Storm Water Detention system including design, engineering, testing, project management, coordination, labor, material and any additional ancillary support necessary to fulfill the requirements as noted within the plans and specification for an Owner approved underground storm water detention system.
- B. Delegated Design: Design of the Underground Storm Water Detention System **by the General Contractor and Licensed Professional Engineer, PE.** This system shall be designed by the General Contractor, North Carolina Licensed Engineer, system manufacturer, manufacturer vendor/supplier for the facility (underground storm water system). Upon completion of the design the Contractor shall submit the signed seal design & calculation for reviewed and approval by the Owner. Contractor/Engineer's Design Team shall permit this facility as necessary, install, inspect, licensed engineer & product manufacturer shall be on site during ALL construction activities, provide construction observation with written reports, construction observation certifying the construction/material of the system and provide close-out documents as required.
- C. General Contractor shall submit 'As Built' for this system. Sealed survey required prior to substantial acceptance indicating size, material, vertical and horizontal locations of the sub-assemblies and the entire system. See Section 33-41-00, Part 3.13 for additional requirements.
- D. General Contractor shall submit three (3) original signed/sealed copies of the Construction Compliance Certificate Letter certifying the Underground Storm Water Detention System including materials, equipment, installation etc. meets and exceeds the requirements of the contract and the NC PE & manufacturer design guidelines. The Compliance Certificate Letter

shall be certified/signed by the General Contractor, NC Licensed Engineer/(System Eng), Product Manufacture, Vendor.

2.11 ACCESSORIES

- A. Warning Tape: See Section 31 20 00 "Earthwork", Part 2.3 for additional information.
- B. Detectable Warning Tape: See Section 31 20 00 "Earthwork", Part 2.3 for additional information.

PART 3 - EXECUTION

3.1 EARTH MOVING

- A. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

3.2 IDENTIFICATION

- A. Materials and their installation are specified in Division 31 Section "Earth Moving." Arrange for installation of warning tape and magnetic detectable warning tapes directly over piping and at outside edges of underground structures. Burry warning tape at 8-10" above pipe/detectable tape 24-30" below finish grade or 12" below subgrade of pavements. See Section 31 20 00 Earthwork for more information.
 - 1. Use warning tapes or detectable warning tape over ferrous piping.
 - 2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

3.3 DRAINAGE PIPING APPLICATIONS

- A. General: Include watertight joints.
- B. Refer to Part 2 of this Section for detailed specifications for pipe and fitting products listed below. Use pipe, fittings, and joining methods according to the following applications.
- C. Pipe Sizes 15 to 36 Inches: Reinforced-concrete sewer pipe and fittings; Buytl mastic joints.
- D. Pipe Sizes: 4 to 10 Inches: As indicated on plan.

3.4 INSTALLATION, GENERAL

- A. General Locations and Arrangements: Drawings (plans and details) indicate the general location and arrangement of underground sewerage and drainage systems piping. Location and arrangement of piping layout take into account many design considerations. Install piping as indicated, to an extent practical.
- B. Install piping beginning at low point of systems, 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 recommendations for use of lubricants, cements, and other installation requirements. Maintain swab or drag in line and pull past each joint as it is completed.

- C. Use manholes for changes in direction, except where fittings are indicated. Use fittings for branch connections, except where direct tap into existing sewer is indicated. Use proper size increasers, reducers, and couplings, where different sizes or materials of pipes and fittings are connected. Reduction of the size of piping in the direction of flow is prohibited.
- D. Install gravity-flow, non-pressure drainage piping according to the following:
 - 1. Install piping pitched down in direction of flow, at minimum slope as indicated on drawings.
 - 2. Install reinforced-concrete sewer piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."
 - 3. Install HDPE sewer piping according to ASTM D2321 and manufacturer's written instructions.
- E. Extend drainage piping and connect to building's storm drains, of sizes and in locations indicated. Terminate piping as indicated.
- F. Install drainage piping pitched down in direction of flow, at slope indicated.
- G. Use proper size increasers, reducers, and couplings, where different sizes or materials of pipes and fittings are connected.
- H. Access to the Work shall be along public rights of way or easements indicated on the Plans. Any encroachment upon private property shall not be permitted unless the Contractor secures specific authorization from the individual property owners concerned. All properties used for access, storage, construction, etc. shall be left in "as good" condition.
- I. Contractor shall contact U-LO-CO at 1-800-632-4949 for location and flagging of utilities at least forty-eight (48) hours prior to start of excavations. See "Earthwork" specifications for additional utility locating requirements.
- J. Contractor shall be fully responsible for damage and repair, or replacement of any existing utility caused by construction operations.
- K. All pipe, precast concrete manhole, drainage structures, grates; fittings shall be carefully handled to avoid damage and shall be inspected by the Architect or his representative prior to installation, preferably while suspended over the trench.
- L. The Contractor shall install temporary watertight plugs in incomplete manholes or sewer lines prior to leaving the job site for any extended period of time. At a minimum, the pipes or manholes shall be plugged at the end of each workday.
- M. Install pipe to slopes noted on drawings in the storm schedule. The maximum allowable slope variation is 1:1000 (0.1' per 100'). All storm piping shall be installed to have positive drainage (.50% min.).
- N. Clean interior of pipe and structures of dirt and other material as work progresses.
- O. Plug ends of pipe of uncompleted work at the end of the day for non-active lines.

3.5 STORM PIPE BEDDING

- A. RCP – Lay gravity storm sewer lines with Category I, II or III bedding as per Design Data 40 by American Concrete Pipe Association. Compaction per Design Data 40, Type 3 installation. Class IA, IB and II per ASTM D321 may also be used. Class IA and IB must be used in wet conditions. Bedding material shall be placed on trench bottom 4-inch minimum depth. Haunching material to be Category I, II, or III, compaction per Type 3 Installation. Initial

backfill from the top of the haunching material up to 12 inches above pipe top consisting of select finely divided earth, hand placed and compacted before placing the remaining backfill.

3.6 PIPE JOINT CONSTRUCTION AND INSTALLATION

- A. General: Join and install pipe and fittings according to the following.
- B. Install with top surfaces of components, except piping, flush with final finished surface.
- C. Concrete Pipe and Fittings: Install according to ACPA "Concrete Pipe Handbook." Use the following seals:
 - 1. Round Pipe and Fittings: Butyl Mastic Joint
- D. Polyvinyl Chloride (PVC) Plastic Pipe and Fittings: As follows:
 - 1. Join solvent-cement-joint pipe and fittings with solvent cement according to ASTM D 2855 and ASTM F 402.
 - 2. Join pipe and gasketed fittings with elastomeric seals according to ASTM D 2321.
 - 3. Join profile sewer pipe and ribbed drainpipe and gasketed fittings with elastomeric seals according to ASTM D 2321 and manufacturer's written instruction.
 - 4. Install according to ASTM D 2321.
- E. System Piping Joints: Make joints using system manufacturer's couplings, except where otherwise specified.
- F. Join piping made of different materials or dimensions with couplings made for this application. Use couplings that are compatible with and fit both systems' materials and dimensions.

3.7 STORM DRAINAGE INLET AND OUTFALL INSTALLATION

- A. Construct riprap of broken stone, as indicated.
- B. Install outlets that spill onto grade, with flared end sections that match pipe, where indicated.

3.8 MANHOLE INSTALLATION

- A. General: Install manholes, complete with appurtenances and accessories indicated.
- B. Form continuous concrete channels and benches between inlets and outlet.
- C. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches above finished surface elsewhere, unless otherwise indicated.
- D. Install precast concrete manhole sections with gaskets according to ASTM C 891.
- E. Construct cast-in-place manholes as indicated.

3.9 CATCH-BASIN INSTALLATION

- A. Construct catch basins to sizes and shapes indicated.
- B. Set frames and grates to elevations indicated.

3.10 CONCRETE PLACEMENT

- A. Place cast-in-place concrete according to ACI 318, ACI 350R, and as indicated.

3.11 TAP CONNECTIONS

- A. Make connections to existing piping and underground structures so finished work conforms as nearly as practical to requirements specified for new work.
- B. Use commercially manufactured wye fittings for piping branch connections. Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye fitting plus 6-inch overlap, with not less than 6 inches of 3000-psi, 28-day, compressive-strength concrete. Tap shall be made by local utility company, fee paid by contractor.
- C. Protect existing piping and structures to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

3.12 CLEANOUT INSTALLATION

- A. Install cleanouts and riser extension from sewer pipe to cleanout at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts and cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.
- B. Set cleanout frames and covers in earth in cast-in-place concrete block, 18 by 18 by 12 inches deep. Set with tops 1/2 inch above surrounding earth grade.
- C. Set cleanout frames and covers in concrete pavement with tops flush with pavement surface.

3.13 FIELD QUALITY CONTROL

- A. Clear interior of piping and structures of dirt and superfluous material as the work progresses. Maintain swab or drag in piping and pull past each joint as it is completed.
 - 1. In large, accessible piping, brushes and brooms may be used for cleaning.
 - 2. Place plug in end of incomplete piping at end of day and whenever work stops.
 - 3. Flush piping between manholes and other structures, if required by authorities having jurisdiction, to remove collected debris.
- B. HDPE Performance Assurance:
 - 1. Upon completion of final backfill, all lines shall be checked for deflection by pulling a nine-point mandrel through the line or by taking diameter measurements (a minimum of 4 measurements space equal distance apart at each location) at completion of final backfill and again at 11 months after installation. If diameter measurements are taken in lieu of pulling a mandrel, each pipe shall be measured at the joint and a distance of 1/3 the length from each end. Maximum allowable deflection shall be 5 percent. If any pipeline fails to pass the deflection test, the pipe shall be removed and replaced with new pipe at no expense to the Owner within the next 30 days. The new pipe shall be retested at completion of final backfill and 11 months. Contractor to perform testing with Owner's representative present. Re-rounding of installed pipe shall not be allowed.
- C. 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 the 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 visual between structures.
 - b. Deflection: Flexible piping with deflection that prevents passage of a ball or cylinder of a size not less than 92.5 percent of piping diameter.

- c. 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. Reinspect and repeat the procedure until results are satisfactory.
- D. 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 authorities having jurisdiction.
 3. Schedule tests, and their inspections by authorities having jurisdiction, with at least 24 hours' advance notice.
 4. Submit separate reports for each test.
 5. Replace leaking piping using new materials and repeat testing until leakage is within allowances specified.
 6. TV quality Camera testing and documentation of as built condition of each foot of pipe and each structure required prior to close out. Any defects shall be corrected and retested.
 7. Contractor to provide Owner with DVD of camera test and written report/Key map for referencing structures and pipe runs.
 8. As Built: Sealed survey required prior to acceptance indicating vertical and horizontal locations of the entire system.

Contractor shall provide a field verify record documented conditions with TV camera quality video and field verify 'As-Built' Record Document(s). Record Documents shall be signed and sealed by a Professional Registered NC Land Surveyor for the entire storm system including all permanent pipes, detention systems & storm ponds/holding systems (stormwater and water quality systems) . 'As-Built' documents shall accurately document the field verified constructed system of the entire system including material & size of all pipes, structures, ancillary structures, pipes, pipe inverts & rims, FES, fittings stormwater pond/stormwater bmp (pipes, structures, ground shots/proposed pond grading ie), etc including both vertical / horizontal identifications.

As-Built Document shall be submitted to the Owner/Owners Project Representative for review and Final Approval/Acceptance prior to request for Substantial Completion. If As-Built material is in conflict, represents deficiencies or unacceptable to the Owner and the proposed storm system design. The contractor shall make the field corrections necessary to bring the constructed system in compliance with the Bid Documents per Base Bid requirement. These modifications shall be completed within the time frame of the Base Contract/Substantial Completion schedule.

3.14 CLEANING

- A. Clean interior of piping of dirt and superfluous materials. Flush with potable water.

END OF SECTON 33 41 00

33 46 00 - SUBDRAINAGE

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. This Section includes subdrainage systems for the following:
 - 1. Retaining Wall: Wall Drain system
 - 2. Restraint Band: Wall Drain system

1.3 DEFINITIONS

- A. HDPE: High-density polyethylene plastic.
- B. PE: Polyethylene plastic.
- C. Subdrainage: Drainage system that collects and removes subsurface or seepage water.

1.4 SUBMITTALS

- A. Product Data: For the following:
 - 1. Perforated-wall pipe and fittings.
 - 2. Solid-wall pipe and fittings.
 - 3. Geotextile filter fabrics.
 - 4. Stone aggregate used in field drainage.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 PIPING MATERIALS

- A. Refer to the "Piping Applications" Article in Part 3 for applications of pipe, tube, fitting, and joining materials.

2.3 PERFORATED-WALL HIGH DENSITY POLYETHYLENE PIPE AND FITTINGS

- A. High Density Polyethylene Pipe and fittings (HDPE): According to the following:
High Density Polyethylene single wall, corrugated pipe meeting AASHTO M252; Type S.
HDPE pipe will only be accepted where indicated on plans.

1. Joints: Use bell and spigot joint meeting AASHTO M252, M294, or ASTM F2306. The joint shall be soil-tight and gasketed to meet ASTM F477.
2. Fittings and accessories: Provide and install similar to joint angles shown on plan. Conform to AASHTO M252, M294, or ASTM F2306.
3. Approved manufacturers:
 - a. ADS N-12 ST 1B.
 - b. Hancor.
 - c. Lane.

2.4 SOLID-WALL PIPES AND FITTINGS

- A. High Density Polyethylene Pipe and fittings (HDPE): According to the following:
High Density Polyethylene single wall, corrugated pipe meeting AASHTO M252; Type S. HDPE pipe will only be accepted where indicated on plans.
1. Joints: Use bell and spigot joint meeting AASHTO M252, M294, or ASTM F2306. The joint shall be soil-tight and gasketed to meet ASTM F477.
 2. Fittings and accessories: Provide and install similar to joint angles shown on plan. Conform to AASHTO M252, M294, or ASTM F2306.
 3. Approved manufacturers:
 - a. ADS N-12 ST 1B.
 - b. Hancor.
 - c. Lane.

2.5 SOIL MATERIALS

- A. Backfill, drainage course, impervious fill, and satisfactory soil materials are specified in Division 31 Section "Earth Moving."

2.6 GEOTEXTILE FILTER FABRICS

- A. Description: Fabric of PP or polyester fibers or combination of both, with flow rate range from 110 to 330 gpm/sq. ft. (4480 to 13 440 L/min. per sq. m) when tested according to ASTM D 4491.
1. Structure Type: woven, monofilament or multifilament.
 2. Style(s): Flat.
 3. Basis of Design: Mirafi 140N or equal.

2.7 STONE – NCDOT #57 washed at prescribed depths, see details on plans.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine surfaces and areas for suitable conditions where subdrainage systems are to be installed.
- B. Locate and mark existing utilities, underground structures, and aboveground obstructions before beginning installation and avoid disruption and damage of services.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

3.3 PIPING APPLICATIONS

- A. Underground Subdrainage Piping:
 - 1. Perforated and solid wall HDPE pipe and fittings.

3.4 RETAINING-WALL DRAINAGE INSTALLATION

- A. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
- B. Place supporting layer of drainage course over compacted subgrade to compacted depth of not less than 4 inches (100 mm).
- C. Install drainage piping as indicated in Part 3 "Piping Installation" Article for retaining-wall subdrainage.
- D. Add drainage course to width of at least 6 inches (150 mm) on side away from wall and to top of pipe to perform tests.
- E. After satisfactory testing, cover drainage piping to width of at least 6 inches (150 mm) on side away from footing and above top of pipe to within 12 inches (300 mm) of finish grade.
- F. Place drainage course in layers not exceeding 3 inches (75 mm) in loose depth; compact each layer placed and wrap top of drainage course with flat-style geotextile filter fabric.
- G. Place layer of flat-style geotextile filter fabric over top of drainage course, overlapping edges at least 4 inches (100 mm).
- H. Fill to Grade: Place satisfactory soil fill material over compacted drainage course . Place material in loose-depth layers not exceeding 6 inches (150 mm). Thoroughly compact each layer. Fill to finish grade.

3.5 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 written instructions and other requirements indicated.
 - 1. Retaining-Wall Subdrainage: When water discharges at end of wall into stormwater piping system, install piping pitched down in direction of flow, at a minimum slope of 0.5 percent and with a minimum cover of 36 inches (915 mm), unless otherwise indicated.
 - 2. Synthetic Grass Surface Subdrainage: Install piping pitched down in direction of flow, at a minimum slope of 0.5 percent and with a minimum cover of 18 inches, unless otherwise indicated on drawings.
 - 3. Lay perforated pipe with perforations down.
 - 4. Excavate recesses in trench bottom for bell ends of pipe. Lay pipe with bells facing upslope and with spigot end entered fully into adjacent bell.
- 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.
- C. Install HDPE sewer piping according to ASTM D2321 and manufacturer's written instructions.

3.6 PIPE JOINT CONSTRUCTION

- A. Join HDPE pipe and fittings according to ASTM F477 and manufacturer's written instructions.
- B. Join perforated, PE pipe and fittings with couplings for soil-tight joints according to AASHTO's "Standard Specifications for Highway Bridges," Division II, Section 26.4.2.4, "Joint Properties"; or according to ASTM D 2321.
- C. Join PVC pipe and fittings according to ASTM D 3034 with elastomeric seal gaskets according to ASTM D 2321.

3.7 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect low elevations of subdrainage system to solid-wall-piping storm drainage system or drain to daylight if indicated on drawings.

3.8 IDENTIFICATION

- A. Materials and their installation are specified in Division 31 Section "Earth Moving." Arrange for installation of green warning tapes directly over piping.
 - 1. Install detectable warning tape over HDPE piping.

3.9 FIELD QUALITY CONTROL

- A. Testing: After installing drainage course to top of piping, test drain piping with water to ensure free flow before backfilling. Remove obstructions, replace damaged components, and repeat test until results are satisfactory.

3.10 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 33 46 00