PROJECT MANUAL

GSP CONSOLIDATED RENTAL CAR FACILITY & PUBLIC PARKING GARAGE

GREENVILLE SPARTANBURG INTERNATIONAL AIRPORT

LS3P PROJECT # : 9550-170760

2000 GSP DRIVE
GREER, SC 29651

100% CONSTRUCTION DOCUMENTS

NOVEMBER 15, 2019

ARCHITECT

LS3P ENGAGE DESIGN TRANSFORM

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Volume 2 – Division 15 thru Division 33

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FOR

GSP CONSOLIDATE RENTAL CARE FACILITY & PUBLIC PARKING GARAGE

Greer, South Carolina

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SECTION 210010 - FIRE SUPPRESSION GENERAL

PART 1 - GENERAL

1.1 DESCRIPTION

A. These fire suppression provisions specified herein apply to all Sections of Division 2l.

B. Refer to the General and Supplementary Conditions and Division 01 for special requirements and conditions which apply to all Sections of Division 21.

C. This Section includes responsibilities and obligations in support of the performance verification specified in Section 210090, Fire Suppression Performance Verification..

1.2 QUALITY ASSURANCE

A. Conform to the following:

1. International Fire Code-2015 with South Carolina Modifications-2016.
2. International Fire Code-2015.
3. NFPA 13-2013.
4. NFPA 14-2013.
5. NFPA 16-2015
6. NFPA 20-2013.
7. NFPA 24-2013.

B. Systems shall comply with the requirements of Factory Mutual Engineering Industrial Risk Insurers as agents of the insurer.

C. Codes, standards and regulations specified herein refer to the edition date. Revisions and addenda to these codes, standards and regulations shall be part of these specifications. Provisions of referenced codes, standards, and regulations do not create duty or responsibility by the Architect or the Owner, unless otherwise specified herein.

D. Codes, standards and regulations referred to are minimum standards. Where the requirements of these specifications or drawings exceed those of the codes, standards and regulations, the drawings or specifications shall govern.

E. Fire Suppression/Electrical Design Coordination:

1. The power ratings of motors and other fire suppression equipment and the electrical characteristics of electrical systems serving them, as specified herein and indicated on the Drawings, have been established as minimums which will allow that equipment to satisfactorily function while producing the required capacities. These power ratings include a safety factor deemed appropriate to accommodate common differences between design parameters and field construction practices. Under no circumstances shall equipment with power ratings less than those indicated on the Drawings or specified herein be provided.
2. Reasonable efforts have been made to coordinate the electrical requirements of the fire suppression equipment with the electrical systems serving that equipment. Differences

among manufacturers of fire suppression equipment make it impossible to produce a single electrical design which will satisfy the varying electrical requirements of those manufacturers. Consequently, the Contractor shall coordinate the electrical requirements of the fire suppression equipment actually furnished on this Project and provide the electrical systems required by that equipment. This coordination effort shall be completed prior to the installation of either the fire suppression equipment or the electrical systems serving that equipment. Electrical system revisions required to coordinate with the fire suppression equipment actually furnished shall be provided at no additional cost to the Owner.

F. Adhesives and Sealants:

1. Adhesives, sealants, and sealant primers used inside the building (defined as inside the weatherproofing envelope and applied on site) shall comply with SCAQMD Rule 1168-2017 for volatile organic compound content limits.
2. Aerosol adhesives shall comply with GS 36-2013 for volatile organic compound content limits.

G. Paints and Coatings:

1. Anticorrosive and antirust paints applied to interior ferrous metal shall not exceed a volatile organic compound content limit of 250 g/L per GS 11-2015.

1.3 SPACE CONDITIONS

A. Drawings are diagrammatic in nature and, unless explicitly dimensioned, indicate approximate locations of apparatus, equipment, and piping. Changes in the location, and offsets, of same which are not shown on the Drawings but are necessary in order to accommodate building conditions and coordination with the work of other trades, shall be made during the preparation of coordination drawings and prior to initial installation, without additional cost to the Owner.

B. Provide access to equipment and apparatus requiring operation, service or maintenance throughout the life of the system.

C. Piping and equipment shall not be installed in electrical equipment rooms, elevator equipment rooms, or elevator shafts unless specifically indicated on the Drawings. In addition, piping or fire suppression equipment shall not be installed in the space equal to the width and depth of switchgear, switchboards, panelboards, and motor control centers from floor to structure above nor within the working space in front, rear and/or side (where rear and/or side access is required to work on equipment) of electrical equipment (switchgear, switchboards, panelboards, motor control centers, variable frequency drives, transformers, and starters). Dimensions of the working space shall be a minimum depth of 42" horizontally, the width of the equipment or 30", whichever is greater, and the height of the equipment or 78", whichever is greater. Minimum depth shall be increased to 60" for equipment rated over 600 V.

1.4 ASBESTOS MATERIALS

A. Materials containing asbestos or any trace of asbestos related materials shall not be used on this Project.

1.5 DEFINITIONS

A. Exposed piping or conduit is that which can be seen when the base building and tenant fit-up is complete without opening or removing access doors or panels or accessible ceiling components.

B. Other piping and conduit is considered to be concealed.

1.6 CONTINUITY OF EXISTING SERVICE AND SYSTEMS

A. Schedule work so existing systems will not be interrupted. when they are required for normal usage of the existing building. Obtain approval from the Owner and Architect at least 7 days prior to any utility interruption or connection.

B. Perform work at such time and in such manner as to cause minimum inconvenience to the Owner and as approved by the Architect. No allowance will be made for lack of knowledge of existing conditions.

C. The existing engine-generator set shall remain operational during construction and shall be accessible to the Owner. Protect the engine-generator set from dust, dirt and damage.

1.7 RELATED WORK DESCRIBED IN OTHER DIVISIONS

A. Installation of access panels in wall and ceiling construction.

B. Cutting, coring, waterproofing, and patching of walls, floors, ceilings, roofs and structure of existing buildings.

C. Painting, except as specified herein.

D. Electric power, interlock, and control wiring, except as specified herein.

E. Installation of starters, contactors, thermal overload switches, and remote push buttons, except as specified herein.

F. Demolition, including removal of piping and equipment.

1.8 UTILITY CONNECTIONS AND SERVICE

A. Water:

1. Arrange for connection to the water main, extension of service and installation of a reduced pressure zone backflow preventer of not less than 8" size. Pay charges in connection therewith.

1.9 SUBMITTALS

A. Within 15 days after notice to proceed, submit a schedule indicating the proposed submission date of each submittal specified herein. Schedule shall anticipate the submittal review time, the possible need for resubmittals, and the time required for fabrication, shipping and integration into

the construction sequence. Architect will advise of any conflicts in reviewing submittals that the proposed schedule presents.

B. Submittals shall be prepared in a line-by-line format corresponding to these Specifications and shall indicate compliance with each requirement specified herein and indicated on the Drawings.

1. In addition to any other transmittals or cover sheets used, fill out and attach to each individual submittal a copy of the Cover Sheet for Submittals to Newcomb & Boyd included at the end of this Section.
2. Indicate manufacturer's installation instructions.
3. Indicate deviations, if any, including any from the manufacturer's installation instructions.
4. Reproductions or electronic versions of design drawings shall not be used in the preparation of shop drawings.
5. Resubmittals that are required to address review comments shall include a cover transmittal with a written explanation of how each review comment has been addressed.
6. Submittals not specifically required, or not complying with the format requirements, will be returned unreviewed.
7. Shop drawings and submittals shall be provided in portable document format (PDF). PDF files containing multiple drawings or components shall include an index of the file contents and electronic bookmarks.

C. Shop drawings shall include the following:

1. Trade shop drawings (i.e., fire suppression sprinkler working drawings) shall be submitted within 30 days after award of contract.
2. Approved trade shop drawings shall be utilized as the basis for the coordination drawings. Coordination drawings shall be submitted within 30 days after approval of trade shop drawings.
3. Coordination drawings shall utilize either manual or electronic means of analyzing the work of each trade in spatial relationship with other trades. Locations of conflicts between trades, and the proposed resolution for each conflict, shall be noted on the coordination drawings submitted.
4. No work shall be fabricated and/or installed prior to receipt by the Contractor of approved trade shop drawings and approved coordination drawings without specific written authorization from the Architect. No change orders will be approved or design assistance provided for remedial field coordination activities for work fabricated and/or installed prior to receipt by the Contractor of approved trade shop drawings and approved coordination drawings.

D. General submittals shall include the following:

1. Performance Verification Supervisor qualifications.
2. Coordination drawings, with dimensions and elevations, of plumbing, HVAC, and fire suppression work, including ductwork, equipment, piping with fittings, valves, dampers, accessories and sleeves where applicable according to trade, coordinated with the work of other trades, including HVAC, plumbing, fire suppression, electrical, structural, and architectural, minimum 1/4" = 1'-0" scale.
3. Seismic restraint devices, including calculations, restraint selection, installation details and written confirmation that a licensed engineer prepared the calculations.

E. Fire suppression submittals shall include the following:

1. Air compressors and pressure maintenance devices.
2. Reduced pressure zone backflow preventers.
3. Contractor's welders qualification test records.
4. Deluge valves and trim.
5. Dry pipe valves and trim.
6. Final hydraulic calculations based on working drawings, including additional fittings for coordination, and conforming to the format given in NFPA 13-2013.
7. Fire department siamese connections.
8. Fire hose valves with adjustment instructions.
9. Fire pumps and controllers, including performance curves and accessories.
10. Pipe hangers.
11. Piping and fittings, aboveground. and underground.
12. Sprinkler heads.
13. Valves.
14. Valve boxes.
15. Valve monitor switches.
16. Water flow switches.
17. Working drawings, approved and stamped by the insurer's agent prior to pipe fabrication, with pipe lengths, hanger locations, hydraulic reference points, and data required by NFPA 13-2013, minimum 1/4" = 1' - 0" scale.

1.10 EQUIPMENT AND INSTALLATION REQUIREMENTS

A. Equipment and materials shall, unless otherwise specified herein, be new and shall be of the customary standard and quality furnished by the designated manufacturer for that catalogue number.

B. Materials and equipment shall be UL listed, and shall bear the UL listing mark on products for which standards have been established and for which listing is regularly furnished by UL.

1. In lieu of the UL listing, or where standards have not been established by UL and UL listing is not regularly furnished, materials and equipment shall be listed by a laboratory recognized under the OSHA Nationally Recognized Testing Laboratory Program or by a laboratory accredited by International Accreditation Service. Examples include:

a. Canadian Standard Association.
b. ETL Testing Laboratories, Inc.
c. MET Electrical Testing Company, Inc.

PART 2 - PRODUCTS

2.1 HANGERS AND SUPPORTS

A. Hangers:

1. General: complete with rods and supports proportioned to the size of piping or equipment to be supported.
2. For steel sprinkler and standpipe piping 4" and smaller: galvanized steel, flat band type; Anvil 69, B-Line B3170 NF, or ERICO 115.

3. For steel sprinkler and standpipe piping larger than 4": galvanized steel, clevis type; Anvil 260, B-Line B3100, or ERICO 401.

B. Hanger Rods:

1. One-piece steel type, threaded as required.
2. Sizes, unless specified otherwise herein, shall be as follows:

Pipe Size	Rod Diameter
2" and smaller	0.375"
2.5" and 3"	0.5"
4"	0.625"
6"	0.75"
8" and larger	0.875"

3. Sizes for gang or multiple hangers: calculated for the combined weight of the piping and accessories.
4. Sizes for equipment hangers: calculated for the weight of the equipment supported.
5. Sizes for sprinkler piping: in accordance with NFPA 13-2013.

C. Inserts:

1. Adjustable type: Anvil 282, B-Line B3014, or ERICO 355.
2. Continuous type: Anvil PS-5000, B-Line B32I, or ERICO CON.

D. Expansion Anchors:

1. In concrete: wedge, self-drilling, or drilled flush type.
2. In masonry: sleeve type.
3. Manufacturer: Hilti, ITW Ramset/Red Head, or Rawl.

E. Clamps for piping in bar joist construction: Anvil 92 or 93, B-Line B3031 or B3033, or ERICO 300.

F. Channel strut systems: 14 gauge minimum galvanized steel, with factory-punched attachment holes. Straps shall be designed so that the attachment nut is captive on the shoulder of the strap when tightened. Attachment nuts shall be designed to provide a surface on the turned down edge while making positive contact with the side walls of the channel. Nuts, bolts, straps, and accessories shall be protected with same finish as channels.

1. Manufacturer: B-Line, Kindorf, Midland-Ross, or Unistrut.

G. Pipe Stand Supports:

1. For fire suppression water piping: adjustable pipe saddles, stanchion type with locknut nipple, reducer, flange and baseplate. Provide U-bolt yoke for pipe 12" and smaller.

a. Manufacturer: Anvil 264, B-Line B3093, or ERICO 723.

2.2 VALVE TAGS

A. Minimum 19 gauge polished brass, 1.5" minimum size. Tags shall be octagonal. Stamped numbers and letters shall be not less than 0.75" high, and filled with black paint.

2.3 IDENTIFICATION MATERIALS

A. Pipe identification shall be 5 mil thick, self-adhering vinyl plastic tape. Tape and legend shall be as follows:

Diameter (Including Insulation)	Width	Size of Legend Letters
0.75 - 1.25"	8"	0.5"
1.5 - 2"	8"	0.75"
2.5 - 6"	12"	1.25"
8 - 10"	24"	2.5"
Over 10"	32"	3.5"

1. Legends shall be in full or abbreviated form, in contrasting color to background color.

B. Nameplates and signs: laminated plastic, engraved with white letters. Background color shall be:

System	Color
Equipment served by emergency power	Red
Fire suppression systems	Red

2.4 SLEEVES

A. Sleeves shall be standard weight steel pipe except sleeves for concealed piping through floors not in structural members, and through interior drywall construction may be formed from 26 gauge galvanized sheet metal lapped and pop riveted.

2.5 PENETRATION SEALS

A. Firestops:

1. Refer to Section 07 84 00, Fire Stopping.

A. Expansion Seals:

1. Waterproof, modular, mechanical expansion type consisting of synthetic rubber grommets or interlocking links shaped to continuously fill the annular space between the penetrating item and the opening. Sizing of links and sleeve shall be determined by the manufacturer.
2. Manufacturer: Calpico Pipe Linx, Metraflex MetraSeal, or Thunderline Link Seal.

2.6 SEISMIC RESTRAINTS

A. Seismic force design shall be determined in accordance with the following seismic design criteria:

1. Seismic Design Category: A. B. C. D. E. F.
2. Risk Category: I. II. III. IV.
3. Component Importance Factor, I_P: 1.5.

B. Provide restraint devices as required for fire suppression components. Provide calculations to determine restraint loadings for specific components to be installed resulting from seismic forces on components. Seismic restraint calculations shall be signed by a licensed engineer in the employ of the seismic restraint device manufacturer.

C. Exceptions for fire suppression components listed within the applicable project building code may be utilized. However, use of exceptions shall be noted with submitted seismic restraint calculations.

D. Suspended Restraints:

1. Restraints for suspended equipment and components shall consist of steel angle or unistrut with anchor bolts and end connection fittings designed to swivel to the final installation angle.
2. Manufacturer: B-Line, International Seismic Application Technology, Kinetics Noise Control, Mason Industries, Tolco, VMC Group, Vibration Eliminator, or Vibro-Acoustics.

2.7 CONCRETE

A. Normal weight concrete (145 pcf) using Type I Portland Cement, 1" maximum size coarse aggregate to provide a minimum 28 day compressive strength of 3000 psi.

2.8 GROUT

A. Nonshrink type, conforming to ASTM C1107/C1107M-2017 when tested at fluid consistency. Grout shall exhibit zero bleeding at every age when mixed to fluid consistency. Minimum 28 day compressive strength, when mixed to fluid consistency, shall be 7000 psi.

B. Manufacturer: Cormix, or Master Builders.

2.9 ACCESS PANELS - BUILDING

A. Refer to Section 083100, Access Door and Panel.

2.10 ESCUTCHEONS

A. Split hinged type, constructed of chromium-plated steel or cast brass, sized to cover sleeve.

2.11 UNDERGROUND WARNING TAPE

A. Tape shall be acid and alkali resistant polyethylene film tape, 6" wide with minimum thickness of 0.004", specifically designed for marking and locating of underground utilities.

B. Tape shall be manufactured with integral wires, foil backing or other means to enable detection by a metal detector when the tape is buried up to 3' deep. The metallic core of the tape shall be encased in a protective jacket or provided with other means of corrosion protection.

C. Tape color shall be blue and shall bear a continuous printed inscription describing the specific utility.

D. Manufacturer: Brady, Boddingtons, Carlton Industries, Seton, or Thor Enterprises.

2.12 PAINTING

A. Paint shall be designed for the temperatures at which the system will operate.

PART 3 - EXECUTION

3.1 PROTECTION OF EQUIPMENT AND MATERIALS DURING CONSTRUCTION

A. Provide protective covers, skids, plugs or caps to protect equipment and materials from damage or deterioration during construction.

B. Store equipment and material under cover, and off the ground or floors exposed to rain.

C. For outdoor storage, protective covers of 10 mil thick black sheet plastic shall be fitted over equipment and materials. Covers shall be reinforced to withstand wind and precipitation. Set equipment and material on skids or platforms of height to avoid damage or deterioration from spattering and ground water.

D. Plug ends of pipes when work is stopped to prevent debris from entering the pipes.

E. Provide dust and debris protection for equipment, motors, and bearings operated during construction up to date of substantial completion.

3.2 EXISTING EQUIPMENT AND SYSTEMS

A. The existing installation shall remain as is except as otherwise indicated on the Drawings or specified herein. Connect the new work with the existing work and adapt the existing work to the changes in the building and systems.

B. Coordinate the installation of new piping and other equipment with existing equipment which is to remain operational to avoid conflict with operating performance and working clearances.

C. Remove exposed piping rendered useless due to changes. Plug outlets in piping.

D. Relocate concealed piping which is exposed by the removal of walls and reconnect.

E. Sleeves left open by removal of piping shall be cut flush with the finished slab, and filled with grout flush with both sides of slab.

F. Material and equipment which has been removed and not accepted by the Owner shall become the property of the Contractor and shall be removed from the site.

G. Material and equipment which has been removed shall not be used in the new work, except as specified herein.

H. Where existing piping and equipment is indicated on the Drawings, its size and location shall be verified.

3.3 EQUIPMENT AND INSTALLATION REQUIREMENTS

A. Equipment shall be installed and connected as specified herein or indicated on the Drawings in accordance with the manufacturers' instructions and recommendations for this Project. Furnish and install auxiliary piping, water seals, valves, and electrical connections recommended by the manufacturer for operation.

B. Motor quantities, sizes and equipment wattage ratings specified herein or indicated on the Drawings are the minimum requirements, unless noted otherwise. Motor quantities, sizes and equipment wattage ratings less than those specified herein or indicated on the Drawings are not acceptable. Larger motor sizes and equipment wattage ratings may only be provided if necessary to meet the prescriptive requirements specified herein or indicated on the Drawings. Where multiple motors or motor sizes or equipment wattage ratings larger than specified herein or indicated on the Drawings are furnished, provide and coordinate the corresponding increased number or capacity of feeders and other electrical equipment serving them, at no additional cost to the Owner.

C. Motors and pumps shall be statically and dynamically balanced and shall have steady state radial vibration levels which do not exceed the following:

Equipment	Peak-to-Peak Displacement (mil)
Pumps and motors	
over 1800 rpm	1
under 1800 rpm	2

D. Field-installed equipment controls or sensor wiring shall be installed in conduit. Low voltage control and sensor wiring shall be installed in conduits separate from line voltage control wiring and power wiring.

E. Where water connection sizes at equipment vary from the pipe size indicated on the Drawings, provide appropriate reducers/increasers directly adjacent to the pipe-equipment unions. Unless otherwise specified herein or indicated on the Drawings, the size of the valves and accessories dedicated to the equipment shall not be less than the pipe size to which they are connected.

3.4 HANGERS AND SUPPORTS

A. Hangers for piping shall be spaced according to NFPA 13-2013.

B. Where several pipes run parallel and in the same plane:

1. 2.5" and smaller: may be supported on gang or multiple hangers. Separate copper tubing from ferrous supports with copper-plated steel or 4 psf sheet lead.
2. 3" and larger: support independently, parallel, and equally spaced.

C. Supports for steel pipe and for copper tubing, except standpipe piping, 1.25" or larger, shall not be more than 10' apart.

D. Support piping independently of equipment.

E. Adjust hangers and supports so that loading is uniform.

F. Hanger rods shall be suspended from the structure. Do not suspend from other piping, or equipment.

G. Inserts:

1. Use for piping 2.5" and larger in new concrete construction.
2. Where the weight to be supported by an insert exceeds 50% of its rated load, install 2 No. 3 reinforcing rods, 3' long through each yoke of insert.

H. Expansion Anchors:

1. Use for piping in existing concrete and masonry construction.
2. Use for piping 2" and smaller in new concrete construction.

I. Where indicated on the Drawings, support piping on pipe stand supports. At the base of each support, weld a slip-on flange to the vertical stanchion. Place stanchion and flange on top of a baseplate, welding the flange to the baseplate. Anchor baseplates to foundations. Provide schedule 40 pipe to increase stanchion height as required by field conditions.

J. Where fire suppression systems are seismically braced, provide listed restraining straps for C-type clamps used to attach piping hangers to the building structure.

3.5 SLEEVES

A. Provide where pipes pass through walls, floors and roofs, except in the following circumstances:

1. Concealed wall openings of the required diameter in non fire- or smoke-rated construction.
2. Concealed floor openings formed by the use of plastic forming devices providing a circular opening of the required diameter.
3. Core drilled concealed openings. Openings in roofs shall not be core drilled. Obtain written permission prior to core drilling.
4. Openings in concrete floor slabs on grade.

B. Sleeves shall be placed into position prior to wall, floor, or roof construction. Sleeves shall be tight-fitting and cut smooth.

C. Floor sleeves shall be cast in place, shall be watertight, and shall extend from the bottom of the slab to 2" above the finished floor.

D. Wall sleeves shall extend 1" on each side of walls.

E. Make sleeves through outside walls above and below grade watertight.

F. Sleeves in nonrated construction shall be sized to provide clearance all around pipe, to accommodate thermal movement. Clearance shall be minimum 0.75".

G. Furnish 4 psf lead flashing for sleeves through flat built-up roofs extending at least 8" from the sleeve in all directions.

H. Where fire suppression systems are seismically braced, sleeves and clearances for all fire suppression piping shall be sized in accordance with the earthquake protection requirements of NFPA 13-2013.

3.6 PENETRATION SEALS

A. General:

1. Install in accordance with the manufacturer's published instructions to achieve ratings and classifications specified herein. A copy of these instructions shall be maintained and available on site.

B. Expansion Seals:

1. Use expansion seals between pipes and sleeves. Where walls exceed the width of expansion seals, use two seals, one being flush with the inside sleeve face and the second with the outside sleeve face. Fill the annular void space between the two seals.

3.7 IDENTIFICATION OF PIPING

A. Identify piping specified under this Division in accordance with ASME A13.1-2015.

B. Legends shall be on the lower quarters of the pipe except where such location would be obscured. Arrow tape shall be wrapped completely around the pipe at each end of the legend with arrows pointing in the direction of flow.

C. Locate pipe identification as follows:

1. Mechanical equipment rooms:

a. Within 18" of each valve or valve assembly.
b. Within 36" of each 90º elbow, connection to equipment, point where pipe enters shafts and pierces outside walls.
c. On not over 20' intervals along exposed piping.

2. Above suspended ceilings: and below raised floors:

a. Within 18" of each valve or valve assembly.
b. At tees within 36" of both main and branch.
c. Within 36" of each 90º elbow.
d. On not over 20' intervals.

3. Piping concealed in chases or shafts:

a. Each pipe visible through an access door or panel.

4. Piping exposed in rooms other than mechanical equipment areas:

a. Omit identification of sprinkler piping.
b. With the above exception, identify at not less than 1 point each piping run visible in each room with identification on not over 20' intervals.

D. Schedule of Piping Identification:

Piping System and Contents	Tape Color	Legend	Abbreviated Legend

Fire Suppression	Red	Fire Line	Fire

E. Piping with temperature maintenance cable shall be labeled Electronically Traced on the outside of the insulation jacket.

3.8 VALVE TAGS AND SCHEDULES

A. Provide numbered brass tags on valves. Attach tags to valve stems with brass S-hooks or brass chain.

B. Tags on new valves shall continue the numbering sequence of existing valves.

C. Provide for each system a typewritten schedule of valves giving number, location (room number), and function of each with a small scale diagram outlining general piping layout and location of each numbered valves.

3.9 IDENTIFICATION OF EQUIPMENT

A. General:

1. Identification shall consist of upper case letters.
2. Each starter, contactor, push button station, control switch, disconnect, and thermal overload switch shall be appropriately identified by nameplates with 0.25" high letters.

    a. Identification shall include the equipment designation and device function, e.g., FPC-1 Fire Pump Controller.

3.10 EQUIPMENT AND EQUIPMENT ROOMS

A. Remove dust, dirt, rust, stains, and temporary covers.

B. Foreign matter shall be blown, vacuumed, flushed, or cleaned out of and from new equipment, piping, pumps, motors, bearings, devices, switches, controls, and panels.

C. Clean and polish identification plates.

D. In equipment rooms, clean equipment, piping, conduit, and room surfaces from dust and dirt and maintain in a clean condition from date of substantial completion until final completion of work and corrective work.

E. Remove excess material from the Project site.

3.11 SEISMIC RESTRAINTS

A. Restraints shall be installed after the equipment is mounted, piped, connected, and operating to ensure that no contact occurs during normal equipment operation.

B. Installation of seismic restraints shall not cause any change of position of equipment or components resulting in stress and misalignment.

C. Do not brace a system to two different structures, such as a wall and a ceiling.

D. After installation, manufacturer shall verify that seismic restraints are installed and operating properly, and shall submit a certificate so stating.

3.12 FOUNDATIONS

A. Provide concrete foundations for the following floor-mounted equipment:

Fire Suppression Equipment	Foundation
Fire pumps	4" high pad
Jockey pumps	4" high pad
Air compressors	4" high pad

1. Foundation height shall accommodate seismic anchors, but shall be not less than the minimum specified above.

B. Foundations shall be continuous and shall have beveled edges and smooth float finish. Foundations shall be reinforced with No. 3 bars a maximum of 12" on center each way, and held in place with dowel rods at each corner anchored in the slab. Dowel rods shall not penetrate through the slab.

C. Roughen and clean exposed slabs before pouring foundations. Apply bonding agent to surfaces in contact.

D. Foundations shall extend a minimum of 6" beyond the equipment footprint or 1.5 times seismic anchor embedment depth from the point of anchoring (whichever is larger) in all directions, including appurtenances, base elbow supports, and motors.

E. Equipment attached directly to foundations; bases provided with grout holes; and bases consisting of a structural frame shall have voids filled with grout after attachment to foundation.

F. Fill voids between baseplates and foundations, and level equipment, with grout.

3.13 ACCESS PANELS - BUILDING

A. Where fire suppression work is concealed by walls or ceilings, or is inaccessible, provide an access panel to provide access for service and maintenance.

B. Fire suppression work located above ceilings is considered accessible if the ceiling is the accessible type and is arranged for access to the equipment.

C. Fire-rated access panels shall be provided in fire barriers with ratings to match the construction fire rating.

D. Installation of access panels is specified under another Division.

3.14 ESCUTCHEONS

A. Provide escutcheons where exposed piping passes through walls, floors and ceilings in finished areas.

3.15 UNDERGROUND WARNING TAPE

A. During backfill, install tape continuously along length of piping, 12" to 18" above the fire suppression piping.

3.16 PAINTING

A. Except where otherwise specified herein, painting shall be done under another Division. Surfaces shall be left clean and free from oil.

B. Equipment factory finishes damaged or deteriorated during construction shall be repaired to match original finish.

C. Where galvanizing is broken during fabrication or installation, recoat exposed areas with zinc-rich paint.

D. Exterior ferrous equipment, piping and supports shall be painted with 2 coats of rust preventive paint, color selected by the Architect.

E. Exposed interior uninsulated black steel piping, and exposed nongalvanized ferrous accessories, hangers, rods, inserts, and mechanical supports shall be prepared and painted with 1 coat of rust preventive paint prior to other painting or identification, or 2 coats of rust preventive paint if no other painting is specified.

F. Conduits and pipe visible through architectural return air openings, grilles, registers and diffusers shall be painted flat black.

3.17 EXCAVATION AND BACKFILLING

A. Install underground piping outside the building with 36" minimum cover, unless specified otherwise herein.

B. Determine exact location of existing underground utilities before excavation.

C. Excavations shall be no longer or deeper than necessary. Backfill material shall be free from rocks and debris.

D. Compact backfill as the excavation is filled.

E. Excavation, shoring, bracing, backfilling, and compaction, cutting and patching of hardscape, and restoration of landscape shall conform to Division 31, Earthwork.

3.18 COORDINATION

A. Provide offsets, transitions, and fittings to coordinate the work of each trade with that of other trades, including HVAC, plumbing, fire protection, electrical, structural, and architectural.

3.19 OPERATION AND MAINTENANCE MANUALS

A. These operation and maintenance manual requirements supplement operation and maintenance manual documentation requirements of other Sections of these specifications.

B. Operation and maintenance documentation, in hardback 3-ring loose-leaf binders except full size drawings and diskettes, shall cover the fire suppression systems. Documentation shall include an operation and maintenance documentation directory, emergency information, operation manual, maintenance manual, test reports, and construction documents.

C. The operation and maintenance documentation package shall be submitted as one comprehensive package to the Architect 3 months before systems start-up, and shall be updated, revised and completed at completion of, construction.

D. Compile and coordinate the documentation for equipment and systems installed. Documentation shall be typewritten and shall contain, at a minimum, the following information.

1. Introduction:

    a. Project name, contractors' and subcontractors' names, addresses, and telephone and facsimile numbers.
    b. Index.

2. Operation and Maintenance Documentation Directory:

    a. Explanation of the identification system used, including lists of systems, equipment, and component identifiers and names.

3. Emergency Information:

    a. Information for technical and nontechnical personnel about actions recommended during emergency situations to protect life and property and to minimize disruption to the building occupants. Emergencies shall, at a minimum, include:

        1) Fire.
        2) Security breach.
        3) Water outage.
        4) Power failure.

4. Operation Manual:

    a. General Information:

        1) Building function.
        2) Building description.
        3) Operating standards and logs.

    b. Technical Information:

        1) System description.
        2) Operating routines and procedures.
        3) Special procedures.
        4) Basic troubleshooting.

5. Maintenance Manual:

    a. Descriptions (specifications) of the equipment and components.
    b. Description of function, as applicable: the function of the equipment, procedures before start-up, functional parameters (input, output) at the design load and at part loads, and performance verification procedures.
    c. Recommended maintenance and lubrication procedures and their recommended frequency for this Project.
    d. Recommended list of spare parts, part numbers, and the place(s) from which they can be obtained.
    e. Original purchase order number; date of purchase; name, address, and the telephone number of the vendor; and warranty information.
    f. Installation information.
    g. Other information needed for the preparation of documents supporting the management of operation and maintenance programs.

6. Test Reports and Certifications:

    a. Copies of tests and certifications performed during manufacture and construction, including but not limited to the following:

        1) Receipt for instruction of operating personnel.
        2) Certification of seismic restraints.
        3) Contractor's Material and Test Certificate for Underground Piping per NFPA 24-2013.
        4) Contractor's Material and Test Certificate for Aboveground Piping per NFPA 13-2013.
        5) Manufacturer's certified fire pump shop test curve.
        6) Fire pump acceptance test report.
        7) Certification that pressure restricting and pressure reducing equipment is installed and adjusted per NFPA and manufacturers' requirements.

7. Construction Documents:

    a. Record drawings.
    b. Approved submittals, including revised shop drawings indicating as-installed conditions.
    c. One copy of shop drawings bearing insurance company approval stamps.
    d. Equipment identification charts and schedules.
    e. Warranty certificates.
    f. Inspection certificates.
    g. Performance verification report.

E. Submit a receipt signed by the Owner acknowledging receipt of the operation and maintenance documentation package.

F. Provide metal cabinets mounted on the wall of the _____ to house the operation and maintenance documentation package. Cabinets shall be approximately 12" wide x 18" high x 6" deep constructed of 18 gauge sheet metal with hinged door with latch. Cabinets shall be painted black and shall be labeled with 0.5" stenciled letters.

3.20 RECORD DRAWINGS

A. Refer to Section _____, _____.

B. A record of field and as-installed conditions shall be maintained at the site, shall be kept current throughout the Project, and shall be used in the preparation of the final record drawings. Field and as-installed conditions shall be recorded on design drawings and shall be marked to include addenda, change orders, field changes and selections made during construction.

C. Upon completion of the Project, submit marked-up design drawings indicating field and as-installed conditions, and shop drawings incorporating changes made during construction for piping and equipment. Submit the following:

1. _____ sets of bound prints.
2. Full size PDFs on CDs.

3.21 MAINTENANCE

A. Equipment operated prior to the date of substantial completion shall be maintained in accordance with manufacturer's recommendations.

B. Prepare and submit a lubrication chart listing for each piece of equipment:

1. Points requiring lubrication.
2. Recommendations for a single manufacturer's lubricants with brand name and designation.
3. Frequency of lubrication required.

C. Lubricate each item of apparatus requiring lubrication prior to start-up in accordance with the manufacturer's recommendations.

3.22 INSTRUCTION OF OPERATING PERSONNEL

A. Provide the designated Owner's personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of equipment specified in Division 21. Conduct 2 formal instruction sessions for operating personnel. The first session shall be conducted at the time of start-up and check-out, and the second session shall be approximately 2 months later. Sessions shall be a minimum of 2 days for basic systems, and as specified herein. Sessions shall be conducted at the site.

B. Prepare and submit a syllabus describing an overview of the proposed training program, describing how the training program will be conducted, when and where meetings are to be held, names and company affiliations of lecturers, description of contents and outline for each lecture, and recommended reference material and outside reading. Obtain direction from the Architect on which operating personnel shall be instructed in each system. Proposed training schedules, materials, and lesson plans shall be submitted to the Owner for review of the content and adequacy of the training of the Owner's personnel.

C. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor, or manufacturer’s representative. More than one party may be required

to execute the training. The training program shall include the following, as appropriate for the system or equipment:

1. Training shall normally start with classroom sessions followed by hands-on training for each piece of equipment, which shall illustrate the various modes of operation, including start-up, shutdown, fire/smoke alarm modes, and power failure.
2. During any demonstration, should the system fail to perform in accordance with the requirements of the operation and maintenance manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
3. Attend training sessions for each type of equipment or system controlled by the automation system, to discuss the interaction of the automation system as it relates to the equipment or system, in addition to the training required for the automation system.
4. Training shall include:

    a. Use of the printed installation, operation and maintenance instruction material included in the operation and maintenance manuals.
    b. A review of the written operation and maintenance instructions emphasizing safe and proper operating requirements, preventative and routine maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover, and any emergency procedures.
    c. Discussion of relevant health and safety issues and concerns.
    d. Discussion of warranties and guarantees.
    e. Common troubleshooting problems and solutions.
    f. Explanatory information included in the operation and maintenance manuals and the location of plans and manuals in the facility.
    g. Discussion of any peculiarities of equipment installation or operation.
    h. Classroom sessions shall include the use of multimedia instruction material as appropriate.

5. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance for all pieces of equipment.
6. Explain and demonstrate the operation, function and overrides of local packaged controls not controlled by the central control system.
7. Training shall occur after testing is complete, unless approved otherwise by the Architect.
8. Provide DVD format video recordings of training sessions and a complete record copy of training materials, handouts, and other printed materials used in each training session.
9. Obtain a receipt acknowledging completion of each item of instruction.

END OF SECTION 210010

COVER SHEET FOR

SUBMITTALS TO NEWCOMB & BOYD

Project: _____ Date: _____

Item: _____ Submittal Number: _____

Manufacturer: _____ Model: _____

Specification Paragraph and/or Drawing Number: _____

Capacity: _____

Electrical Characteristics (including identification of all separate connections or services required): _____

_____

_____

_____

Accessories: _____

_____

_____

_____

Options: _____

_____

_____

_____

Deviations (if any; if none, state so): _____

_____

General Contractor Approval: _____

SECTION 210090 - FIRE SUPPRESSION PERFORMANCE VERIFICATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other fire suppression systems are specified in other Sections of Division 21.

B. Performance verification is an ongoing process and shall be performed throughout construction. Performance verification verifies that systems are operating in a manner consistent with the Construction Documents.

C. This Section covers fire suppression systems performance verification, as required to demonstrate that the equipment and systems of Division 21 are ready for safe and satisfactory operation, as defined by the Construction Documents. Performance verification shall include, but shall not be limited to, identification of piping and equipment, cleaning, lubrication, start-up, check-out, and testing, adjusting, and balancing of systems, preparation of equipment and systems documentation and of operation and maintenance manuals, Owner training, and preparation of record drawings.

D. Performance verification shall conclude with the completion of required deferred testing, training, and system documentation as specified herein and required to demonstrate the proper operation of the fire suppression equipment and systems provided by this Division.

E. Verify, at a minimum, the performance of the following systems and equipment and witness the following tests:

1. Section 210010, Fire Suppression General:

    a. Seismic restraints.

2. Section 213000, Fire Suppression Systems:

    a. Aboveground pipe.
    b. Air compressors.
    c. Alarm and supervisory devices.
    d. Deluge valves.
    e. Dry pipe valves.
    f. Fire pump suction control valves.
    g. Fire pumps and controller.
    h. Underground pipe.

1.2 QUALITY ASSURANCE

A. Provide a Fire Suppression Performance Verification Supervisor with ten years experience in fire suppression contracting. The Fire Suppression Performance Verification Supervisor shall become familiar with the Owner's project requirements and the requirements of the performance

verification process as defined in this Section. The Fire Suppression Performance Verification Supervisor shall coordinate and execute the required performance verification activities.

B. The Fire Suppression Performance Verification Supervisor shall review submittal data for conformance with the requirements of the Project, shall monitor compliance with the requirements specified herein for storage and protection of equipment during construction, shall authorize the initial starting of equipment and systems in a manner to avoid damage to equipment, shall oversee start-up, testing and balancing, and shall document that the scheduled and specified performance requirements of each system have been accomplished.

C. Refer to ASHRAE Guideline 0.2-2015, Commissioning Process for Existing Systems & Assemblies, and Guideline 4-2008 (RA 2013), Preparation of Operating and Maintenance Documentation for Building Systems.

1.3 PERFORMANCE VERIFICATION RESPONSIBILITIES

A. The Fire Suppression Performance Verification Supervisor shall be responsible for scheduling, supervising, and coordinating and executing the start-up, testing, and performance verification activities as specified herein. Include and itemize the cost of performance verification in the contract price, and in each purchase order or subcontract written, include requirements for submittal data, performance verification efforts and documentation, operation and maintenance data, and training as specified herein.

B. Fire suppression performance verification shall take place in three phases. Performance verification requirements for each phase are as follows:

1. Construction Phase:

a. Attend a performance verification scoping meeting and additional such meetings, initially scheduled monthly until prefunctional testing of equipment and systems begins, and weekly thereafter during the construction phase to facilitate the performance verification process. The Fire Suppression Performance Verification Supervisor shall coordinate meeting attendance.
b. Report in writing to the Architect, at least as often as performance verification meetings are scheduled, concerning the status of fire suppression activities as they affect the performance verification process, the status of each discrepancy identified the prefunctional and functional testing process, explanations of any disagreements with the identified deficiencies, and the proposed resolution and schedule for correction of the deficiency.
c. Provide documentation of installed systems and equipment, and develop functional testing procedures. This documentation shall include detailed manufacturer installation, start-up, operating, troubleshooting and maintenance procedures; full details of any Owner-contracted tests; pump curves; full factory testing reports, if any; and full warranty information, including responsibilities of the Owner to keep the warranty in force. In addition, the installation, start-up and check-out materials that are actually shipped inside the equipment and the actual field check-out sheet forms to be used by the factory or field technicians shall be submitted to the Architect.
d. Develop and submit to the Architect for review and comment, prior to equipment or system start-up, a complete start-up and initial check-out plan using manufacturer's

start-up procedures and prefunctional checklists for the performance of the equipment to be verified.

e. Assist in clarifying the proposed operation and control of equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
f. Prepare the specific functional test procedures as specified herein and review the proposed functional test procedures to ensure feasibility, safety, and equipment protection, and provide necessary written alarm limits to be used during the tests. Obtain Architect approval for proposed functional test procedures.
g. Prepare a preliminary schedule for performance verification activities, including pipe pressure and leakage testing, flushing and cleaning, equipment start-up, and testing and adjusting start and completion, and update the schedule during the construction period, as appropriate. Notify the Architect immediately when the performance verification activities not yet performed or not yet scheduled will delay construction.
h. Fire suppression equipment start-up shall not be initiated until completion of pressure and leakage testing and cleaning as specified in other Sections of Division 21.
i. Provide start-up and prefunctional testing for equipment, and execute the fire suppression-related portions of the prefunctional checklists for the verification of the performance of all the equipment during the start-up and initial check-out process.
j. Perform and document start-up and system operational check-out procedures, providing a copy to the Architect.
k. Correct noncompliance items before beginning functional performance testing.

2. Acceptance Phase:

a. Place equipment and systems into operation and continue their operation during each working day of the testing and performance verification activities, as required.
b. For each system or area, have required prefunctional checklists, calibrations, start-up and prefunctional tests of the fire suppression systems and associated controls completed prior to beginning the testing and adjusting process.
c. Provide skilled technicians to execute starting and prefunctional testing of equipment and to execute the functional tests for each individual piece of equipment and system. Technicians shall be available and present during the agreed upon scheduled tests and for sufficient duration to complete the necessary tests, adjustments and problem-solving.
d. Perform functional testing for specified equipment and interpret the test data, as necessary.
e. Correct deficiencies (differences between specified and observed performance) as identified by the Fire Suppression Performance Verification Supervisor. and interpreted by the Architect and retest the equipment, as required to demonstrate proper operation and performance.
f. Prepare operation and maintenance manuals as specified herein, including clarifying and updating the original sequences of operation to as-built conditions.
g. Maintain marked-up record drawings and produce final record drawings of Project drawings and contractor-generated coordination drawings.
h. Provide specified training of the Owner’s operating personnel.
i. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

3. Warranty Period:

    a. Execute deferred functional testing.
    b. Correct deficiencies and make necessary adjustments to operations and maintenance manuals and as-built drawings system or equipment modifications made during the warranty period and those identified in any deferred functional performance testing.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Standard testing equipment required to perform start-up, initial check-out, prefunctional, and required functional testing shall be provided for the equipment or system being tested.

B. Test equipment shall be of the quality and accuracy required to test and/or measure system performance with the tolerances specified and shall have been calibrated within the last 12 months, or as specified herein. Equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates available on request.

1. Temperature sensors and digital thermometers shall have a certified calibration within the past 12 months and a resolution of ±0.1°F. Accuracy of temperature test equipment shall be at least twice that of the instrumentation being tested.
2. Pressure sensors shall have a certified calibration within the 12 months and a resolution of 0.05% of sensor range. Accuracy of pressure test equipment shall be at least twice that of the instrumentation being tested.
3. Accuracy of other sensors shall be at least twice that of the instrumentation being tested.

PART 3 - EXECUTION

3.1 SUBMITTALS

A. Submit additional documentation as required to support the performance verification process. This additional submittal documentation shall include, at a minimum, the proposed start-up and initial check-out procedures, and prefunctional checklists.

3.2 START-UP PLAN AND PREFUNCTIONAL TESTING

A. Prefunctional testing shall be required for each piece of equipment to ensure that the equipment and systems are properly installed and ready for operation, so that functional testing may proceed without delays. Follow the approved start-up, initial check-out, and prefunctional testing procedures. Sampling strategies shall not be used for prefunctional testing. The prefunctional testing for equipment and subsystems of a given system shall be successfully completed and documented prior to functional testing of the system.

B. Procedures for performance verification shall include:

1. Start-up and initial check-out plan: develop the detailed start-up and prefunctional testing plans for equipment and systems that are to be performance verified, as specified herein.

Review the proposed procedures and prefunctional testing documentation to ensure that there is written documentation that each of the manufacturer-recommended procedures have been completed.

2. The start-up and initial check-out plan shall consist, as a minimum, of the following:

   a. The manufacturer's standard written start-up and check-out procedures copied from the installation manuals and manufacturer's normally used field check-out sheets. The plan shall include checklists and procedures with specific boxes or lines for recording and documenting the checking and inspections of each procedure and a summary statement with a signature block at the end of the plan.

   b. First-run checklist for equipment, including:

      1) Equipment properly set.

      2) Alignment of shafts and couplings.

      3) Piping and equipment properly connected.

      4) Completion of initial lubrication procedures.

      5) Wiring properly connected.

      6) Electrical overload relays appropriate for load.

      7) Electrical accessories properly installed and adjusted.

      8) Controls, safeties, and time switches properly set.

      9) Verification of direction of motor rotation after final electrical connections by jogging motor.

      10) Measurement of ampere draw of electric motors and comparison with nameplate rating and with overload heater ratings.

      11) Monitoring of temperature build-up in motors and bearings.

   c. Contractor-developed prefunctional checklists.

3. Identify which trade is responsible for executing and documenting each of the line item tasks and note that trade on the form. Each form may have more than one trade responsible for its execution.

C. Four weeks prior to start-up, schedule equipment and systems start-up and check-out and notify the Architect in writing. The execution of the prefunctional checklists, start-up and check-out shall be directed and performed by the Contractor, in accordance with manufacturer's published procedures. The Architect shall be present for the start-up, check-out, and prefunctional testing of the first unit of each type of equipment, and any other tests he designates.

D. Sensor calibration: calibration of sensors associated with a given piece of equipment or system shall be included as part of the prefunctional testing and listed on the appropriate test checklists and reports for the system.

E. Completed start-up, check-out, and prefunctional test forms shall be completed and submitted to the Architect for review. List outstanding items of the initial start-up and prefunctional procedures that were not completed successfully, at the bottom of the procedures form or on an attached sheet. The procedures form and any outstanding deficiencies shall be provided to the Architect within 2 days of test completion. The Architect shall review the Contractor's start-up and prefunctional testing reports and shall submit either a noncompliance report or an approval form to the Contractor. The Contractor shall correct items that are deficient or incomplete in the checklists and tests in a timely manner, and shall notify the Architect as soon as outstanding items have been corrected and resubmit an updated start-up report and a statement of correction on the original noncompliance report. When requirements are completed, the Architect shall recommend approval of the start-up and prefunctional testing of each system and schedule the functional testing of the equipment or system.

F. Complete start-up and prefunctional testing for a system before functional test of that system may proceed.

3.3 RETESTING OF EQUIPMENT AND/OR SYSTEMS

A. Provide labor and materials required for retesting of any functional test found to be deficient.

B. Prior to retesting, submit required data indicating that the deficient items have been completed and/or corrected to the Architect for approval and rescheduling of the functional test. If during the retesting it becomes apparent that the deficient items have not been completed and/or corrected as indicated in the data provided by the Contractor, the retesting shall be stopped. Costs for the design team to further supervise the retesting of a functional test shall be the responsibility of the Contractor.

3.4 DEFERRED TESTING

A. Schedule and coordinate, with the approval of the Architect, tests delayed until building construction is completed, required building occupancy or loading, or other conditions are suitable for the demonstration of equipment or system's performance, as specified herein. Deferred testing shall be executed, documented, and deficiencies corrected as specified herein for functional testing.

3.5 TESTING DOCUMENTATION, NONCONFORMANCE, AND APPROVALS

A. List outstanding items of the initial start-up and prefunctional procedures that were not completed successfully, at the bottom of the functional test procedure forms or on an attached sheet. The functional test procedure forms and any outstanding deficiencies shall be provided to the Architect within 2 days of test completion. The Architect shall review the Contractor's start-up and prefunctional testing documentation and shall submit either a noncompliance report or an approval form to the Contractor. Work with the Architect to correct and retest deficiencies or uncompleted items. Correct items that are deficient or incomplete in a timely manner, and notify the Architect as soon as outstanding items have been corrected and resubmit an updated start-up

report and a statement of correction on the original noncompliance report. When requirements are completed, schedule the functional testing of the equipment or system.

B. As functional performance testing progresses and deficiencies are identified, work with the Architect to resolve the issues.

3.6 OPERATION AND MAINTENANCE MANUALS

A. The Fire Suppression Performance Verification Supervisor shall compile and prepare documentation for equipment and systems covered in Division 21 and deliver this documentation for inclusion in the operation and maintenance manuals prior to the training of the Owner's personnel.

3.7 INSTRUCTION OF OPERATING PERSONNEL

A. The Fire Suppression Performance Verification Supervisor shall schedule, coordinate and assemble, and deliver the documentation of training required by Division 21.

3.8 FUNCTIONAL TESTS

A. Functional test requirements for the demonstration of proper system and equipment operation shall be defined by the Fire Suppression Performance Verification Supervisor. Execution of these test and demonstration of the required performance shall be the responsibility of the Contractor.

B. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems or subsystems at the discretion of the Fire Suppression Performance Verification Supervisor. Beginning system testing before full completion of construction shall not relieve the Contractor from fully completing the system, including prefunctional checklists.

C. Functional testing shall be completed and test documentation approved by the Architect before the Project will be considered substantially complete.

END OF SECTION 210090

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SECTION 213000 - FIRE SUPPRESSION SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other fire suppression systems are specified in other Sections of Division 21.

B. This Section covers the fire sprinkler and standpipe systems.

C. The building shall be protected by a system of Class I manual wet standpipes and automatic sprinklers as defined by NFPA 13-2013 and NFPA 14-2013.

D. The connection of the new fire service line to existing water mains and the installation of the detector check valve and meter will be performed by _____. Pay charges and fees associated with this connection and meter.

E. This Section includes responsibilities and obligations in support of the performance verification specified in Section 21 00 90, Fire Suppression Performance Verification.

1.2 QUALITY ASSURANCE

A. Products and components installed in the system shall be listed by Underwriters Laboratories (UL) and approved by Factory Mutual Engineering (FM).

B. Fire suppression systems shall be installed by a company regularly engaged in the installation of sprinkler systems and which holds a current sprinkler contractor's license from the State of South Carolina. Submittals shall bear the stamp or the license number of the installing contractor.

C. Unless indicated otherwise on the Drawings, materials shall be new and free from defects.

D. Materials and equipment used for similar applications shall be the products of one manufacturer unless indicated otherwise on the Drawings.

E. Design shall be prepared under the supervision of a NICET Level **IV** technician certified in Fire Protection Engineering Technology Water-Based Systems Layout. Submittals, drawings, and hydraulic calculations shall bear the NICET technician's certification number.

F. Minimum service pressure rating for aboveground pipe, valves, and fittings shall be 175 psig unless otherwise specified herein or indicated on the Drawings.

1.3 BASIS OF DESIGN

A. The design of fire suppression systems shall be based on the following waterflow test conducted at Hydrant 10 on 4/14/18: static pressure, 90 psig; residual pressure, 58 psig; and flow1125 gpm.

B. Hydraulic calculations shall include a minimum safety factor of 10 psig.

C. Water velocity in sprinkler piping shall not exceed 20 fps**.**

D. Drawings and calculations shall show hydraulic reference points from the source to the remote design areas and shall indicate losses for meters and backflow preventers.

E. Sprinkler spacing shall not exceed 225 ft² for Light Hazard areas and 130 ft² for Ordinary Hazard areas.

F. Contractor shall develop coordinated installation drawings and hydraulic calculations including the following:

1. Site plan showing location of water supply, underground water lines and valves, water flow test data, location of test hydrants, and relative elevations.
2. Reflected ceiling plan showing the location, type, and temperature rating of sprinkler heads mounted on the ceiling.
3. Piping plans showing offsets, pipe elevations, sizes, and lengths; hangers types and locations; seismic restraint locations and types; hydraulic calculation reference points; remote area location and density; and the volumetric capacity of dry pipe and preaction systems.
4. Hydraulic calculations shall be performed by a computer calculation program specifically designed for the analysis of fire sprinkler systems. Calculations shall use the area/density method described in NFPA 13-2013.

G. System design densities and remote area of sprinkler operation shall be as indicated on the Drawings.

PART 2 - PRODUCTS

2.1 UNDERGROUND PIPE, FITTINGS AND ACCESSORIES

A. Underground pipe: ductile iron, thickness Class 50 with cement lining and bituminous coating, conforming to AWWA C151-2017. Joints shall be gasketed slip-on type meeting AWWA C111/A21.11-2017.

1. Manufacturer: American, Clow, Griffin, McWayne, or US Pipe.

B. Underground fittings: cement-lined ductile iron with mechanical joint connections. Working pressure shall be 350 psig. Fittings shall comply with AWWA C104/A21.4-2016 and AWWA C153-2011.

1. Manufacturer: American Cast Iron, Clow, or US Pipe.

C. Tie rods and clamps: carbon steel rods with socket clamps, bolts, and washers.

D. Thrust blocks: concrete, poured-in-place. Minimum 2000 psi compressive strength.

E. Underground gate valves: designed for use with an indicator post or roadway box as indicated on the Drawings. Valves shall be nonrising stem gate valves with cast iron body, bronze mountings, and mechanical joint connections. Valves with indicator post shall have an indicator post flange. Valves shall open counterclockwise.

1. Manufacturer: Mueller A-2052, NIBCO M-609, or Stockham G-635.

F. Indicator posts: vertical, adjustable indicator post with cast iron casing, steel operating stem, threaded opening for a position monitor switch, operating wrench, and locking staple. Provide an extension piece to set the indicator post plumb with the top 36" to 40" above finished grade.

1. Manufacturer: Mueller A-20800, NIBCO NIP-1, or Stockham G-951.

G. Roadway boxes: 3-piece, adjustable, cast iron valve box with 5.25" shaft, cover marked "Water", and T-handle operating wrench.

1. Manufacturer: Clow F-2450, Kennedy 121, or Mueller H-10357.

H. Fire hydrants: 3-way, dry barrel, compression type hydrant with cast iron body and bronze mountings, complying with AWWA C502-2014. Hydrant shall have a break-away flange and stem, 6" mechanical joint inlet, 5.25" main valve, one 4.5" hose connection, and two 2.5" hose connections set 180º apart. Hose threads and operating nut shall match the local fire department standard. Provide caps and chains for outlets. Hydrant working pressure shall be 150 psig. Provide a barrel extension to set the hydrant plumb with the break-away flange exposed and 2.5" outlets set 18" above finished grade.

1. Manufacturer: American-Darling B-84-B, Kennedy K-11, or Mueller A-423.

I. Tapping sleeve and valves: cast iron split sleeve with mechanical joints and gaskets on the main and a flanged side outlet. Tapping valve shall be AWWA approved cast iron, bronze-mounted valve with flanged inlet connection and mechanical joint outlet connection. Provide a 3-piece cast iron valve box with cover marked "Water".

2.2 ABOVEGROUND PIPE AND FITTINGS

A. Steel pipe: black steel conforming to ASTM A53/A53M-2012, ASTM A135/A135M-2009 (2014), or ASTM A795/A795M-2013. Use galvanized pipe where indicated on the Drawings or specified herein. Piping 2" and smaller shall be schedule 40. Dry system piping 2.5" and larger shall be schedule 40. Wet system piping 2.5" and larger shall be schedule 10 conforming to NFPA 13-2013.

1. Use galvanized pipe for dry pipe and preaction systems, compressed air trim, drains subject to alternate wetting and drying, and watermotor piping.

B. Cast iron fittings: standard weight fittings shall be UL classified for 175 psig. Fittings shall comply with ASTM A126-2004 (2014). Threaded fittings shall comply with ASME B16.4-2016. Flanged fittings shall comply with ASME B16.1-2015. Gaskets for flanged fittings shall be full-face type of red sheet rubber. Fittings on galvanized piping systems shall be galvanized.

C. Malleable iron fittings: standard weight threaded fittings, UL classified for 300 psig, conforming to ASME B16.3-2016 and ASTM A197/A197-2000 (2015).

D. Welding fittings: UL listed and FM approved class 150 factory-fabricated welded outlets, with foundry mark. No other type of welded outlet shall be used.

1. Manufacturer: Allied, Bonny Forge, or Sprinkler Fittings.

E. Grooved couplings and fittings: grooved mechanical fittings and couplings using an elastomeric gasket enclosed by a split malleable or ductile iron housing. Fittings and couplings on dry piping systems shall be cut-grooved type. Malleable iron shall comply with ASTM A47/A47M-1999 (2014). Ductile iron shall comply with ASTM A536-1984 (2014). Self-grooving couplings and fittings employing set screws or plain end pipe shall not be used. Segment-welded fittings shall not be used. Fittings on galvanized piping systems shall be galvanized.

1. Manufacturer: Central Sprink, Grinnell, or Victaulic.

2.3 VALVES

A. Valve size, working pressure, and the manufacturer's name or trademark shall be permanently affixed to valve bodies. Drain, test and gauge valves are exempt from this requirement.

B. Indicating control valves shall be the OS&Y gate or indicating butterfly type.

C. Valves for service pressure up to and including 175 psig:

1. Gate valves smaller than 2.5" shall be UL listed OS&Y (rising stem) design with bronze body and mountings, and threaded connections.

a. Manufacturer: Kennedy 66, NIBCO T-104-0, or Stockham B133.

2. Gate valves 2.5" and larger for above ground service shall be UL listed OS&Y (rising stem) design with cast iron body, bronze mountings and flange connections. Open counterclockwise.

a. Manufacturer: Kennedy 68, NIBCO F-607-0, or Stockham G634.

3. Indicating butterfly valves: UL listed, FM approved, with cast iron body, bronze mountings, flange or groove connections, integral tamper switch, and handwheel operator.

a. Manufacturer: Grinnell 8000FP, NIBCO 3510, or Pont-A-Mousson JPL.

4. Check valves smaller than 2.5" shall be Y-pattern clapper type with renewable seat and disc, bronze body, and threaded connections. Minimum water working pressure 200 psig.

a. Manufacturer: Kennedy 440, NIBCO T413W, or Stockham B345.

5. Check valves 2.5" and larger shall be UL listed clapper type with cast iron body and bronze mountings, rubber faced disc, flanged connections and bolted access bonnet.

a. Manufacturer: Kennedy 126A, NIBCO 908, or Stockham G940.

6. Trim valves: gate, globe, angle, and check valves used for trim shall have bronze construction and threaded connections, with a minimum 200 psig working pressure.
7. Pressure relief valves: UL listed, field-adjustable type to maintain constant pressure on the discharge side of the fire pump regardless of demand changes by relieving excess system pressure. Working inlet pressure shall be 175 psig maximum. Body shall be cast iron. Valve shall be hydraulically operated, pilot-controlled, diaphragm type. Valves shall reseat driptight within 5% of the pressure setting. Valves shall be sized in accordance with NFPA 20-2013 based on rated fire pump capacity.

a. Manufacturer: CLA-VAL 50B-4KG-1, or Watts 1115F.

2.4 BACKFLOW PREVENTERS

A. UL listed and ASSE approved reduced pressure backflow preventer assembly with two main-line spring loaded check valves, intermediate chamber with relief valve, inlet and outlet OS&Y gate valves with tamper switches, and test cocks. A 0.75" bypass shall include a reduced pressure backflow preventer assembly, inlet and outlet valves, and test cocks.

B. Manufacturer: Ames, Conbraco, Febco, Watts, or Wilkins.

2.5 FIRE PUMPS AND CONTROLLERS

A. The fire and jockey pumps, drivers, controllers, and accessories shall be purchased from a single supplier. The supplier shall conduct two field tests of the fire pump system as specified herein.

B. Fire pumps: UL listed horizontal split case, double-suction, cast iron, bronze-fitted centrifugal type. Maximum allowable shutoff (churn) pressure at no flow shall be 120% of rated pressure.

1. Manufacturer: Allis-Chalmers, Aurora, Fairbanks, or Patterson.

C. Drivers: the pump shall be directly connected through a coupling, with guard, to a horizontal, open dripproof induction motor complying with NFPA 20-2013. Mount pump and motor on a one-piece drip-rim base of fabricated steel.

D. Fittings: provide the following trim and fittings conforming to NFPA 20-2013:

1. Eccentric suction side reducer.
2. Concentric discharge side increaser.
3. Automatic air release valve.
4. Casing relief valve.
5. Suction and discharge pressure gauges with gauge cocks.
6. Pilot-operated pressure relief valve.
7. Discharge cone.
8. Test header.
9. 2.5" straight-way hose valves.

E. Fire pump controllers: UL listed combined motor starter and power transfer switch for automatic start-stop operation and across-the-line wye delta closed-transition starting. Controller shall conform to NFPA 20-2013 and shall include the following features:

1. Heavy gauge steel cabinet with dripproof hood.
2. Front-mounted isolation switch.
3. Controller withstand rating greater than the maximum fault current value at the point of application as indicated on the Electrical Drawings.
4. Magnetic trip type circuit breaker with time delay relay.
5. Pressure switch with individually adjustable high and low setpoints.
6. Adjustable running period timer.
7. Contacts for external circuits to the building fire alarm system for remote alarm of:

a. Pump running.

b. Loss of line power.
c. Phase reversal.
d. Transfer switch on emergency.
e. Emergency isolation switch open.

8. Digital display, readable with the door closed, to indicate line voltages, line currents, and system pressure.
9. Manufacturer: Clark, Firetrol, GE, Hubbell, Master, or Metron.

F. Jockey pumps: multistage, vertical centrifugal type, with cast iron casing, stainless steel impellers and shaft, mechanical seals, and open dripproof induction motor.

1. Manufacturer: Grundfos C series.

G. Jockey pump controllers: combined manual and automatic start-stop controller of same manufacturer as the fire pump controller. Provide manual-off-automatic starter, bourdon tube type pressure switch with adjustable high and low setpoints, and fusible disconnect switch with externally operable handle. Install in a wall-mounted dripproof cabinet.

H. Fire pump flow meters: FM approved flow meter element and gauge operating on the orifice or venturi principle. Test capacity shall be at least twice the rated pump capacity. Gauge shall be designed for permanent wall mounting and shall be a dry-type device responding to the movement of a diaphragm or bellows. The gauge face shall be graduated to read in gpm. Mercury-filled gauges are not acceptable. Tubing connecting the flow element and gauge shall be hard drawn copper.

1. Manufacturer: Barco, Gerand, or Meriam.

I. Fire pump test headers: header with 3" outlets, galvanized pipe nipples, 3" x 2.5" straight-way hose valves with caps and chains, and escutcheon plate lettered "Pump Test Connection". Provide a minimum of one valve for each 250 gpm of fire pump rated capacity. Surfaces exposed to view outside the building shall be polished chrome. Hose threads on valves and adaptors shall match the local fire department standard.

1. Manufacturer: Croker 6800 series, or Potter-Roemer 5860 series.

2.6 FIRE HOSE VALVES, RACKS AND ACCESSORIES

A. Hose threads on valves and adaptors shall match the local fire department standard.

B. Hose valves for dry standpipes: 2.5" rough brass angle type with threaded brass cap and chain, and working pressure of 300 psig.

1. Manufacturer: Croker 5035, Elkhart U-25, or Potter-Roemer 4065.

C. Provide a 2.5" x 1.5" brass reducer, threaded cap, and chain for each 2.5" hose valve.

2.08 FIRE DEPARTMENT CONNECTIONS

A. Polished chrome-plated brass, flush-mounted, with plastic caps. Hose threads on valves and adaptors shall match the local fire department standard. Provide matching escutcheon lettered "Auto Spklr".

1. Manufacturer: Croker 6010 series, Elkhart 166, or Potter-Roemer 5020.

B. Polished chrome-plated brass, free-standing, with plastic caps. Hose threads on valves and adaptors shall match the local fire department standard. Provide matching sleeve and round identification plate lettered "Standpipe".

1. Manufacturer: Croker 6510 series, Elkhart 15, or Potter-Roemer 5760.

2.09 SPRINKLER HEADS

A. General:

1. Sprinkler heads shall be the product of one manufacturer.
2. Unless indicated otherwise on the Drawings, sprinkler heads shall have a 0.5" orifice and 0.5" threaded connection. , and a glass-bulb thermal element.

B. Upright sprinklers: standard or quick response type with rough brass body.

C. Pendent sprinklers: standard or quick response type with chrome body and 2-piece chrome escutcheon.

D. Pendent sprinklers: recessed, standard or quick response type with chrome body and white ceiling cup.

E. Pendent sprinklers: concealed, standard or quick response type with brass body with white coverplate.

F. Sidewall sprinklers: horizontal, standard or quick response type with chrome body and shallow chrome escutcheon. , UL listed for extended coverage up to 16' x 20', with 0.53" orifice and 0.75" connection.

G. Pendent sprinklers: dry, standard or quick response type with chrome body with 2-piece chrome escutcheon.

H. Pendent sprinklers: recessed, dry, standard or quick response type with chrome body with white ceiling cup.

I. Pendent sprinklers: concealed, dry, standard or quick response type with brass body and white coverplate.

J. Sidewall sprinklers: horizontal, dry, standard or quick response type with chrome body with 2-piece chrome wall escutcheon.

K. Upright sprinklers: intermediate level, standard or quick response type with brass body and integral water deflector disc.

L. Upright sprinklers: large orifice type with rough brass body, 0.53" orifice, and 0.75" connection.

M. Manufacturer: Automatic, Central, Grinnell, Reliable, Star, Victaulic, or Viking.

2.10 DELUGE VALVES

A. Cast iron, bronze-mounted type, with electric release trim. Release solenoid valve shall operate at 24 V DC and shall not trip the system upon loss of power.

B. Provide an air pressure maintenance device and desiccant dryer with transparent bowl and silica gel crystals.

C. Configured for preaction service unless otherwise indicated on the Drawings.

D. Manufacturer: Automatic, Grinnell, Reliable, or Viking.

2.11 DRY PIPE VALVES

A. Cast iron, bronze-mounted type with trim, accelerator, gauges, and air pressure maintenance device.

B. Manufacturer: Automatic, Central, Grinnell, Reliable, or Viking.

2.12 AIR COMPRESSORS

A. Air compressors: air-cooled, motor-driven single stage compressor mounted on a 15 gal horizontal receiver, designed, constructed, certified, and stamped in accordance with ASME BPVC-VIII-1-2017. Provide controls for automatic start-stop operation including unloading device, pressure switch, gauge, and relief valve. Normal receiver operating range shall be 30 psig to 40 psig 75 psig to 100 psig. The compressor shall deliver a minimum of cfm free air when driven by a minimum hp motor. be sized in accordance with NFPA 13-2013 to restore normal air pressure within 30 min.

B. Manufacturer: Bell & Gossett, Emglo, General, Kellog-American, or Quincy.

2.13 ALARM AND SUPERVISORY DEVICES

A. Alarm switches for wet pipe systems: vane type with flexible vane, SPDT contacts, a tamperproof cast aluminum housing with red enamel finish, and a steel U-bolt. The switch shall have an instantly recycling pneumatic retard mechanism field adjustable from 0 s to 60 s.

B. Alarm switches for dry pipe systems: pressure type with adjustable setpoint. Switch shall operate on rising pressure. Provide a water-resistant metal housing with red enamel finish.

C. Valve tamper switches: designed for OS&Y valves or valves with indicator posts as indicated on the Drawings. The switch shall mount without the use of blocks and shall not interfere with valve operation. A signal shall be initiated before the valve stem moves more than 20% of its total travel or if the housing cover is removed.

D. Air pressure supervisory switches: pressure operated type with field-adjustable setpoints. Switches shall supervise both high and low air pressure conditions in the piping system.

E. Manufacturer: Potter Electric, or System Sensor.

2.14 ACCESSORIES

A. Hangers and supports: UL listed and FM approved, and as specified in Section 210010, Fire Suppression General.

B. Valve tags and nameplates: as specified in Section 210010, Fire Suppression General.

C. Pressure gauges: bourdon tube type with metal case, 4.5" dials, accuracy within 1% of full scale range, equipped with snubbers and brass needle valves. Maximum gauge limit shall be approximately twice the normal working pressure where the gauge is installed.

1. Manufacturer: Ashcroft, Marsh, Trerice, Weiss, or Weksler.

D. Automatic ball drip valves: ball check type, closed when inlet is pressurized, with bronze body and threaded connections.

E. Test and drain connections: UL listed, FM approved, factory-assembled unit consisting of a control valve, sight glass, and 0.5" orifice. The device shall be tapped for a pressure gauge. The drain connection shall allow unobstructed flow through the device. Working pressure shall be 300 psig.

1. Manufacturer: AGF 1000, or Victaulic 718.

F. Flexible sprinkler connections: UL listed, FM approved, factory-assembled units including a 1" diameter braided stainless steel hose with threaded adaptors at each end, a ceiling mounting bracket, and an adjustable sprinkler clamping device. Minimum working pressure shall be 300 psig.

1. Manufacturer: Flexhead Industries.

G. Strainers: Y-type, except those furnished by the manufacturer as part of standard equipment trim, with bronze body, threaded connections, threaded cleanout plug, and 30-mesh stainless steel screen. Minimum working pressure shall be 200 psig.

H. Air vents: float-operated automatic type with cast iron body, stainless steel trim and 0.75" piping connections.

1. Manufacturer: Anderson, Armstrong, or Hoffman.

PART 3 - EXECUTION

3.1 UNDERGROUND PIPE, FITTINGS AND ACCESSORIES

A. The installer of underground piping systems which carry fire protection water shall hold a current competency certificate issued by Fire Marshal of the State of South Carolina..

B. Excavation and backfill: as specified in Section 210010, Fire Suppression General.

C. Underground pipe shall terminate in the building with a flanged ductile iron transition piece rodded to the underground pipe. Space between the pipe and floor slab shall be filled with nonshrink grout. Where pipe passes through the building wall below grade, provide a cast iron sleeve and fill the annular space between pipe and sleeve with a mechanical seal.

D. Tie rods: coat rods, clamps, nuts and washers with bituminous coating.

E. Fire hydrants shall be installed with the outlet butts facing the roadway. Hydrant laterals shall be rodded solid from the main to the hydrant inlet.

F. Changes in direction exceeding 22.5º shall be anchored with tie rods and clamps and thrust blocks.

G. Free-standing connections, fire hydrants, and indicator posts shall be set plumb.

H. Thrust blocks shall bear against undisturbed earth and shall have bearing areas meeting the requirements of NFPA 24-2013. Blocks shall be poured to leave pipe joints accessible for inspection and repair.

3.2 ABOVEGROUND PIPE AND FITTINGS

A. Run pipe parallel to column centerlines. Pipe shall be installed as high as possible to maintain maximum head room. Provide auxiliary drains to drain the piping system.

B. Piping arrangements shall be made as compact as possible. Spool pieces and pipe nipples shall be as short as installation will allow.

C. Use galvanized piping and fittings for fire pump suction pipes, compressed air piping, ball drip discharges, drains subject to alternate wetting and drying, and water motor alarm piping.

D. Fittings and joints shall be assembled using threaded, flanged, or grooved connections. No welded joints or weld formations, either shop- or field-fabricated, shall be used except as specified herein.

E. Threads cut into galvanized pipe shall be painted with zinc-rich paint.

F. Threads on fittings and bolts shall be fully engaged. Threads shall be made up using joint compound or Teflon tape.

G. Drains and discharges from relief valves, ball drips, drip rims and test connections shall be piped to spill directly over the nearest floor drain. High and low pressure drains shall not be connected together unless specifically indicated on the Drawings.

H. Install an air vent with manual isolation valve at the high point of fire pump suction lines and dry standpipes. Pipe the discharge to spill outside the building or directly over the nearest floor drain.

I. Provide inspector's test connection with site glass, orifice, and gate valve for each water flow switch in the system.

J. Torch cutting is not permitted as a means of modifying sprinkler or standpipe systems.

K. Joints and fittings in copper tubing shall be threaded.

L. System layout shall follow the layout and sizes indicated on the Drawings. Provide coordination required with other trades.

3.3 VALVES

A. Gate or butterfly valves located higher than 8' above the floor shall have chain wheel operators. Chains shall hang free of obstructions and shall terminate 7' above the floor.

B. Gate valves shall be installed with the stems pointing above the pipe centerline.

3.4 FIRE PUMPS AND CONTROLLERS

A. Fire pumps shall start automatically on a drop in water pressure.

B. Pumps and drivers shall be aligned and mounted on a heavy one-piece steel frame and grouted to a concrete pad.

C. Controllers shall be arranged for manual stop.

D. Provide control wiring from the transfer switch to the engine-generator set controls as required for start-stop control.

3.5 FIRE HOSE VALVES, RACKS AND ACCESSORIES

A. Locate hose valves 4'-6" above the floor. Piping drops to hose valves shall be supported within 24" of the valve.

B. Install a pressure gauge with gauge cock at the top of each standpipe riser.

3.6 FIRE DEPARTMENT CONNECTIONS

A. Set plumb.

3.7 SPRINKLER HEADS

A. Install sprinkler guards on sprinklers located lower than 7' above the floor, and on sprinklers located in electrical rooms, communications rooms, elevator equipment rooms, and hoistways.

B. Install near the alarm check valve fire pump controller fire service water entrance a painted steel cabinet containing 24 extra sprinkler heads and one sprinkler wrench. Proportion heads as to type and temperature rating.

C. No sprinkler head shall be located closer than 6" from an adjacent wall.

D. Refer to Architectural Reflected Ceiling Plans for exact head locations. Sprinkler heads shall be aligned on the ceiling and centered in the ceiling tiles. Head escutcheon plates shall be set tight against the ceiling.

E. Locate sprinkler heads under exposed ductwork over 48" wide, including insulation.

3.8 ALARM AND SUPERVISORY DEVICES

A. The retard mechanism of vane type flow switches shall be adjusted to 30 s.

B. Valves shall be monitored in the open position unless indicated normally closed on the Drawings.

3.9 ACCESSORIES

A. Hangers and Supports:

1. The installation and spacing of hangers for sprinklers shall conform to NFPA 13-2013.
2. The installation and spacing of hangers on standpipe feed mains and risers shall conform to NFPA 14-2013.
3. Sprinkler piping below ductwork shall not be supported directly from the ductwork but by trapeze hangers or angles conforming to NFPA 13-2013.
4. Seismic restraints shall be as specified in Section 21 00 10, Fire Suppression General.

B. Hydraulic identification nameplates: provide nameplates for each sprinkler system recording data required by NFPA 13-2013, Chapter 7.

C. Test and drain connections: where failure of a pressure reducing valve would subject the sprinkler system to pressures exceeding 175 psig, install a pressure gauge with cock on the inlet of the drain connection and a 0.5" automatic pressure relief valve in a bypass position around the drain connection. Set relief valve to open at 175 psig.

3.10 PAINTING

A. Interior: fire protection pipe and fittings exposed to view without the removal of ceilings shall be cleaned to remove grease, oil, and scale and then painted 1 coat of Rust-Oleum X-60 metal primer followed by 1 coat of Rust-Oleum 964 red, high gloss finish. Do not paint copper, brass, or glass surfaces, sprinkler heads, valve stems, or nameplates.

B. Exterior: as specified in Section 210010, Fire Suppression General.

3.11 TESTS

A. Prior to covering the joints of underground pipe, the pipe shall be hydrostatically tested for 2 hours at a pressure of 200 psig. Leakage allowance shall be within the limit specified in NFPA 24-2013. The municipal water main and the plumbing system shall be isolated for this test. Submit a Contractor's Material and Test Certificate for Underground Piping in accordance with NFPA 13-2013 and NFPA 24-2013.

B. Prior to being concealed by walls or ceilings, each portion of the interior piping shall be hydrostatically tested for 2 hours at 200 psig measured at the bottom of the system. Leaks shall be repaired until the system test pressure is maintained for 2 hours. Hydrostatic tests shall be made after drop nipples have been cut back and sprinkler heads have been installed. Submit a Contractor's Material and Test Certificate for Aboveground Piping in accordance with NFPA 13-2013.

C. In addition to the standard hydrostatic test, an air leakage test shall be performed on dry pipe and double interlocked preaction sprinkler systems. Air leakage test at 40 psig shall be conducted for 24 hours. Any leakage which results in a loss of pressure in excess of 1.5 psig for the 24 hours shall be corrected.

D. The sprinkler system acceptance tests shall be witnessed by representatives of the Owner, Architect, the Contractor, insurance underwriters, and the local fire department. Provide test equipment and instruments. The acceptance test shall demonstrate operation of initiating detector system, water flow switches, time to trip valve, time to discharge water from test connection, and manual and automatic operating sequences. Submit a typed report, similar to that shown in NFPA 13-2013, recording test results, pressure switch settings, motor current and voltage readings, and witnesses.

E. Fire pumps shall be field tested in accordance with NFPA 20-2013. Prior to scheduling the formal acceptance test, the pumps shall be run and the entire installation shall be checked to ensure proper operation and to ensure that accessories have been provided. When preliminary tests have been completed, submit a written request for formal acceptance testing. This request shall be accompanied by a letter from the pump manufacturer's representative outlining the results of the preliminary tests. Submit the request at least 7 days prior to the scheduled test date.

F. The fire pump acceptance tests shall be witnessed by representatives of the Owner, Architect, the Contractor, insurance agencies, and the local fire department. Factory-trained representatives of the pump supplier and the engine manufacturer shall be present to assist with the test. Provide test equipment and instruments including hose, discharge diffusers, pressure gauges, tachometer, and ammeter. Provide a hose and discharge diffuser for each outlet on the pump test header. A copy of the manufacturer's certified fire pump shop test curve shall be available at the test. The acceptance test shall demonstrate operation on emergency power and operation of remote pump monitor signals. Submit a typed report, similar to that shown in NFPA 20-2013 Appendix A, recording test results, pressure switch settings, motor current and voltage readings, and witnesses.

G. Pressure restricting and pressure reducing equipment shall be set and tested in accordance with NFPA 13-2013 and NFPA 14-2013 and the manufacturers’ instructions. Submit a letter certifying such equipment has been properly set. Letter shall individually list each piece of equipment, location, purpose, manufacturer, model number, size, and field set pressures.

3.12 CLEANING:

A. Prior to connection of inside piping, new underground pipe shall be flushed in accordance with NFPA 24-2013 until foreign matter is blown out and the stream runs clear.

END OF SECTION 213000

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SECTION 220010 - PLUMBING GENERAL

PART 1 - GENERAL

1.1 DESCRIPTION

A. These plumbing general provisions specified herein apply to all Sections of Division 22.

B. Refer to the General and Supplementary Conditions and Division 01 for special requirements and conditions which apply to all Sections of Division 22.

C. This Division and the following Sections include responsibilities and obligations in support of the performance verification specified in Section 220090, Plumbing Performance Verification.

D. This Section covers the plumbing general requirements.

1.2 QUALITY ASSURANCE

A. Conform to the following:

1. International Energy Conservation Code-2009.
2. International Plumbing Code-2015 with South Carolina Modifications.
3. International Fuel Gas Code-2015 with South Carolina Modifications-2016.

B. Codes, standards and regulations specified herein refer to the edition date. Revisions and addenda to these codes, standards and regulations shall be part of these specifications. Provisions of referenced codes, standards, and regulations do not create duty or responsibility by the Architect or the Owner, unless otherwise specified herein.

C. Codes, standards and regulations referred to are minimum standards. Where the requirements of these specifications or drawings exceed those of the codes, standards and regulations, the drawings or specifications shall govern.

D. Plumbing Design Coordination:

1. Reasonable efforts have been made to coordinate plumbing with the following associated trades.
2. Electrical:

a. The power ratings of motors, and other plumbing electrical equipment with the electrical characteristics serving them, as specified herein and indicated on the Drawings, have been established as minimums which will allow that equipment to satisfactorily function while producing the required capacities. These power ratings include a safety factor deemed appropriate to accommodate common differences between design parameters and field construction practices. Under no circumstances shall equipment with power ratings less than those indicated on the Drawings or specified herein be provided.

b. Differences among manufacturers of plumbing equipment make it impossible to produce a single electrical design which will satisfy the varying electrical requirements of those manufacturers. Consequently, the Contractor shall coordinate the electrical requirements of the plumbing equipment actually furnished on this Project, and provide the electrical systems required by that equipment. This coordination effort shall be completed prior to the installation of either the plumbing equipment or the electrical systems serving that equipment. Electrical system revisions required to coordinate with the plumbing equipment actually furnished shall be provided at no additional cost to the Owner.
c. Coordinate the location of the engine-generator set and fuel supply requirements.

3. HVAC:

a. Coordinate with the HVAC equipment for final locations of floor drains, make-up water, and gas supply.

4. Fire Suppression:

a. Coordinate with fire pumps for final locations of floor sinks.

5. Equipment Specified in Other Divisions:

a. Specialty equipment: car wash and car fueling.

E. Adhesives, Mastics, and Sealants:

1. Adhesives, mastics, sealants, and sealant primers used inside the building (defined as inside the weatherproofing envelope and applied on site) shall comply with SCAQMD Rule 1168-2005 for low volatile organic compound content limits.
2. Aerosol adhesives that are applied on-site and used inside the building shall comply with Green Seal Standard for Commercial Adhesives, GS 36-2000 for low volatile organic compound content limits.

F. Paints and Coatings:

1. Anticorrosive and antirust paints applied on-site to interior ferrous metal substrates that will be used inside the building shall not exceed a volatile organic compound content limit of 250 g/L per Green Seal Standard GC-03, Anti-Corrosive Paints, 2nd Edition, January 7, 1997.
2. Clear finishes, primers, sealers, and shellacs applied to interior elements must not exceed the VOC content limits established for those coating types in South Coast Air Quality Management District (SCAQMD) Rule 1113, Architectural Coatings, rules in effect on January 1, 2004.

G. Low-Emitting Materials

1. Adhesives, sealants, sealant primers, paints, and coatings used inside the building (defined as inside the weatherproofing envelope and applied on-site) shall be tested and determined compliant with California Department of Public Health (CDPH) Standard Method v1.1-2010, using the applicable exposure scenario.

2. Methylene chloride and perchloroethylene shall not be intentionally added in paints, coatings, adhesives, or sealants that are applied on-site.
3. All paints and coatings that are wet-applied on site and used inside the building must meet the applicable VOC content limits of one of the following:

    a. California Air Resources Board (CARB) 2007, Suggested Control Measure (SCM) for Architectural Coatings
    b. South Coast Air Quality Management District (SCAQMD) Rule 1113, effective June 3, 2011.

4. All adhesives and sealants that are wet-applied on site and used inside the building must meet the applicable VOC content requirements of SCAQMD Rule 1168, July 1, 2005.

H. Install all plumbing systems specified in Division 22, including connections to equipment provided by others, in accordance with the applicable manufacturer's instructions, except where the requirements are more stringent herein, then these specifications shall govern.

1.3 SPACE CONDITIONS

A. Drawings are diagrammatic in nature and, unless explicitly dimensioned, indicate approximate locations of fixtures, apparatus, equipment and piping. Changes in the location, and offsets, of same which are not shown on the Drawings but are necessary in order to accommodate building conditions and coordination with the work of other trades, shall be made during the preparation of coordination drawings and prior to initial installation, without additional cost to the Owner.

B. Provide access to equipment and apparatus requiring operation, service or maintenance throughout the life of the system.

C. Piping or equipment shall not be installed in electrical equipment rooms, elevator equipment rooms, or elevator shafts unless specifically indicated on the Drawings. In addition, piping or plumbing equipment shall not be installed in the space equal to the width and depth of switchgear, switchboards, panelboards, and motor control centers from floor to structure above nor within the working space in front, rear and/or side (where rear and/or side access is required to work on equipment) of electrical equipment (switchgear, switchboards, panelboards, motor control centers, variable frequency drives, transformers, and starters). Dimensions of the working space shall be a minimum depth of 42" horizontally, the width of the equipment or 30", whichever is greater, and the height of the equipment or 78", whichever is greater. Minimum depth shall be increased to 60" for equipment rated over 600 V.

1.4 ASBESTOS MATERIALS

A. Materials containing asbestos or any trace of asbestos related materials shall not be used on this Project.

1.5 DEFINITIONS

A. Exposed piping or conduit is that which can be seen when the base building is complete without opening or removing access doors or panels or accessible ceiling components.

1. Other piping or conduit is considered to be concealed.

B. Exterior piping is exposed to outdoor temperatures.

C. Rainwater piping conveys water from areas exposed to rainfall.

D. Secondary rainwater piping conveys emergency water from areas exposed to rainfall.

1.6 PROVISION FOR FUTURE ADDITIONS

A. The design does not contemplate future additions.

1.7 RELATED WORK DESCRIBED IN OTHER DIVISIONS

A. Installation of access panels in wall and ceiling construction.

B. Cutting, coring, waterproofing, and patching of walls, floors, ceilings, roofs and structure of existing buildings.

C. Painting, except as specified herein.

D. Electric power, interlock, and control wiring, except as specified herein.

E. Installation of starters, contactors, thermal overload switches, and remote push buttons, except as specified herein.

F. Pipe trenches with grates.

G. Masonry plenums.

H. Car wash and car fueling.

I. Foundation drainage system.

J. Outside sheet metal downspouts.

K. Catch basin construction.

L. Concrete pump pits.

M. Manhole construction.

N. Engine-generator sets.

1.8 UTILITY CONNECTIONS AND SERVICE:

A. Water:

1. Arrange for connection to the water main, extension of service and installation of a meter of not less than 3" size, with a pressure drop of not more than 5 psi at 170 gpm flow. Pay charges in connection therewith.

B. Sewer:

1. Arrange for the sewer connection and pay charges in connection therewith.
2. The installation shall comply with the requirements of the Water Pollution Control Division of the City.

C. Natural Gas:

1. Arrange with the Gas Company to make connection to the gas main, extend the service and install a meter together with regulators and accessories to provide gas service for a flow of 2200 ft^3/h. Pay charges in connection therewith.

1.9 SUBMITTALS

A. Within 15 days after notice to proceed, submit a schedule indicating the proposed submission date of each submittal specified herein. Schedule shall anticipate the submittal review time, the possible need for resubmittals, and the time required for fabrication, shipping and integration into the construction sequence. Architect will advise of any conflicts in reviewing submittals that the proposed schedule presents.

B. Submittals shall be prepared in a line-by-line format corresponding to these Specifications and shall indicate compliance with each requirement specified herein and indicated on the Drawings.

1. In addition to any other transmittals or cover sheets used, fill out and attach to each individual submittal a copy of the Cover Sheet for Submittals to Newcomb & Boyd included at the end of this Section.
2. Indicate manufacturer's installation instructions.
3. Indicate deviations, if any, including any from the manufacturer's installation instructions.
4. Reproductions or electronic versions of design drawings shall not be used in the preparation of shop drawings.
5. Resubmittals that are required to address review comments shall include a cover transmittal with a written explanation of how each review comment has been addressed.
6. Submittals not specifically required, or not complying with the format requirements, will be returned unreviewed.
7. Shop drawings and submittals shall be provided in portable document format (PDF). PDF files containing multiple drawings or components shall include an index of the file contents and electronic bookmarks.

C. Shop drawings shall include the following:

1. Trade shop drawings (i.e., plumbing piping system drawings, and electrical main feeder raceway drawings) shall be submitted within 30 days after award of contract.

2. Approved trade shop drawings shall be utilized as the basis for the coordination drawings. Coordination drawings shall be submitted within 30 days after approval of trade shop drawings.
3. Coordination drawings shall utilize either manual or electronic means of analyzing the work of each trade in spatial relationship with other trades. Locations of conflicts between trades, and the proposed resolution for each conflict, shall be noted on the coordination drawings submitted.
4. No work shall be fabricated and/or installed prior to receipt by the Contractor of approved trade shop drawings and approved coordination drawings without specific written authorization from the Architect. No change orders will be approved or design assistance provided for remedial field coordination activities for work fabricated and/or installed prior to receipt by the Contractor of approved trade shop drawings and approved coordination drawings.

D. General submittals shall include the following:

1. Performance Verification Supervisor qualifications.
2. Coordination drawings, with dimensions and elevations, of plumbing work including equipment, piping with fittings, valves, accessories and sleeves where applicable, coordinated with the work of other trades, including HVAC, fire suppression, electrical, structural, and architectural, minimum 1/4" = 1'-0" scale.
3. Inertia bases.
4. Seismic restraint devices, including calculations, restraint selection, installation details and written confirmation that a licensed engineer prepared the calculations.

E. Plumbing submittals shall include the following:

1. Backflow preventers.
2. Backwater valves.
3. Domestic water piping and fittings.
4. Drains and cleanouts.
5. Fuel gas piping and fittings.
6. Gas pressure regulators.
7. Gauges and thermometers.
8. Oil interceptors.
9. Hot water circulating pumps.
10. Insulation.
11. Sand interceptors.
12. Waste diverter valves.
13. Foam storage tank.
14. Piping system drawings, showing equipment, piping, fittings, elevations, dimensions, valves, sleeves, and accessories, coordinated with building conditions and other trades, minimum 1/4" = 1'- 0" scale.
15. Plumbing fixtures and trim.
16. Sanitary and rainwater piping and fittings.
17. Sump pumps.
18. Temperature maintenance cable.
19. Valves.
20. Wall hydrants and hose bibs.
21. Water heaters, and thermal expansion tanks.

1.10 EQUIPMENT AND INSTALLATION REQUIREMENTS:

A. Equipment and materials shall, unless otherwise specified herein, be new and shall be of the customary standard and quality furnished by the designated manufacturer for that catalogue number.

B. Materials and equipment shall be UL listed, and shall bear the UL listing mark on products for which standards have been established and for which listing is regularly furnished by UL.

1. In lieu of the UL listing, or where standards have not been established by UL and UL listing is not regularly furnished, materials and equipment shall be listed by a laboratory recognized under the OSHA Nationally Recognized Testing Laboratory Program or by a laboratory accredited by International Accreditation Service. Examples include:

a. Canadian Standard Association.
b. ETL Testing Laboratories, Inc.
c. MET Electrical Testing Company, Inc.

PART 2 - PRODUCTS

2.1 HANGERS AND SUPPORTS

A. General:

1. Make hanger assemblies and channel strut systems complete with hanger rods, nuts, bolts, screw attachments, and upper supports attached to the structure as applicable to Project requirements.
2. Select hanger assemblies for single piping, using the weight of piping, insulation, and valves being supported.
3. Select channel strut systems for gang piping, using the combined weight of the piping, insulation, and valves being supported.
4. Select supports for equipment with an additional live load of 300 lb for workers and supplies.

B. Pipe Hangers:

1. Steel piping and insulated water piping 0.5" to 3": adjustable band hanger, steel with galvanized finish and threaded swivel knurl nut.

a. Manufacturer: Anvil 69, B-Line B3170NF, or PHD 141.

2. Copper tubing 0.5" to 3", non-insulated: adjustable band hanger, steel with copper finish and threaded swivel knurl nut.

a. Manufacturer: Anvil CT-69, B-Line B3170 CT, or PHD 152.

3. Plastic piping: adjustable vee bottom clevis hanger, steel with vee support trough and galvanized finish.

a. Manufacturer: B-Line B3106, or PHD 450V.

4. Channel strut systems for gang piping: minimum 14 gauge galvanized steel strut with factory-punched attachment holes, and galvanized straps, nuts, bolts, washers, and accessories. Straps shall be designed so that the attachment nut is captive on the shoulder of the strap when tightened, and designed to provide a surface on the turned down edge against the pipe while making positive contact with the side walls of the channel.

    a. Manufacturer: Anvil, B-Line, PHD, or Unistrut.

C. Equipment Supports:

1. Channel strut systems for equipment supports: minimum 14 gauge galvanized steel strut with factory-punched attachment holes for hanger rods, with stainless steel nuts, and washers.

    a. Manufacturer: Anvil, B-Line, PHD, or Unistrut.

D. Hanger Rods:

1. One-piece steel type, threaded as required.
2. Sizes for single hangers:

Pipe Size	Rod Diameter
2" and smaller	0.375"
2.5" and 3"	0.5"
4" and 5"	0.625"
6" and 8"	0.75"
10" and 12"	0.875"

E. Embedded Concrete Inserts:

1. Single hanger type for piping and equipment up to 1400 lb load limit per hanger: malleable iron with galvanized finish, channel nuts, extended anchors, and nut cavity protection.

    a. Manufacturer: Anvil 282, or B-Line B3014.

2. Single hanger type for piping and equipment up to 1000 lb load limit per hanger: steel with galvanized finish, channel nuts, anchor tabs, and nut cavity protection.

    a. Manufacturer: Anvil 281, B-Line 2505-2508, or PHD 951.

3. Multiple hanger type for piping up to 2000 lb/ft: steel with galvanized finish, channel nuts, end caps, anchor tabs, and nut cavity protection.

    a. Manufacturer: Anvil PS-5000, or B-Line B221.

F. Expansion Anchor Type, Concrete/Masonry Inserts:

1. Steel sleeve type: for bolting frames to concrete slabs and walls. Complete with threaded stud body, expansion sleeve, hex nut, washer, and zinc finish. Anchors shall have a minimum 1000 psig pull out strength.

a. Manufacturer: Hilti, ITW, or Powers.

2. Steel overhead sleeve type: to concrete slabs for threaded hanger rods. Complete with threaded stud body, expansion sleeve, female threaded rod coupling nut, washer, and zinc finish. Anchors shall have a minimum of 1000 psig pull out strength.

a. Manufacturer: Hilti, ITW, or Powers.

3. Drop-in shell type: for threaded hanger rods to post-tension and precast concrete structures. Complete with female threaded steel shell, expansion cone, flush embedment lip, and zinc finish. Anchors shall have a minimum of 1000 psig pull out strength.

a. Manufacturer: Hilti, ITW, or Powers.

4. Steel sleeve type for bolting to concrete block and brick walls: complete with split expansion sleeve over a threaded stud bolt body with integral expander, nut, washer, and zinc finish. Anchors shall have a minimum 300 psig pull out strength.

a. Manufacturer: Hilti, ITW, or Powers.

G. Steel Beam and Joist Clamps:

1. Wide mouth flange clamp with galvanized finish, cup point set screw with lock nut, and retaining strap.

a. Manufacturer: Anvil 93, B-Line 3033, or PHD 360.

2. Center of beam clamp, steel with galvanized finish, screw and tightening nut, and adjustable for 4" to 12" flange widths.

a. Manufacturer: Anvil 133/134, B-Line 3055, or PHD 625.

H. Split Ring Clamps:

1. Steel piping 0.5" to 3": hinged split ring pipe clamp, malleable iron with galvanized finish, threaded rod, and base plate with mounting holes.

a. Manufacturer: Anvil 138R, B-Line B3198H, or PHD 508R.

2. Copper piping 0.5" to 2": hinged split ring pipe clamp, malleable iron with copper finish, threaded rod, and base plate with mounting holes.

a. Manufacturer: Anvil CT138R, B-Line B3198HCT, or PHD 512H.

I. Pipe Stand Supports:

1. Piping 4" and larger: steel floor stanchion type with galvanized finish, adjustable pipe saddles with U-bolt yoke, locknut nipple, threaded riser, and threaded baseplate with mounting holes.

a. Manufacturer: Anvil 265, B-Line B3092, or PHD 876.

J. Offset Pipe Clamps:

1. Piping 0.75" to 12": steel offset pipe clamp with galvanized finish, top and bottom rings with nuts and bolts.

a. Manufacturer: Anvil 103, B-Line B3148, or PHD 535.

K. Riser Clamps:

1. Steel piping: standard type, steel with galvanized finish, nuts, and bolts.

a. Manufacturer: Anvil 40, B-Line B3373, or PHD 551.

2. Cast iron piping: AWWA type, steel with galvanized finish, nuts, and bolts.

a. Manufacturer: Anvil 261, B-Line B3373DI, or PHD 522.

3. Copper tubing to 6" in size: steel with copper finish, nuts, and bolts.

a. Manufacturer: Anvil CT-121, B-Line B3373CT, or PHD 552.

4. Plastic piping: standard type, steel with plain finish, PVC lining, nuts, and bolts.

a. Manufacturer: B-Line B3373C, or PHD 553.

L. Accessories:

1. Insulation protectors: minimum 18 ga galvanized rolled steel with radius to fit the outside diameter (OD) of the insulation. Provide protectors 12" long for 6" and smaller ODs, 18" long for 8" to 10" ODs, and 24" long for 12" and larger ODs.

a. Manufacturer: Anvil 167, B-Line B3151, or PHD 170.

2.2 VALVE TAGS:

A. Minimum 19 gauge polished brass, 1.5" minimum size. Tags shall be round. Stamped numbers and letters shall be not less than 0.75" high, and filled with black paint.

2.3 IDENTIFICATION MATERIALS

A. Pipe identification shall be 5 mil thick self-adhering laminated vinyl label, meeting ASME A13.1-2015. Lengths may vary due to wording. Widths and legends shall be as follows:

Diameter (Including Insulation)	Width	Size of Legend Letters
0.75 - 1.25"	8"	0.5"
1.5 - 2"	8"	0.75"
2.5 - 6"	12"	1.25"
8 - 10"	24"	2.5"
Over 10"	32"	3.5"

1. Legends shall be in full words, easy to read and understand, and in contrasting color to background color.
2. Roll tape flow arrows: 5 mil thick self-adhering laminated vinyl tape, meeting ASME A13.1-2015. The tape's background shall match the pipe identification label's background, and flow arrow shall match the legend lettering.

B. Nameplates and signs: rigid laminated plastic, engraved with white letters. Background color shall be:

System	Color
Equipment served by emergency power	Red
Other equipment	Black

2.4 SLEEVES

A. Sleeves shall be standard weight steel pipe except sleeves for concealed piping through floors not in structural members, and through interior drywall construction may be formed from 26 gauge galvanized sheet metal lapped and pop riveted.

B. Sleeves in rated floor slabs shall be cast-in-place, factory-assembled one-piece watertight type.

2.5 PENETRATION SEALS

A. Firestops:

1. Refer to Section 078400, Fire Stopping.

B. Expansion Seals:

1. Waterproof, modular, mechanical expansion type consisting of synthetic rubber grommets or interlocking links shaped to continuously fill the annular space between the penetrating item and the opening. Sizing of links and sleeve shall be determined by the manufacturer.
2. Manufacturer: Calpico Pipe Linx, Metraflex MetraSeal, or Thunderline Link Seal.

2.6 MOTORS AND STARTERS

A. Motors:

1. Motors shall be as specified within the various sections of Division 22, and as may be indicated on the Drawings, and as a minimum include:

   a. Compliance with NEMA MG 1-2016.
   b. Have a temperature rise as designed by the manufacturer for the motor type, and installation.
   c. Motors 1 hp and larger shall be NEMA premium efficiency type, in accordance with NEMA MG 1-2016.

2. Refer to Electrical Drawings for motor's electrical characteristics.

3. Motors and pumps shall be statically and dynamically balanced and shall have steady state radial vibration levels which do not exceed the following:

Equipment	Peak-to-Peak Displacement (mils)
Motors	
under 600 rpm	4
600 to 1000 rpm	3
1000 to 2000 rpm	2
over 2000 rpm	1
Pumps and motors	
over 1800 rpm	1
under 1800 rpm	2

B. Starters:

1. Motor starters shall be as supplied by the pump or compressor manufacturer as specified within the various sections of Division 22, and as a minimum include:

a. Manufactured in accordance with NEMA ICS 2-2000 (R2005).

2. 3-phase motors, unless otherwise specified herein as a minimum provide:

a. Combination magnetic type with fused disconnect switch.
b. Fuses having type and UL class rating as specified in Division 26, providing Type 2 protection.

3. 1-phase motors, unless otherwise specified herein as a minimum provide:

a. Manual starting switch with thermal overload protection.

2.7 VIBRATION ISOLATION

A. General:

1. Apparatus shall be by one manufacturer, except where herein specified otherwise.

B. Floor Mounted Isolators:

1. Type NP - Neoprene Pad Type: minimum 0.25" thick ribbed or waffled on both sides. Isolator pads shall be selected for less than 80% maximum rated load.

a. Manufacturer: Kinetics Noise Control NP, Mason W, Vibration Eliminator 200N, VMC Group Shear-Flex, or Vibro-Acoustics N.

2. Type NS - Sandwich pad type, with minimum 0.25" thick ribbed or waffled neoprene pad bonded to each side of 16 gauge plate. Isolator pads shall be selected for less than 80% maximum rated load.

a. Manufacturer: Kinetics Noise Control NG, Mason WSW, Vibration Eliminator P, or VMC Group Multi-Layer Shear Flex, Vibro-Acoustics 400 NP.

3. Type DN - Double-deflection Neoprene Type: with neoprene-coated metal surfaces, and top and bottom surfaces ribbed. Isolators shall have bolt holes in the base.

    a. Manufacturer: Kinetics Noise Control RD, Mason ND, Vibration Eliminator T44 or D44, VMC Group M, or Vibro-Acoustics RD.

4. Type FS - Free-standing Spring Type: laterally stable, unhoused spring type with leveling bolts for bolting to the equipment. Spring diameter shall be not less than 0.8 of the compressed height of the spring. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Springs shall be complete with neoprene or fiberglass noise isolation pads, minimum 0.25" thick, bonded to the baseplate.

    a. Manufacturer: Kinetics Noise Control FDS, Mason SLF, Vibration Eliminator OST, VMC Group AW/AWH, or Vibro-Acoustics FS.

C. Hanger Mounted Isolators:

1. Type SH - Spring Hanger Type: combination type hanger with steel spring and double-deflection neoprene or natural rubber element in series. The neoprene or natural rubber element shall have a minimum static deflection of 0.35". Spring diameter shall be not less than 0.8 of the compressed height of the spring. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Hangers shall be designed for a minimum of 15° angular misalignment from vertical before rod contacts housing.

    a. Manufacturer: Kinetics Noise Control SRH, Mason 30N, Vibration Eliminator SNRC, VMC Group HRSA, or Vibro-Acoustics SHR.

2. Type PSH - Pre-compressed Spring Hanger Type: with a deflection scale and compressed to two-thirds of the load's rated deflection. Hangers shall have a release mechanism to free the spring after installation is complete.

    a. Manufacturer: Kinetics Noise Control SFH, Mason PC 30N, Vibration Eliminator PCSR, VMC Group HSRA-PR, or Vibro-Acoustics PSHR.

3. Type NH - Neoprene Hanger Type: double-deflection neoprene or natural rubber hanger type, with neoprene or natural rubber grommet between hanger rod and housing. Neoprene or natural rubber element shall have neoprene- or natural rubber-coated metal surfaces.

    a. Manufacturer: Kinetics Noise Control RH, Mason HD, Vibration Eliminator C, VMC Group HR, or Vibro-Acoustics NH.

D. Piping In-line Isolators:

1. Flexible metal hose connector type: 316 stainless steel inner corrugated hose and outer woven braid sheath, with threaded ends for natural gas piping. Connectors shall be American Gas Association approved, rated for 150 psig at 70°F, and have a flexible length to provide a minimum of 0.375" offset.

    a. Manufacturer: Flexicraft, Metraflex, or Proco.

2. Flexible metal hose connector type: 316 stainless steel inner corrugated hose and outer woven braid sheath, with flanged ends for domestic water piping 4" and larger to domestic water booster pumps. Connectors shall meet FDA and NSF requirements for lead free, rated for 150 300 psig at 70°F and have a flexible length to provide a minimum of 0.25" offset.

    a. Manufacturer: Flexicraft, Metraflex, or Proco.

2.8 SEISMIC RESTRAINTS:

A. Seismic force design shall be determined in accordance with the following seismic design criteria:

1. Seismic Design Category: C.
2. Occupancy Category: II.
3. Risk Category: II.
4. Component Importance Factor, I_P: 1.0.

B. Provide restraint devices as required for vibration isolated and non-vibration isolated plumbing components. Provide calculations to determine restraint loadings for specific components to be installed resulting from seismic forces on components. Seismic restraint calculations shall be signed by a licensed engineer in the employ of the seismic restraint device manufacturer.

C. Exceptions for plumbing components listed within the applicable project building code may be utilized. However, use of exceptions shall be noted with submitted seismic restraint calculations.

D. Seismic restraints and vibration isolators provided with integral seismic restraint capacity shall have Anchorage Preapproval "R" Number from OSHPD in the State of California listing minimum certified horizontal and vertical load ratings.

E. Floor-Mounted Restraints:

1. All-directional external seismic restraints for floor-mounted components shall consist of interlocking steel assemblies restrained when engaged under seismic motion by elastomeric material with a minimum thickness of 0.25". The minimum air gap between interlocking assemblies shall be 0.125".
2. Restraints for neoprene vibration isolators shall consist of Type DN isolators with the addition of welded steel housings to resist seismic forces.
3. Restraints for free-standing floor springs shall consist of Type FS isolators with the addition of welded steel housings to resist seismic forces. Restraints shall allow a maximum movement of 0.25" in all directions.
4. Manufacturer: Kinetics Noise Control, Mason Industries, VMC Group, Vibration Eliminator, or Vibro-Acoustics.

F. Suspended Restraints:

1. Restraints for vibration isolated suspended equipment and components shall consist of galvanized or stainless steel aircraft cables with end connection fittings designed to swivel in order to ensure proper cable alignment and avoid bending of cable.

2. Restraints for nonvibration isolated suspended equipment and components shall consist of steel angle or unistrut with anchor bolts and end connection fittings designed to swivel to the final installation angle.
3. Manufacturer: B-Line, International Seismic Application Technology, Kinetics Noise Control, Mason Industries, Tolco, VMC Group, Vibration Eliminator, or Vibro-Acoustics.

2.9 CONCRETE

A. Normal weight concrete (145 pcf) using Type I Portland Cement, 1" maximum size coarse aggregate to provide a minimum 28 day compressive strength of 3000 psi.

2.10 GROUT

A. Nonshrink type, conforming to ASTM C1107/C1107M-2017 when tested at fluid consistency. Grout shall exhibit zero bleeding at every age when mixed to fluid consistency. Minimum 28 day compressive strength, when mixed to fluid consistency, shall be 7000 psi.

B. Manufacturer: Cormix, or Master Builders.

2.11 ACCESS PANELS - BUILDING

A. Refer to Section 083100, Access Door and Panel.

2.12 ESCUTCHEONS

A. Split hinged type, constructed of chromium-plated steel or cast brass, sized to fit over insulation and to cover sleeve.

2.13 UNDERGROUND WARNING TAPE

A. Tape shall be acid- and alkali-resistant polyethylene film tape, 6" wide with minimum thickness of 0.004", specifically designed for marking and locating of underground utilities.

B. Tape shall be manufactured with integral wires, foil backing or other means to enable detection by a metal detector when the tape is buried up to 3' deep. The metallic core of the tape shall be encased in a protective jacket or provided with other means of corrosion protection.

C. Tape color shall be as specified below and shall bear a continuous printed inscription describing the specific utility:

Utility	Color
Domestic cold water	Blue
Natural gas	Yellow
Rainwater	Green
Soil	Green
Waste	Green

D. Manufacturer: Brady, Boddingtons, Carlton Industries, Seton, or Thor Enterprises.

PART 3 - EXECUTION

3.1 PROTECTION OF EQUIPMENT AND MATERIALS DURING CONSTRUCTION

A. Equipment and Materials-Storage:

1. Provide protective covers, skids, plugs or caps to protect equipment and materials from damage or deterioration during construction.

2. Store equipment and material under cover, and off the ground or floors exposed to rain.

3. For outdoor storage, protective covers of 10 mil thick black sheet plastic shall be fitted over equipment and materials. Covers shall be reinforced to withstand wind and precipitation. Set equipment and material on skids or platforms of height to avoid damage or deterioration from spattering and ground water.

4. Plastic piping shall not be stored in direct sunlight or at temperatures higher than 95°F: Install the protective covering with 12" clearance over the piping top and sides, and provide for air circulation. Store the piping on skids that will protect from heat sagging or bending.

B. Equipment and Materials-Construction:

1. Plug ends of pipes when work is stopped to prevent debris from entering the pipes.
2. Provide dust and debris protection for equipment, motors, and bearings operated during construction up to date of substantial completion.
3. Provide protective covers on floor drains and floor sinks during construction to prevent debris from entering the waste piping system. Do not use any covering that will deface the drain grate's finish.

3.2 EQUIPMENT INSTALLATION REQUIREMENTS:

A. Equipment shall be installed and connected as specified herein or indicated on the Drawings in accordance with the manufacturers' instructions and recommendations for this Project. Furnish and install auxiliary piping, water seals, valves, and electrical connections recommended by the manufacturer for operation.

B. Refer to manufacturer's or equipment supplier's shop drawings for exact type, number, location, dimensions and size of connections to equipment, and provide rough-ins and connections accordingly, including, but not limited to:

1. Car wash equipment.

C. For equipment that does not have water cross connection within, provide check valves in the cold and hot water supplies.

D. Motor quantities, sizes and equipment wattage ratings specified herein or indicated on the Drawings are the minimum requirements, unless noted otherwise. Motor quantities, sizes and equipment wattage ratings less than those specified herein or indicated on the Drawings are not acceptable. Larger motor sizes and equipment wattage ratings may only be provided if necessary to meet the prescriptive requirements specified herein or indicated on the Drawings. Where

multiple motors or motor sizes or equipment wattage ratings larger than specified herein or indicated on the Drawings are furnished, provide and coordinate the corresponding increased number or capacity of feeders and other electrical equipment serving them, at no additional cost to the Owner.

E. Field-installed equipment controls or sensor wiring shall be installed in conduit. Low voltage control and sensor wiring shall be installed in conduits separate from line voltage control wiring and power wiring.

F. Where water pipe sizes at equipment vary from the pipe size indicated on the Drawings, provide appropriate reducers/increasers directly adjacent to the pipe-equipment unions.

G. Unless otherwise specified herein or indicated on the Drawings, the size of the valves, piping, and accessories dedicated to a piece of equipment shall not be less than the pipe size to which they are connected.

3.3 HANGERS AND SUPPORTS:

A. General:

1. Piping support spacing shall be from center to center of the support.
2. Support connected piping and equipment independently of each other.
3. Adjust hangers, clamps, and supports so that loading and support is uniform.
4. Suspend hanger rods only from the structure: do not suspend from piping, equipment, or ductwork.
5. Isolate bare copper tubing from ferrous metal hangers, channel strut supports, and building components with felt or rubber liners.

B. Hangers and Supports:

1. Support 2.5" and smaller piping independently in a parallel plane, and equally spaced side to side, except where a channel strut is used.
2. Support 3" and larger piping independently in a parallel plane, and equally spaced side to side.
3. Provide supports for piping 3" and larger, within 1' of each elbow and tee, and at each valve and strainer.
4. At groups of close-coupled valves and strainers installed in the same line, provide multiple hangers to eliminate any stress on the piping and valve joints.
5. Support domestic hot and cold water piping in chases and walls behind plumbing fixtures with plastic brackets and U-bolts secured to the cast iron, fixture carriers, or wall studs as applicable. Select U-bolts to bear on the piping.
6. Install restraints on drainage piping 5" and larger, at changes in direction, and changes in pipe diameters greater than two pipe sizes, as required by the International Plumbing Code-2015.

C. Channel Struts:

1. Where multiple pipes 0.5" to 2.5" run parallel and in the same plane, a channel strut system may be used.
2. The strut spacing shall support the smaller diameter pipe.

D. Insulated Piping:

1. For insulated piping, provide insulation protectors at each hanger and/or channel strut.
2. For insulated piping, except cast iron select hangers and channel strut clamp sizes, for the insulation's outside diameter. Select hangers and clamps to not compress the insulation.
3. Insulated piping shall run continuous, without any breaks at hangers or channel struts, except cast iron which shall rest directly on the hanger or channel strut.
4. Select hangers for insulated cast iron pipe to bear on the pipe. Wrap the insulation around the hanger bottom and fill and seal any voids within the hanger's upper part.

E. Horizontal Support Spacing:

1. Supports for copper tubing: 0.5" to 1.25" maximum of 5', 1.5" to 2.5" maximum of 8', and 3" and larger maximum of 10'.
2. Supports for cast iron piping: excluding fittings, maximum of 5'.
3. Supports for steel piping: 0.5" to 1" maximum of 7', 1.5" to 2.5" maximum of 9', and 3" and larger maximum of 12'.

F. Vertical Support Spacing:

1. Anchor vertical water piping 6' and longer in chases or walls, to plumbing fixtures or equipment, at the pipe's midpoint with split ring clamps attached to the studs.
2. Anchor vertical piping 8' to 16' in length, located within one space at the pipe's midpoint with offset pipe clamps or split ring clamps, as applicable, attached to the building.
3. Anchor vertical piping over 16' in length, located within one space at 8' intervals, with offset pipe clamps or split ring clamps, as applicable, attached to the building.
4. Support soil, waste, vent, and rainwater stacks with riser clamps at each floor.
5. Support soil, waste, vent, and rainwater piping vertical to horizontal offsets above grade, with a hanger on the first elbow of the offset.
6. Support water, and gas risers with riser clamps at each floor.
7. Support vertical piping in open shafts on channel struts at every floor line, and as specified above.

G. Embedded Concrete Inserts:

1. Use for piping and equipment supports in new concrete construction.
2. Single hanger type: where the weight to be supported exceeds 50% of the inserts rated load capacity, install 2 No. 3 reinforcing rods 30" long, attached to the extended anchors at each end of the insert.
3. Multiple hanger type: where the weight to be supported exceeds 50% of the inserts rated load capacity, install No. 3 reinforcing rods 30" long, attached to the extended anchors at each end of the insert, and on 12" centers.

H. Expansion Anchor Type Concrete and Masonry Inserts:

1. Use for piping in cured concrete construction.
2. Install per manufacturer's requirements.
3. Select for maximum load plus a safety factor of 3 times the calculated load.

3.4 SLEEVES

A. Provide sleeves where pipes pass through walls, floors and roofs, except in the following circumstances:

1. Cast iron pipe built into masonry walls.
2. Concealed wall openings of the required diameter in non fire- or smoke-rated construction, unless specified herein to have voids packed with fiberglass and caulking.
3. Concealed floor openings formed by the use of plastic forming devices providing a circular opening of the required diameter.
4. Core drilled concealed openings. Openings in roofs shall not be core drilled. Obtain written permission prior to core drilling.
5. Pipes passing through concrete floor slabs on grade.

B. Sleeves shall be placed into position prior to wall, floor, or roof construction. Sleeves shall be tight-fitting and cut smooth.

C. Floor sleeves shall be cast in place, watertight, and extend from the bottom of the slab to 2" above the finished floor.

D. Wall sleeves shall extend 1" on each side of walls.

E. Make sleeves through outside walls above and below grade watertight, and provide stainless steel escutcheons inside and outside.

F. Size sleeves to have a minimum of 1" annular space to the outside diameter of pipe and/or the pipe insulation, except as follows:

1. Sleeves in nonrated construction shall be sized to provide clearance all around pipe, including insulation, to accommodate thermal movement. Clearance shall be minimum 0.75".
2. Sleeves for borosilicate glass piping shall be 2" larger than pipe diameter.

G. Furnish 4 psf lead flashing for sleeves through flat built-up roofs extending at least 8" from the sleeve in all directions.

3.5 PENETRATION SEALS

A. General:

1. Install in accordance with the manufacturer's published instructions to achieve ratings and classifications specified herein. A copy of these instructions shall be maintained and available on site.

B. Exterior Wall Seals:

1. Piping without insulation: use expansion seals between pipes and sleeves. Where walls exceed the width of expansion seals, use two seals, one being flush with the inside sleeve face and the second with the outside sleeve face. Fill the annular void space between the two seals.

2. Piping with insulation: pack center annular space between the insulation and the sleeve with fiberglass, then caulk 1" deep from each face to the fiberglass with nonhardening sealant. Smooth sealant with face of sleeve.

3.6 IDENTIFICATION OF PIPING

A. Label piping specified under this Division in accordance with ASME A13.1-2015.

B. Labels shall be on the lower quarters of horizontal piping, except where such location would be obscured and at the plane of observation on vertical piping.

C. Wrap arrow tape completely around the pipe at each end of the label, with arrows pointing in direction of flow.

D. Locate pipe labels as follows:

1. Within mechanical rooms and above suspended ceilings:0

   a. Within 18" of each valve or valve assembly.
   b. Within 36" of tees at both main and branch.
   c. Within 36" of each 90º elbow.
   d. Not over 20' intervals along horizontal piping.
   e. At midpoint on vertical risers where visible.
   f. Within 18" on each side of a wall.
   g. Within 36" of connections to equipment or vessels.

2. Piping concealed in chases or shafts:

   a. Each pipe visible through an access door or panel on each level.

3. Piping exposed in finished rooms:

   a. Omit identification of piping 0.5" and smaller exposed at connections to equipment or plumbing fixtures.
   b. With the above exception, identify not less than 1 point on each piping run visible in each room with identification on not over 20' intervals.

E. Piping with temperature maintenance cable shall be additionally labeled, "Electronically Traced" on the outside of the insulation jacket.

F. Schedule of Piping Identification:

Piping System	Color Coding Background/Lettering	Legend
Drainage Systems		
Sanitary	Green/White	Sanitary
Waste	Green/White	Waste
Vent	Green/White	Vent
Rainwater	Green/White	Rainwater
Secondary Rainwater	Green/White	Secondary Rainwater

Piping System	Color Coding Background/Lettering	Legend
Pumped Discharge	Green/White	Pumped Discharge
Water Systems		
Cold Water	Green/White	Domestic Cold Water
Hot Water	Green/White	Domestic Hot Water
Hot Water Circulating	Green/White	Domestic Hot Water Circulation
Non-potable Water	Yellow/Black	Non-potable Water
Fuel Gas Systems		
Natural Gas	Yellow/Black	Natural Gas
Natural Gas Vent	Yellow/Black	Natural Gas Vent

3.7 VALVE TAGS AND SCHEDULES

A. Provide numbered brass tags on valves except at plumbing fixtures. Attach tags to valve stems with brass S-hooks or brass chain.

B. Tags on new valves shall continue the numbering sequence of existing valves.

C. Provide for each system a typewritten schedule of valves giving number, location (room number), and function of each with a small scale diagram outlining general piping layout and location of each numbered valves.

3.8 IDENTIFICATION OF EQUIPMENT

A. General:

1. Identification shall consist of upper case letters.

2. Each piece of equipment shall be appropriately identified by nameplates with 0.25" high letters.

a. Identification shall include the equipment designation and device function, e.g., Water Pressure Booster Pump, WPB-1.

3.9 MOTORS AND STARTERS

A. Provide motors for equipment covered in Division 22 unless otherwise specified herein. Select motors for operation not exceeding a 1.0 service factor and within the nameplate amperage and nominal power rating.

B. Provide starters, push buttons, thermal overload switches, and contactors for equipment covered in Division 22 unless otherwise specified herein.

C. Provide 120 V secondary control power transformers for control circuits where equipment is served at 208 V or higher.

3.10 FUSES

A. Provide fuses in equipment furnished under this Division of the specifications.

B. Provide 3 spare fuses of each size, UL class, and voltage rating furnished under this Division of the specifications and turn over to the Owner. Obtain a receipt for same.

3.11 EQUIPMENT AND EQUIPMENT ROOMS

A. Remove dust, dirt, rust, stains, and temporary covers.

B. Foreign matter shall be blown, vacuumed, flushed, or cleaned out of and from new equipment, fixtures, floor drains, piping, pumps, motors, bearings, devices, switches, controls, and panels.

C. Clean and polish identification plates.

D. In equipment rooms, clean equipment, insulation, piping, conduit, and room surfaces from dust and dirt and maintain in a clean condition from date of substantial completion until final completion of work and corrective work.

E. Remove excess material from the Project site.

3.12 SEISMIC RESTRAINTS

A. Restraints shall be installed after the equipment is mounted, piped, connected, and operating to ensure that no contact occurs during normal equipment operation.

B. Installation of seismic restraints shall not cause any change of position of equipment or components resulting in stress and misalignment.

C. No rigid connections between equipment or components and the building structure shall be made that degrade the vibration isolated system specified herein.

D. Equipment that is internally vibration isolated and restrained shall have its entire unit assembly seismically attached to the structure.

E. Do not brace a system to two different structures, such as a wall and a ceiling.

F. After installation, manufacturer shall verify that seismic restraints are installed and operating properly, and shall submit a certificate so stating.

3.13 FOUNDATIONS

A. Provide concrete foundations for the following floor-mounted equipment:

Equipment	Foundation
Water heaters	4" high pad

1. Foundation height shall accommodate seismic anchors, but shall be not less than the minimum specified above.

B. Foundations shall be continuous and shall have beveled edges and smooth flat finish. Foundations shall be reinforced with No. 3 bars a maximum of 12" on center each way, and held in place with dowel rods at each corner anchored in the slab. Dowel rods shall not penetrate through the slab.

C. Roughen and clean exposed slabs before pouring foundations. Apply bonding agent to surfaces in contact.

D. Foundations shall extend a minimum of 6" beyond the equipment footprint or 1.5 times the seismic anchor embedment depth from the point of anchoring (whichever is larger) in all directions, including appurtenances, vibration isolators, base elbow supports, and motors.

E. For equipment attached directly to foundations or inertia bases: and where equipment bases are provided with grout holes, or consist of a structural frame, shall have voids filled with grout after attachment to foundation.

F. Fill voids between baseplates and foundations, and level equipment, with grout.

3.14 ACCESS PANELS - BUILDING

A. Where plumbing work is concealed by walls or ceilings, or is inaccessible, provide an access panel to provide access for service and maintenance.

B. Plumbing work located above ceilings is considered accessible if the ceiling is the accessible type and is arranged for access to the equipment.

C. Fire-rated access panels shall be provided in fire barriers with ratings to match the construction fire rating.

D. Installation of access panels is specified under another Division.

3.15 ESCUTCHEONS

A. Provide escutcheons where exposed piping passes through walls, floors and ceilings in finished areas.

3.16 UNDERGROUND WARNING TAPE

A. During backfill, install tape continuously along length of piping, 12" to 18" above the piping for:

1. Domestic cold water.
2. Natural gas.
3. Rainwater.
4. Soil.
5. Waste.
6. Utility located underground, not listed above.

3.17 PAINTING

A. Except where otherwise specified herein, painting shall be done under another Division. Surfaces shall be left clean and free from oil.

B. Equipment factory finishes damaged or deteriorated during construction shall be repaired to match original finish.

C. Where galvanizing is broken during fabrication or installation, recoat exposed areas with zinc-rich paint.

D. Exterior ferrous equipment, piping and supports shall be painted with 2 coats of rust preventive paint, color selected by the Architect.

E. Exposed interior uninsulated black steel piping, and exposed nongalvanized ferrous accessories, hangers, rods, inserts, and mechanical supports shall be prepared and painted with 1 coat of rust preventive paint prior to other painting or identification, or 2 coats of rust preventive paint if no other painting is specified.

F. Conduits, insulation, pipe, hangers, and saddles visible through architectural openings shall be painted flat black.

3.18 EXCAVATION AND BACKFILLING

A. General:

1. As applicable to the building and site plumbing work, excavation, shoring, bracing, backfilling, and compaction shall conform to Division 31, Earthwork, except as superseded herein.
2. The cutting and patching of hardscapes, and restoration of landscapes shall conform to Division 31, Earthwork.
3. Determine exact location of existing underground utilities before excavation. Immediately repair any damage to existing underground utilities at the Contractor's expense.
4. Install underground piping outside the building with 36" minimum cover, unless specified otherwise herein.

B. Excavation:

1. General:

a. At minimum excavations shall comply with OSHA 29 CFR 1926.651-2017 and 29 CFR 1926.652-2017, or where applicable, an OSHA approved state plan.
b. Excavations shall be no longer or deeper than necessary.
c. When the excavated bottom contains rock or any similar material, excavate a minimum of 4" deeper than the required bottom grade, and restore with specified backfill material then compact.
d. When the bottom is over excavated, backfill to the required bottom grade with specified material then compact.
e. When the excavated bottom contains non-compactable soil and vegetation, refer to Division 31, Earthwork, for directions in removal and grade restoration.

2. Piping:

    a. Excavate to the pipe's bottom line and grade. Provide recesses for pipe hubs where applicable. Pipe barrels shall be laid full length on firm bedding.
    b. For plastic piping, excavate 4" deeper than the bottom line and grade, then prepare for beding backfill to restore pipe's bottom line and grade.

3. Structures: excavate to 4" below the bottom grade as indicated on the structure's detail, and prepare for a bed of leveling backfill. Keep the excavation to within the minimum area needed to install or construct the structure.

C. Backfilling:

1. General:

    a. Backfill material shall be free from rocks and debris.
    b. Backfill material where applicable, shall be compactable to a minimum 95% Standard Procter Density.
    c. At any settling of backfill, refill the void area, recompact, and leave level with adjacent grade.

2. Backfill Material:

    a. From excavated grade to 12" above pipe: compaction grade sand, crushed gravel, crushed stone, or rock dust.
    b. From 12" above the pipe to finished grade: compaction grade sand, crushed gravel, crushed stone, rock dust, or excavated material free of rocks over 2" in diameter.
    c. The top 18" under lawn and planting areas is required to be approved planting soil per Project’s requirements.

3. Backfill Requirements:

    a. Install backfill evenly in layers not over 6" deep, compacting each layer.
    b. Piping: work backfill material under each lower quarter of pipes, and along barrels, taking caution not to damage pipe material or coating.
    c. Structures: apply backfill material around structures, and bring up to grade in even layers.

4. Compaction:

    a. Compaction inside buildings and in paved areas shall be a minimum 95% Standard Procter Density. In other areas it shall meet the compaction of the adjacent grade.
    b. For all 95% compactions, a third party testing laboratory shall perform compaction test every 30', or fraction thereof, on piping runs, and at every 6' around structures.
    c. Piping: use hand held tampers only around piping to 12" above the pipe. Above 12" hand guided electric tampers may be used. Do not use heavy compaction equipment or machinery which would displace or damage piping.
    d. Structures: hand guided electric tampers may be used. Use caution not to damage the structure. Do not use heavy compaction equipment or machinery which would displace or damage structures.
    e. Do not use water for compaction.

3.19 COORDINATION

A. Provide offsets, transitions, and fittings to coordinate the work of each trade with that of other trades, including HVAC, fire suppression, electrical, structural, and architectural.

3.20 PHASING

A. Install work in phases as required by the Architectural Documents.

3.21 OPERATION AND MAINTENANCE MANUALS

A. These operation and maintenance manual requirements supplement operation and maintenance manual documentation requirements of other Sections of these specifications.

B. Operation and maintenance documentation, in hardback 3-ring loose-leaf binders except full size drawings and CDs, shall cover the plumbing, medical gas, laboratory gas, and fuel systems. Documentation shall include an operations and maintenance documentation directory, emergency information, operating manual, maintenance manual, test reports, and construction documents.

C. The operation and maintenance documentation package shall be submitted as one comprehensive package to the Architect 3 months before systems start-up, and shall be updated, revised and completed at completion of, construction.

D. Compile and coordinate the documentation for equipment and systems installed. Documentation shall be typewritten and shall contain, at a minimum, the following information.

1. Introduction:

    a. Project name, contractors' and subcontractors' names, addresses, and telephone and facsimile numbers.
    b. Index.

2. Operations and Maintenance Documentation Directory:

    a. Explanation of the identification system used, including lists of systems, equipment, and component identifiers and names.

3. Emergency Information:

    a. Information for technical and nontechnical personnel about actions recommended during emergency situations to protect life and property and to minimize disruption to the building occupants. Emergencies shall, at a minimum, include:

        1) Fire.
        2) Security breach.
        3) Water outage.
        4) Power failure.
        5) Plumbing overflow or rupture.
        6) Heating failure.
        7) Cooling failure.

4. Operating Manual:

    a. General Information:

        1) Building function.
        2) Building description.
        3) Operating standards and logs.

    b. Technical Information:

        1) System description.
        2) Operating routines and procedures.
        3) Special procedures.
        4) Basic troubleshooting.

5. Maintenance Manual:

    a. Descriptions (specifications) of the equipment and components.
    b. Description of function, as applicable: the function of the equipment, procedures before start-up, functional parameters (input, output) at the design load and at part loads, and performance verification procedures.
    c. Recommended maintenance and lubrication procedures and their recommended frequency for this Project.
    d. Recommended list of spare parts, part numbers, and the place(s) from which they can be obtained.
    e. Original purchase order number; date of purchase; name, address, and the telephone number of the vendor; and warranty information.
    f. Installation information.
    g. Other information needed for the preparation of documents supporting the management of operation and maintenance programs.

6. Test Reports and Certifications:

    a. Copies of tests and certifications performed during manufacture and construction, including but not limited to the following:

        1) Certification of installation of vibration isolation.
        2) Certification of seismic restraints.
        3) Receipt for spare fuses.
        4) Receipt for instruction of operating personnel.
        5) Certification of installation of underground preinsulated piping systems.
        6) Certification of plumbing piping tests.
        7) Results of domestic water system disinfection tests.

7. Construction Documents:

    a. Record drawings.
    b. Approved submittals, including revised shop drawings indicating as-installed conditions.
    c. Equipment identification charts and schedules.
    d. Warranty certificates.

e. Inspection certificates.
f. Performance verification report.

E. Submit a receipt signed by the Owner acknowledging receipt of the operation and maintenance documentation package.

3.22 RECORD DRAWINGS

A. A record of field and as-installed conditions shall be maintained at the site, shall be kept current throughout the Project, and shall be used in the preparation of the final record drawings. Field and as-installed conditions shall be recorded on design drawings and shall be marked to include addenda, change orders, field changes and selections made during construction.

3.23 MAINTENANCE

A. Equipment operated prior to the date of substantial completion shall be maintained in accordance with manufacturer's recommendations.

B. Prepare and submit a lubrication chart listing for each piece of equipment:

1. Points requiring lubrication.
2. Recommendations for a single manufacturer's lubricants with brand name and designation.
3. Frequency of lubrication required.

C. Lubricate each item of apparatus requiring lubrication prior to start-up in accordance with the manufacturer's recommendations.

3.24 INSTRUCTION OF OPERATING PERSONNEL

A. Provide the designated Owner's personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of equipment specified in Division 22. Conduct 2 formal instruction sessions for operating personnel. The first session shall be conducted at the time of start-up and check-out, and the second session shall be approximately 2 months later. Sessions shall be a minimum of 2 days for basic plumbing systems, and as specified herein for specialty systems and equipment. Sessions shall be conducted at the site.

B. Prepare and submit a syllabus describing an overview of the proposed training program, describing how the training program will be conducted, when and where meetings are to be held, names and company affiliations of lecturers, description of contents and outline for each lecture, and recommended reference material and outside reading. Obtain direction from the Architect on which operating personnel shall be instructed in each system. Proposed training schedules, materials, and lesson plans shall be submitted to the Owner for review of the content and adequacy of the training of the Owner's personnel.

C. The appropriate manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor, or manufacturer’s representative. More than one party may be required to execute the

training. The training program shall include the following, as appropriate for the system or equipment:

1. Training shall normally start with classroom sessions followed by hands-on training for each piece of equipment, which shall illustrate the various modes of operation, including start-up, shutdown, and power failure.
2. During any demonstration, should the system fail to perform in accordance with the requirements of the operation and maintenance manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
3. Training shall include:

    a. Use of the printed installation, operation and maintenance instruction material included in the operation and maintenance manuals.
    b. A review of the written operation and maintenance instructions emphasizing safe and proper operating requirements, preventative and routine maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover, and any emergency procedures.
    c. Discussion of relevant health and safety issues and concerns.
    d. Discussion of warranties and guarantees.
    e. Common troubleshooting problems and solutions.
    f. Explanatory information included in the operation and maintenance manuals and the location of plans and manuals in the facility.
    g. Discussion of any peculiarities of equipment installation or operation.
    h. Classroom sessions shall include the use of overhead projections, slides, video/audio-taped material as appropriate.
    i. Factory-trained technicians shall give instruction on the following specialty systems and equipment:

System/Equipment	Minimum Session Duration, hours
Drainage systems	3
Water systems	4
Backflow preventers	1
Domestic hot water system	2
Domestic hot water circulation system	1
Foam storage tank	1

4. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance for all pieces of equipment.
5. Explain and demonstrate the operation, function and overrides of local packaged controls not controlled by the central control system.
6. Training shall occur after testing is complete, unless approved otherwise by the Architect.
7. Provide DVD format video recordings of training sessions and a complete record copy of training materials, handouts, and other printed materials used in each training session.
8. Obtain a receipt acknowledging completion of each item of instruction.

END OF SECTION 220010

COVER SHEET FOR

SUBMITTALS TO NEWCOMB & BOYD

Project: _____ Date: _____

Item: _____ Submittal Number: _____

Manufacturer: _____ Model: _____

Specification Paragraph and/or Drawing Number: _____

Capacity: _____

Electrical Characteristics (including identification of all separate connections or services required): _____

_____

_____

_____

Accessories: _____

_____

_____

_____

Options: _____

_____

_____

_____

Deviations (if any; if none, state so): _____

_____

General Contractor Approval: _____

SECTION 220090 - PLUMBING PERFORMANCE VERIFICATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other plumbing systems are specified in other Sections of Division 22.

B. Refer to Section 220010, Plumbing General for a list of plumbing Sections included in this specification.

C. This Section covers plumbing systems performance verification, as required to demonstrate that the equipment and systems of Division 22 are ready for safe and satisfactory operation, as defined by the Construction Documents. Performance verification shall include, but shall not be limited to, identification of piping and equipment, cleaning, lubrication, start-up, check-out, and testing and adjusting systems, preparation of equipment and systems documentation and of maintenance and operation manuals, Owner training, and preparation of record drawings.

D. Performance verification is an ongoing process and shall be performed throughout construction. Performance verification verifies that systems are operating in a manner consistent with the Construction Documents.

E. Performance verification shall conclude with the completion of required deferred testing, training, and system documentation as specified herein and required to demonstrate the proper operation of the plumbing equipment and systems provided by this Division.

F. Verify, at a minimum, the performance of the following systems and equipment and witness the following tests:

1. Section 220010, Plumbing General:

    a. Seismic restraints.
    b. Variable frequency drives.
    c. Vibration isolation.

2. Section 224200, Plumbing Fixtures:

    a. Fixture tests.
    b. Plumbing fixtures.

3. Section 224300, Drainage Systems:

    a. Oil/water separator.
    b. Sand interceptor.
    c. Water diverter valves.
    d. Piping and joint tests.
    e. Rainwater and Secondary Rainwater systems.
    f. Sanitary, waste and vent system.
    g. Sump pumps.

h. Foam storage tank.
i. Temperature maintenance cable.

4. Section 224400, Water Systems:

a. Flow and balancing valves.
b. Backflow preventers.
c. Freezeproof hydrants.
d. Hot water circulating pumps and system.
e. Mixing valves.
f. Piping and joint tests.
g. Pressure reducing valves.
h. Temperature maintenance cable.
i. Thermal expansion tanks.
j. Trap primers.
k. Vacuum breakers.
l. Water heaters.
m. Water meters.

5. Section 224500, Fuel Gas Systems:

a. Gas pressure regulators.
b. Piping and joint tests.

1.2 QUALITY ASSURANCE

A. Provide a Plumbing Performance Verification Supervisor with ten years experience in plumbing contracting. The Plumbing Performance Verification Supervisor shall become familiar with the Owner's project requirements and the requirements of the performance verification process as defined in this section. The Plumbing Performance Verification Supervisor shall coordinate and execute the required performance verification activities.

B. The Plumbing Performance Verification Supervisor shall review submittal data for conformance with the requirements of the Project, shall monitor compliance with the requirements specified herein for storage and protection of equipment during construction, shall authorize the initial starting of equipment and systems in a manner to avoid damage to equipment, shall oversee start-up, testing and balancing, and shall document that the scheduled and specified performance requirements of each system have been accomplished.

C. Refer to ASHRAE Guideline 0.2-2015, Commissioning Process for Existing Systems and Assemblies, and Guideline 4-2008 (RA 2013), Preparation of Operating and Maintenance Documentation for Building Systems.

1.3 PERFORMANCE VERIFICATION RESPONSIBILITIES

A. The Plumbing Performance Verification Supervisor shall be responsible for scheduling, supervising, and coordinating and executing the start-up, testing, and performance verification activities as specified herein. Include and itemize the cost of performance verification in the contract price, and in each purchase order or subcontract written, include requirements for

submittal data, performance verification efforts and documentation, operations and maintenance data, and training as specified herein.

B. Plumbing performance verification shall take place in three phases. Performance verification requirements for each phase are as follows:

1. Construction Phase:

a. Attend a performance verification scoping meeting and additional such meetings, initially scheduled monthly until prefunctional testing of equipment and systems begins, and weekly thereafter during the construction phase to facilitate the performance verification process. The Plumbing Performance Verification Supervisor shall coordinate meeting attendance.
b. Report in writing to the Architect, at least as often as performance verification meetings are scheduled, concerning the status of plumbing activities as they affect the performance verification process, the status of each discrepancy identified the prefunctional and functional testing process, explanations of any disagreements with the identified deficiencies, and the proposed resolution and schedule for correction of the deficiency.
c. Provide documentation of installed systems and equipment, and develop functional testing procedures. This documentation shall include detailed manufacturer installation, start-up, operating, troubleshooting and maintenance procedures; full details of any Owner-contracted tests; pump curves; full factory testing reports, if any; and full warranty information, including responsibilities of the Owner to keep the warranty in force. In addition, the installation, start-up and check-out materials that are actually shipped inside the equipment and the actual field check-out sheet forms to be used by the factory or field technicians shall be submitted to the Owner.
d. Develop and submit to the Owner for review and comment, prior to equipment or system start-up, a complete start-up and initial check-out plan using manufacturer's start-up procedures and prefunctional checklists for the performance of the equipment to be verified.
e. Assist in clarifying the proposed operation and control of equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
f. Prepare the specific functional test procedures as specified herein and review the proposed functional test procedures to ensure feasibility, safety, and equipment protection, and provide necessary written alarm limits to be used during the tests. Obtain Owner approval for proposed functional test procedures.
g. Prepare a preliminary schedule for performance verification activities, including pipe and system pressure and leakage testing, flushing and cleaning, equipment start-up, and testing, and update the schedule during the construction period, as appropriate. Notify the Owner immediately when the performance verification activities not yet performed or not yet scheduled will delay construction.
h. Plumbing equipment start-up shall not be initiated until completion of pressure and leakage testing and cleaning as specified in other Sections of Division 22.
i. Provide start-up and prefunctional testing for equipment and execute the plumbing-related portions of the prefunctional checklists for the verification of the performance of all the equipment during the start-up and initial check-out process.
j. Perform and document start-up and system operational check-out procedures, providing a copy to the Owner.

k. Correct noncompliance items before beginning functional performance testing. Water testing and adjusting shall be completed with discrepancies and problems remedied before functional testing of the respective water-related systems.

2. Acceptance Phase:

a. Place equipment and systems into operation and continue their operation during each working day of the testing, adjusting and balancing, and performance verification activities, as required.
b. For each system or area, have required prefunctional checklists, calibrations, start-up and prefunctional tests of the plumbing systems and associated controls completed prior to beginning the testing, adjusting and balancing process.
c. Provide skilled technicians to execute starting and prefunctional testing of equipment and to execute the functional tests for each individual piece of equipment and system. Technicians shall be available and present during the agreed upon scheduled tests and for sufficient duration to complete the necessary tests, adjustments and problem-solving.
d. Perform functional testing for specified equipment and interpret the test data, as necessary.
e. Correct deficiencies (differences between specified and observed performance) as identified by the Plumbing Performance Verification Supervisor and interpreted by the Architect and retest the equipment, as required to demonstrate proper operation and performance.
f. Prepare operation and maintenance manuals as specified herein, including clarifying and updating the original sequences of operation to as-built conditions.
g. Maintain marked-up record drawings and produce final record drawings of Project drawings and contractor-generated coordination drawings. List and identify on these record drawings the locations of control system components, and sensor installations that are not equipment mounted.
h. Provide specified training of the Owner's operating personnel.
i. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

3. Warranty Period:

a. Execute deferred functional testing.
b. Correct deficiencies and make necessary adjustments to operations and maintenance manuals and as-built drawings system or equipment modifications made during the warranty period and those identified in any deferred functional performance testing.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Standard testing equipment required to perform start-up, initial check-out, prefunctional, and required functional testing shall be provided for the equipment or system being tested.

B. Test equipment shall be of the quality and accuracy required to test and/or measure system performance with the tolerances specified and shall have been calibrated within the last 12 months, or as specified herein. Equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates available on request.

1. Temperature sensors and digital thermometers shall have a certified calibration within the past 12 months and a resolution of ±0.1ºF. Accuracy of temperature test equipment shall be at least twice that of the instrumentation being tested.
2. Pressure sensors shall have a certified calibration within the 12 months and a resolution of 0.05% of sensor range. Accuracy of pressure test equipment shall be at least twice that of the instrumentation being tested.
3. Accuracy of other sensors shall be at least twice that of the instrumentation being tested.

PART 3 - EXECUTION

3.1 SUBMITTALS

A. Submit additional documentation as required to support the performance verification process. This additional submittal documentation shall include, at a minimum, the proposed start-up and initial check-out procedures, and prefunctional checklists.

3.2 START-UP PLAN AND PREFUNCTIONAL TESTING

A. Prefunctional testing shall be required for each piece of equipment to ensure that the equipment and systems are properly installed and ready for operation, so that functional testing may proceed without delays. Follow the approved start-up, initial check-out, and prefunctional testing procedures. Sampling strategies shall not be used for prefunctional testing. The prefunctional testing for equipment and subsystems of a given system shall be successfully completed and documented prior to functional testing of the system.

B. Procedures for performance verification shall include:

1. Start-up and initial check-out plan: develop the detailed start-up and prefunctional testing plans for equipment and systems that are to be performance verified, as specified herein. Review the proposed procedures and prefunctional testing documentation to ensure that there is written documentation that each of the manufacturer-recommended procedures have been completed.
2. The start-up and initial check-out plan shall consist, as a minimum, of the following:

a. The manufacturer's standard written start-up and check-out procedures copied from the installation manuals and manufacturer's normally used field check-out sheets. The plan shall include checklists and procedures with specific boxes or lines for recording and documenting the checking and inspections of each procedure and a summary statement with a signature block at the end of the plan.
b. First-run checklist for equipment, including:

1) Equipment properly set.
2) Alignment of shafts and couplings.

3) Adjustment of vibration isolators.
4) Piping and equipment properly connected.
5) Completion of initial lubrication procedures.
6) Wiring properly connected.
7) Electrical overload relays appropriate for load.
8) Electrical accessories properly installed and adjusted.
9) Controls, safeties, and time switches properly set.
10) Verification of direction of motor rotation after final electrical connections by jogging motor.
11) Measurement of ampere draw of electric motors and comparison with nameplate rating and with overload heater ratings.
12) Monitoring of temperature build-up in motors and bearings.

c. Contractor-developed prefunctional checklists.

3. Identify which entity is responsible for executing and documenting each of the line item tasks and note that trade on the form. Each form may have more than one trade responsible for its execution.

C. Four weeks prior to start-up, schedule equipment and systems start-up and check-out and notify the Architect in writing. The execution of the prefunctional checklists, start-up and check-out shall be directed and performed by the Contractor, in accordance with manufacturer's published procedures. The Architect shall be present for the start-up, check-out, and prefunctional testing of the first unit of each type of equipment, and any other tests he designates.

D. Sensor calibration: calibration of sensors associated with a given piece of equipment or system shall be included as part of the prefunctional testing and listed on the appropriate test checklists and reports for the system.

E. Completed start-up, check-out, and prefunctional test forms shall be completed and submitted to the Architect for review. List outstanding items of the initial start-up and prefunctional procedures that were not completed successfully, at the bottom of the procedures form or on an attached sheet. The procedures form and any outstanding deficiencies shall be provided to the Architect within 2 days of test completion. The Architect shall review the Contractor's start-up and prefunctional testing reports and shall submit either a noncompliance report or an approval form to the Contractor. The Contractor shall correct items that are deficient or incomplete in the checklists and tests in a timely manner, and shall notify the Architect as soon as outstanding items have been corrected and resubmit an updated start-up report and a statement of correction on the original noncompliance report. When requirements are completed, the Architect shall recommend approval of the start-up and prefunctional testing of each system and schedule the functional testing of the equipment or system.

F. Complete start-up and prefunctional testing for a system before functional test of that system may proceed.

3.3 RETESTING OF EQUIPMENT AND/OR SYSTEMS

A. Provide labor and materials required for retesting of any functional test found to be deficient.

B. Prior to retesting, submit required data indicating that the deficient items have been completed and/or corrected to the Architect for approval and rescheduling of the functional test. If during the retesting it becomes apparent that the deficient items have not been completed and/or corrected as indicated in the data provided by the Contractor, the retesting shall be stopped. Costs for the design team to further supervise the retesting of a functional test shall be the responsibility of the Contractor.

3.4 DEFERRED TESTING

A. Schedule and coordinate, with the approval of the Architect, tests delayed until building construction is completed, required building occupancy or loading, weather, or other conditions are suitable for the demonstration of equipment or system's performance, as specified herein. Deferred testing shall be executed, documented, and deficiencies corrected as specified herein for functional testing.

3.5 TESTING DOCUMENTATION, NONCONFORMANCE, AND APPROVALS

A. List outstanding items of the initial start-up and prefunctional procedures that were not completed successfully, at the bottom of the functional test procedure forms or on an attached sheet. The functional test procedure forms and any outstanding deficiencies shall be provided to the Architect within 2 days of test completion. The Architect shall review the Contractor's start-up and prefunctional testing documentation and shall submit either a noncompliance report or an approval form to the Contractor. Work with the Architect to correct and retest deficiencies or uncompleted items. Correct items that are deficient or incomplete in a timely manner, and notify the Architect as soon as outstanding items have been corrected and resubmit an updated start-up report and a statement of correction on the original noncompliance report. When requirements are completed, schedule the functional testing of the equipment or system.

B. As functional performance testing progresses and deficiencies are identified, work with the Architect to resolve the issues.

3.6 OPERATION AND MAINTENANCE MANUALS

A. The Plumbing Performance Verification Supervisor shall compile and prepare documentation for equipment and systems covered in Division 22 and deliver this documentation for inclusion in the operation and maintenance manuals prior to the training of the Owner's personnel.

3.7 INSTRUCTION OF OPERATING PERSONNEL

A. The Plumbing Performance Verification Supervisor shall schedule, coordinate and assemble, and deliver the documentation of training required by Division 22.

3.8 FUNCTIONAL TESTS

A. Functional test requirements for the demonstration of proper system and equipment operation shall be defined by the Plumbing Performance Verification Supervisor. Execution of these test and demonstration of the required performance shall be the responsibility of the Contractor.

B. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems or subsystems at the discretion of the Plumbing Performance Verification Supervisor. Beginning system testing before full completion of construction shall not relieve the Contractor from fully completing the system, including prefunctional checklists.

C. Functional testing shall be completed and test documentation approved by the Architect before the Project will be considered substantially complete.

END OF SECTION 220090

SECTION 222500 - PLUMBING INSULATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other plumbing systems are specified in other Sections of Division 22.

B. Refer to Section 220010, Plumbing General, for a list of plumbing Sections included in this specification.

C. This Section covers thermal insulation for plumbing piping and equipment.

D. Items not to be insulated:

1. Chrome plated water supplies to plumbing fixtures. See Section 224200, Plumbing Fixtures for insulation of water supplies to ADA fixtures.
2. Underground domestic cold water piping.
3. Vents from pressure relief valves.
4. Rainwater and secondary (emergency overflow) rainwater piping in parking decks.

1.2 QUALITY ASSURANCE

A. Conform to the following:

1. International Energy Conservation Code-2009.
2. International Plumbing Code-2015 with South Carolina Modifications.

B. Products of the manufacturers listed will be acceptable for use for the specific functions specified herein. Materials shall be compatible with the materials to which they are applied, and shall not corrode, soften or otherwise attack such material in either the wet or dry state.

C. Materials shall be applied subject to their temperature limits. Methods of application of insulating materials or finishes not specified in detail herein shall be in accordance with the particular manufacturer's published recommendations.

D. Insulation shall be applied by experienced workers regularly employed for this type of work.

1.3 RATINGS

A. Insulation and accessories, unless specifically excepted herein, shall have a maximum composite flame spread rating of 25 and a maximum smoke developed rating of 50. Materials that are factory-applied shall be tested as assembled. Materials which are field-applied may be tested individually. No fugitive or corrosive treatments shall be employed to impart flame resistance.

B. Flame spread and smoke developed ratings shall be in accordance with ASTM E84-2018. Products or their shipping cartons shall bear a label indicating flame spread and smoke developed ratings.

C. Treatment of pipe jackets to impart flame and smoke safety shall be permanent. The use of water-soluble treatments is prohibited.

D. Vapor retarders shall have a maximum permeance of 0.02 perm at 73.4°F.

1.4 ALTERNATE THICKNESSES

A. Specified thicknesses may be increased or reduced for insulation materials having thermal resistivity, K-values, different from those listed. Submit calculations in accordance with ASHRAE/IES 90.1-2016, and documentation of product performance.

PART 2 - PRODUCTS

2.1 INSULATION

A. Fiberglass Pipe and Blanket Insulation:

1. Pipe insulation: maximum K-value for preformed pipe insulation: 0.23 Btu·in/(h·ft²·°F) at 75°F.

a. Manufacturer: CertainTeed, Johns Manville, Knauf, Manson Insulation, or Owens Corning.

2. Blanket insulation: maximum K-value for blanket insulation: 0.28 Btu·in/(h·ft²·°F) at 75°F.

a. Manufacturer: CertainTeed, Johns Manville, Knauf, Manson Insulation, or Owens Corning.

B. Flexible Elastomeric Tubing Insulation:

1. Insulation: flexible closed-cell elastomeric tubing insulation, plenum rated per ASTM E84-2018 with low VOC, and CFC-free. Thermal conductivity (K-value) at 75°F 0.25 Btu·in/(h·ft²·°F).
2. Fittings: tube miter-cut, and/or factory fabricated.
3. Joints and seams: contact adhesive.
4. Manufacturer: Aeroflex Aerocel, Armacell AP Armaflex and AP Armaflex FS, or K-Flex Insul-Tube.

2.2 ACCESSORIES

A. Adhesives and Mastics:

1. Manufacturer: Aeroflex, Armacell, Childers, Epolux, Foster, Marathon, Pittsburg Corning PC 88, Pittsburgh Corning Pittcote 300 (interior) or 404 (exterior), or Vimasco.

B. Insulating Cement:

1. Mineral wool type, asbestos free, maximum K-value of 0.20 Btu·in/(h·ft²·°F) at 75°F.
2. Manufacturer: Industrial Insulation Group CalCoat-127, or Ramco Ramcote 1200.

C. Glass fabric: 10 x 10 threads per square inch construction white fiberglass scrim fabric.

D. Tape: pressure sensitive, foil-scrim-kraft backed.

E. PVC Fitting Jackets:

1. High impact, UV resistant, 30 mil thick, white polyvinyl chloride (PVC) fitting jackets with formaldehyde-free insulation inserts, and stainless steel attachments. Provide additional insulation inserts as required for larger pipes. Flame and smoke ratings shall comply with Paragraph 1.04, Ratings.
2. Manufacturer: Johns Manville Zeston 2000 PVC, or Knauf Proto.

F. Coal Tar:

1. Self-priming, cold-applied type.
2. Manufacturer: Koppers Bitumastic 50.

2.3 ALUMINUM JACKETING

A. Piping where indicated on drawings: corrugated aluminum jackets, 0.016" thick with an embossed finish, and a factory heat laminated 3 mil moisture retarder film on the inner surface, and meeting ASTM B209-2014.

B. Fittings: stamped 2-piece (matching halves) aluminum fitting covers and end caps, 0.024" thick, with a factory heat lamination moisture retarder film on the inner surface.

PART 3 - EXECUTION

3.1 GENERAL

A. Surfaces to be insulated shall be clean, dry, and free of foreign material, rust, scale and dirt when insulation is applied.

B. Perform pressure and leakage tests and submit results required by other Sections before applying insulation.

C. Where existing insulation is damaged due to the new work, repair damage to match existing work or replace damaged portion with insulation specified for new work.

D. On piping where temperature maintenance cable is specified, to ensure the insulation's adequate fit, increase the insulation size as required to comply with the cable manufacturer's installation instructions.

3.2 INSULATION FOR TEMPERED, HOT, AND HOT WATER CIRCULATING PIPE

A. Insulate the following pipe with preformed fiberglass pipe insulation of the thickness indicated, with vapor retarder and white all service jacket with self-sealing lap:

		Insulation Thickness, Inches	
	Fluid Design Operating Temperature Range, °F	Pipe Sizes 0.5"- 1.25"	1.5"- 6"
Tempered water and tempered water circulating	85 to 109	1	1
Hot water and hot water circulating	110 to 140	1	1.5

1. Install insulation with jacket drawn tight and side laps and end joint butt strips secured. End joint butt strips shall be minimum 3" wide and of material identical to jacket. Seal ends of insulation at fittings, valves, and riser clamps.

B. Insulate fittings, flanges, strainers, and valve bodies with packing nut and stem left open, with preformed or mitered fiberglass. Wire fiberglass in-place and cover with a smoothing coat of insulating cement. Finish with glass fabric embedded into a coat of white breather mastic. Glass fabric shall overlap adjoining insulation at least 2".

1. Cover exposed fittings with glass fabric and mastic.

C. Do not insulate unions.

3.3 INSULATION FOR COLD PIPE

A. Insulate the following pipe with preformed fiberglass pipe insulation of the thickness indicated, with vapor retarder, white all service jacket, and self-sealing lap:

Domestic cold water above grade, 0.5" thick.
Water cooler waste, trap, and waste arm to vertical stack, 1" thick.
Branch waste, including drain and P-trap, receiving drainage from air conditioning and boiler equipment, and cooler/freezer equipment, 1.5" thick.
Exposed horizontal rainwater, and secondary (emergency overflow) rainwater, (not in parking deck) including connections to roof drains and vertical leaders within the top floor, 1" thick.

1. Install insulation with jacket drawn tight with side-laps and end joint butt strips secured. End joint butt strips shall be same material as jacket, and not less than 3" wide. Seal ends of insulation at fittings, valves, and riser clamps.

B. Insulate fittings, flanges, strainers, and valve bodies with packing nut and stem left open, with preformed or mitered fiberglass. Wire fiberglass in-place and vapor seal with a layer of glass fabric embedded between two 0.063" coats of white vapor retarder mastic. Glass fabric shall overlap adjoining insulation at least 2".

C. Do not insulate unions.

D. Insulate the following pipe with preformed flexible elastomeric insulation, 0.5" thick for piping 2" and smaller, and 0.75" for piping 2.5" and larger:

Cold water piping in parking deck.

1. Insulation shall be slipped on before pipe joints are made up, held back from hot joints and joints cemented with contact adhesive.
2. Insulate fittings, flanges, and valve bodies with packing nut and stem left open, with multiple layers of flexible elastomeric tape, totaling 0.5", finished with 2 coats of white vinyl coating.
3. Do not insulate unions.

E. Insulate the following pipe with 1 pcf density, fiberglass blanket with foil-scrim-kraft facing:

Concealed horizontal rainwater and secondary (emergency overflow) rainwater (not in parking deck) to 48" down into the vertical, including connections to drains and drain under bodies, 1" thick.

1. Seal joints, breaks, and punctures with tape provided by the insulation manufacturer.
2. Secure joints along pipe runs with nonferrous wire 9" on center.

3.4 ACCESSORIES

A. Adhesives and Mastics:

1. Seal open ends of insulation with a thick mastic coating.

B. Insulating Cement:

1. Install a minimum 0.5" thick coat with a smooth finish, and even with the adjacent insulation.

C. Glass Fabric:

1. For piping fittings and valves use tape form and for water storage tanks use sheet form.

D. Tape:

1. When applied to jacket insulation, wrap tape as tight as possible without crushing the insulation jacket.

E. Fitting Jackets:

1. Installation in mechanical rooms and exterior locations only.

F. Coal Tar:

1. Apply to underground piping to:

a. Isolate copper from masonry or concrete flooring.

b. Repair slightly damaged pipe-wrap for gas piping.
c. Repair slightly damaged cellular glass insulation jacketing.

3.5 INSTALLATION

A. Install insulation after piping has been tested and approved.

B. Insulation shall be clean and dry during installation and during application of any finish.

C. Provide removable and replaceable covers on equipment, and removable ends of strainers requiring insulation, that must be opened periodically for inspection, cleaning, or repair.

D. Install insulation materials with smooth and even surfaces, jackets drawn tight and cemented down smoothly at longitudinal and end laps. Do not use scrap pieces of insulation where a full length section will fit.

E. Install insulation, jackets and coatings continuous through openings and sleeves in nonrated construction. For penetrations of fire- or smoke-rated construction, insulation shall be butted tightly against firestops specified in Section 220010, Plumbing General. Tape butt joints.

F. Banding wires shall have the twisted terminals turned down toward the insulation without damaging the vapor retarder.

3.6 INSULATION PROTECTION

A. Protect interior fiberglass piping insulation exposed to damage with a corrugated aluminum jacket. Locate the longitudinal joints to shed water, and secure with aluminum bands at end joints and every 12" on center. Tightly abut end joints together. Install aluminum fitting-covers over fittings, overlapping the adjacent butt ends of the piping's aluminum jacket. Secure with aluminum bands.

B. Protect exterior piping insulation, except flexible elastomeric, with a corrugated aluminum jacket. Locate the longitudinal joints to shed water, and secure with aluminum bands at end joints and every 12" on center. Provide a 2" overlap at each end joint and seal with joint sealant. Install aluminum fitting-covers over fittings, overlapping the adjacent butt ends of the piping's aluminum jacket. Seal with joint sealant, and secure fitting covers with aluminum bands.

C. Protect exterior flexible elastomeric insulation with a UV resistant white acrylic latex coating.

END OF SECTION 222500

SECTION 224200 - PLUMBING FIXTURES

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other mechanical systems are specified in other Sections of Division 22.

B. Refer to 220010, Plumbing General, for a complete list of plumbing sections included in this specification.

C. This Section covers plumbing fixtures, trim and related equipment.

1.2 QUALITY ASSURANCE

A. Conform to the following:

1. All applicable codes referenced in 220010, Plumbing General.
2. ICC A117.1-2017 for Accessible and Usable Buildings and Facilities.
3. Americans with Disabilities Act (ADA) - 1990 (Revised 2008).
4. Safe Drinking Water Act-2016.
5. Wetted components in the potable water (fixture) system, where the water is anticipated for human consumption shall comply with the Reduction of Lead in Drinking Water Act - 2011.

1.3 PLUMBING FIXTURES - GENERAL

A. Fixtures shall have smooth impervious surfaces, free from defects with no concealed fouling surfaces, and be Grade-A quality. Fixtures shall comply with ASME A112.19.1/CSA B45.2-2013, ASME A112.19.2/CSA B45.1-2013, ASME A112.19.3/CSA B45.4-2017, and ASME A112.19.5/CSA B45.15-2017. The name or trademark of the manufacturer is required to be printed on or pressed into the fixtures. In addition, a label which cannot be removed without destroying it, containing the manufacturer's name or trademark, and the quality or class of the fixture, shall be affixed to fixtures and not removed until after the work is accepted.

B. Exposed waste and supply piping, including piping exposed when millwork doors are open, and mounting bolts of fixtures shall be chromium-plated.

C. All faucets, flush valves, and associated trim shall be chromium-plated.

D. Fixtures and trim of the same construction shall be by the same manufacturer, e.g., vitreous china, water fountains, stainless steel, flush valves, and supplies, etc., unless otherwise specified herein.

E. Vitreous china fixtures shall be white.

F. Plumbing fixtures shall be complete, with installation, and all fittings, trim, and equipment to provide for proper operation and usage, as defined by the product manufacturers, industry standards, and applicable codes.

G. Plumbing Fixtures basis of design shall be by Toto USA.

PART 2 - PRODUCTS

2.1 WATER CLOSETS AND TRIM

A. Fixtures:

1. F1A, Water Closet - Wall Type, Flush Valve, Regular Use:

a. Elongated vitreous china wall type, with siphon jet bowl, flush valve and trim for 1.6 gal per flush, seat, chair carrier, and chromium-plated nuts and washers.
b. Manufacturer: American Standard 2237.001, Kohler K-4325, Sloan ST-2459-A, or Toto CT708E.

2. F1B, Water Closet - Wall Type, Flush Valve, ADA Use:

a. Elongated vitreous china wall type, with siphon jet bowl, flush valve and trim for 1.6 gal per flush, seat, chair carrier, and chromium-plated nuts and washers.
b. Manufacturer: American Standard 3351.001, Kohler K-4325, Sloan ST-2459-A, or Toto CT708E.

B. Flush Valves:

1. Flush Valve - Sensor, 1.6 GPF, EcoPower: , Water Closets F1A:

a. 1.6 gal per flush, with self-powered hydroelectric flush valve system, heavy-duty stainless steel cover plate with satin finish and solid bronze valve body, self-cleaning piston, manual flush override, smart senor with self-adjusting detection range, concealed flush valve with 1” angle stop and vacuum breaker.
b. Manufacturer: Toto TET2GA

2. Flush Valve - Sensor, 1.6 GPF Hard-Wired, Trap Primer, Water Closets F1B:

a. 1.6 gal per flush, with self-powered hydroelectric flush valve system, heavy-duty stainless steel cover plate with satin finish and solid bronze valve body, self-cleaning piston, manual flush override, smart senor with self-adjusting detection range, concealed flush valve with 1” angle stop, trap primer connection and vacuum breaker.
b. Manufacturer: Toto TET2GA

C. Water Closet Seats:

1. Seat - Elongated, Extra Heavy Weight, Water Closets F1A/F1B:

a. Solid high impact plastic with open front seat, stainless steel posts, washers and nuts, and self-sustaining check hinges.
b. Manufacturer: Bemis 1955SSCT, Beneke 527SS, or Church 29500SSCT.

D. Floor-Mounted Carriers:

1. Carrier - Commercial Type:

a. For wall-hung water closets: commercial type with a 500 lb supported weight capacity, adjustable vertically and horizontally from the faceplate, with base support, adjustable coupling, gasket, and chromium-plated through-bolts and acorn nuts.
b. Manufacturer: Josam, Smith, Wade, or Zurn.

2. Carrier - Heavy Duty Type:

a. For wall-hung water closets: heavy duty type with a 1000 lb supported weight capacity, adjustable vertically and horizontally from the faceplate, with base support, adjustable coupling, gasket, and chromium-plated through-bolts and acorn nuts.
b. Manufacturer: Smith, Wade, or Zurn.

2.2 LAVATORIES AND TRIM

A. Fixtures:

1. F2A, Lavatory - Countertop Type, Regular/ADA Use:

a. Vitreous china lavatory, nominal 20"x17" oval with 4" centers and fitted with faucet, supplies with stop valves, grid drain, P-trap, waste to wall, and escutcheons.
b. Manufacturer: American Standard 0476.028, Kohler K-2196, Sloan SS-3002, or Toto LT501.4.

B. Faucets:

1. Faucet - Electronic, EcoPower, Curved Spout, Regular/ADA Use, Lavatories F2A:

a. Self-generating hydropowered EcoPower system, micro-senor faucet, vandal resistant aerator, chrome plated, smart senor with self-adjusting sensor, single hole mount. Provide each faucet with water mixing valve for nominal104ºF outlet temperature, cold and hot water inlets, integral checks, waterproof electronics with 10 sec wash cycle.
b. Manufacturer: Toto TEL125

C. Supplies:

1. Supplies - Loose-key Control, Lavatories F2A:

a. Angle stops with 0.5" id x 5" inlet sweat tube, bell escutcheon, loose key control, 0.375" od x 12" flexible tube riser, and chromium-plated exposed piping and parts.
b. Manufacturer: Just JL26K, Keeney 2100PCLK12LF, McGuire LF170LK ECO, or Zurn Z8808-XL-LRLK.

D. Drains:

1. Drain - Grid Type, Lavatories F2A:

a. Grid type with chromium-plated cast brass top and strainer, and 1.25" 17 gauge tailpiece.
b. Manufacturer: Just JSG7, Keeney 5680PCCR, McGuire 155A ECO, or Zurn Z8743-PC.

E. P-traps:

1. P-trap - 1.25”, Cleanout Plug, Lavatories F2A:

a. 1.25" tubular chromium-plated brass, with cast brass slip nuts, cleanout plug, minimum 2" water seal, 17 gauge tubing drain to wall, and wall flange.
b. Manufacturer: Just JT125, McGuire 8872 ECO, or Zurn Z8701-9.

F. ADA Insulation:

1. ADA Insulation - ADA Fixtures, Lavatories F2A:

a. White molded closed-cell vinyl, 3-piece set for drain tailpiece, P-trap, and waste arm to wall, and two 2-piece sets for the cold and hot water supply stops, and risers.
b. Manufacturer: Insul-Tect I-T 101 and/or I-T 102, McGuire PW2125 and/or PW2150, Plumberex Handy-Shield MaXX, Pro Flo PF202WH, or Truebro 102 E-Z.

G. Floor-mounted Carriers:

1. For wall-hung lavatories: floor-mounted commercial type, with concealed arm supports.

a. Manufacturer: Josam, Smith, Wade, or Zurn.

2.3 URINALS AND TRIM

A. Fixtures:

1. F 3A, Urinal - Wall Type, 0.125 GPF, Regular Use:

a. Vitreous china wall type with washout bowl, extended shields, flushing rim, top spud flush valve and trim for 0.125 gal per flush, and floor-mounted carrier.
b. Manufacturer: American Standard 6590.001, Kohler K-4904-ET, Sloan SU-1009-A, or Toto UT105U.

2. F3B, Urinal - Wall Type, 0.125 GPF, ADA Use:

a. Vitreous china wall type with washout bowl, extended shields, flushing rim, top spud flush valve and trim for 0.125 gal per flush, and floor-mounted carrier.
b. Manufacturer: American Standard 6590.001, Kohler K-4904-ET, or Sloan SU-1009-A, or Toto UT105U.

B. Flush Valves:

1. Flush Valve - Sensor, EcoPower, 0.125 GPF, Regular/ADA Use, Urinals F3A/F3B:

a. 0.125 gal per flush, self-powered hydroelectric flush valve system, neutral rough-in and adjustable tail piece connection, manual override, 6-sec detection, smart senor with self-adjusting detection range, brushed stainless steel finish, ADA compliant.
b. Manufacturer: Toto TEU3UA

C. Floor-mounted Carriers:

1. Carrier - Commercial Type:

a. For wall-hung urinals: dual post with cross bracing, floor-mounted pads, and hanger plates.
b. Manufacturer: Josam, Smith, Wade, or Zurn.

2.4 WATER FOUNTAINS AND TRIM

A. Fixtures:

1. F4A, Water Fountain - Wall Hung, Bi-Level, Refrigerated, Bottle Filler, Regular/ADA Use:

a. Wall hung electric water cooler, packaged as a single unit, with stainless steel panels, regular and barrier-free stainless steel tops, refrigeration unit, sensor activated bottle filling station with 1.0 gpm laminar flow located over the ADA unit, chrome plated bubbler heads with guards, self-closing push bar valves, supply with stop valve, P-traps, waste to wall, escutcheons, and mounting frame. Units shall be certified in accordance with NSF 61-2017.
b. Manufacturer: Elkay EZSTL8WSSK, Halsey Taylor HTHB-HAC8BLSS-ADA, or Oasis PG8EBFSL.

B. Supplies:

1. Angle stops with 0.5" sweat inlet, 0.375" od outlet, 0.375" od flexible tube riser, and wall escutcheon. Exposed piping and parts shall be chromium-plated.
2. Manufacturer: Just JVA22, Keeney 2048PCL12LF, or McGuire LF2165 ECO.

C. P-traps:

1. 1.25", 17 gauge tubular chromium-plated brass, with tubing drain to wall, wall flange, cast brass slip nuts, and cleanout plug.
2. Manufacturer: Just JT125, Keeney 5303PC866CR, McGuire 8872 ECO, or Zurn Z-8701-9.

2.5 SERVICE SINKS AND TRIM

A. Fixtures:

1. F5, Service Sink - Floor Type:

B. Terrazzo neo-corner service sink, 24"x24"x12", with cast integral drain, 6" drop front with stainless steel rim guard over drop, wall hung faucet, hose with wall bracket, wall-mounted mop bracket, and stainless steel wall guard.

C. Manufacturer: Fiat TSBC-1610, Florestone 96-24x24, or Stern-Williams SBC-1700.

D. Faucets:

1. Chromium-plated with hose thread outlet, pail hook, vacuum breaker, integral checks, stop valves in shanks, and wall support.
2. Manufacturer: Chicago 540-LD897SGXKCCP, T&S B-0665-BSTP, or Zurn Z843M1-XL-CS.

E. P-traps:

1. For floor type service sinks: 3" cast iron.
2. For wall-hung service sinks:

a. Deep seal, cast iron chemical resistant type, with grid strainer, and cleanout plug.
b. Manufacturer: Kohler K-6673, or Smith 9120.

F. Hose and Brackets:

1. 0.625" outside diameter x 36" long, heavy duty black hose with 0.75" coupling, and wall-mounted stainless steel hose bracket with spring loaded rubber grip.
2. Manufacturer: Fiat 832-AA, Florestone MR-370, or Stern-Williams T-35.

G. Mop Hangers:

1. 24" long stainless steel with 3 spring loaded rubber mop handle grips.
2. Manufacturer: Fiat 889-CC, Florestone MR-372, or Stern-Williams T-40.

H. Wall Guards:

1. One 24" and one 36" wide x 12” high, polished 20 gauge, type 304 stainless steel panels.
2. Manufacturer: Fiat MSG-2436, Florestone MR-377, or Stern-Williams BP.

2.6 COUNTER SINKS AND TRIM

A. Fixtures:
1. F6A, Sink - Stainless Steel, Two Bowls, ADA Use:

a. Self-rimming 18 gauge type 304 stainless steel sink, 19"x33"x6", two compartment with 3-hole punch, faucet, supplies with stop valves, rear drains, continuous waste, P-trap, waste to wall, and escutcheons.

b. Manufacturer: Elkay LRAD-3319, or Just DL-ADA-1933-A-GR.

B. Faucets:

1. Faucet – Gooseneck Spout, Dual Lever, Regular/ADA Use: , Sinks F6A:

a. Swing gooseneck type with 8" spread in spout, polished chromium-plated with double 4" brass blade handles, color-coded indexes, ceramic cartridges, 0.5" rigid brass inlet shanks on rigid 8" centers, and 1.5 gpm vandal resistant aerator flow control.

b. Manufacturer: Chicago 201-AGN8AE35VP317VPABCP, T&S B-2862-B-199-7-CR-WS, or Zurn Z-831C4-2F-ICT-23F.

B. Supplies:

1. Supplies – Angle Type, Loose Key: Sinks F6A:

a. Angle stops with 0.5" id x 5" inlet sweat tube, bell escutcheon, loose key control, 0.5" od x 12" flexible tube riser, and exposed piping and parts chromium-plated.

b. Manufacturer: Just JL27K, Keeney 2780PCLKL12LF, or McGuire LF171LK ECO.

C. Strainers:

1. Strainer - Grid Type: Sinks F6A:

a. Chromium-plated finish brass body and flat strainer with brass lock nut, sealant washers, and 1.5" x 4" seamless 20 gauge tailpiece.

b. Manufacturer: Elkay LK18, Just JSF8W, Keeney 1376PC, McGuire 152 ECO, or Zurn Z8739-PC.

D. P-traps:

1. P-trap – 1.5”:

a. 1.5", tubular chromium-plated brass, with 17 gauge tubing drain to wall, wall flange, cast brass slip nuts, cleanout plug, and minimum 2" water seal.

b. Manufacturer: Just JT150, Keeney 5307PC867CR, McGuire 8912 ECO, or Zurn Z8702-9-B.

E. Continuous Waste:

1. Continuous Waste – 1.5”: Sinks F6A:

a. Continuous waste for multiple bowl counter sinks: chromium-plated 1.5", 17 gauge tubing.

b. Manufacturer: Just JWCH150, Keeney 1569SN, McGuire 113CG17 series, or Zurn Z8750 series.

F. ADA Insulation:

1. ADA Insulation – Waste and Supplies: Sinks F6A:

a. Insulation kit for ADA locations: white molded closed-cell vinyl, 3-piece set for tailpiece, P-trap, and waste arm, and two 2-piece sets for supply stops, and risers.

b. Manufacturer: Insul-Tect I-T 101 and/or I-T 102, McGuire PW2125 and/or PW2150, Plumberex Handy-Shield MaXX, Pro Flo PF202WH, or Truebro 102E-Z.

PART 3 - EXECUTION

3.1 PLUMBING FIXTURES AND TRIM - GENERAL

A. Fixtures:

1. Set fixtures level and in alignment with walls.
2. Caulk between fixtures and mounting surfaces with a white non-hardening mildew-resistant silicone sealant.
3. Install ADA fixtures in accordance with ICC A117.1-2017.
4. Reinforce the wall behind wall-hung fixtures with a galvanized steel plate bolted through the wall and sized for the fixture being installed, unless specified with floor-mounted carrier. Where back-plates are not possible, use minimum 0.375" diameter expansion or toggle bolts.

B. Trim:

1. Bolt chair carrier feet to the floor slab using all holes provided by the manufacturer. Carriers shall not depend upon wall construction or piping to prevent fixture movement.
2. Wrist blade handles on faucet fittings shall be aligned perpendicular to the spout when in the off position.
3. Faucets, shower valves, or flush valves used by ADA persons shall operate with less than a 5 psi operating force.
4. Set P-traps true and level. Tighten and secure all joints.
5. Locate transformers for hard-wired sensor flush valves and faucets as indicated on the Drawings. Provide all low voltage wiring in accordance with code, and coordinate for electrical power connections.

3.2 PLUMBING FIXTURES AND TRIM

A. Water Closets and Trim - (Series F1):

1. Fixtures:

a. Connect floor outlet water closets with cast iron PVC floor flanges. Make the joint between the closet outlet and the floor flange with a gasket.
b. Caulk cast iron closet connectors to the cast iron closet bend or straight closet connection.

2. Trim:

a. Install flush valves for ADA water closets with the handle manual override on the wide side of the toilet stall.
b. Where automatic sensor flush valves are installed, coordinate the distance from the bottom of the ADA grab bar and the highest portion of the flush valve to allow for cap removal and battery replacement.

c. Wrench tighten flush valve stop cover to limit vandalism.

B. Lavatories and Trim - (Series F2):

1. Fixtures:

a. For counter top installed lavatories, coordinate with counter top supplier for size of basin opening.
b. For under-mount lavatories, coordinate with counter top supplier for size of basin opening.

2. Trim:

a. Set the flow period for adjustable metering faucets at 15 seconds.
b. For under-mount lavatories, coordinate with counter top supplier for faucet holes. Coordinate for the faucet to be as close as possible to the basin, for best overhang and use of water spout.

C. Water Fountains and Trim - (Series F4):

1. Fixtures:

a. Anchor the bottom of wall-hung water fountains to the wall.

2. Trim:

a. Install stop valves for water fountains within the water fountain cabinet.
b. For electric water coolers, insulate the P-trap and waste to wall.

D. Service Sinks and Trim - (Series F5):

1. Trim:

a. Rough-in faucets for floor mounted service sinks at 30" above the floor.
b. Install wall hung mop hanger on adjacent wall to faucet, centered with fixture, and with bottom at 48" above the floor.
c.

E. Counter Sinks and Trim - (Series F6):

1. Fixtures:

a. For sinks installed in counter, coordinate with counter top supplier for size of opening.
b. For under-mount sinks, coordinate with counter top supplier for basin opening.

2. Trim:

a. For under-mount sinks, coordinate with counter top supplier for faucet holes. Coordinate for the faucet to be as close as possible to the basin, for best overhang and use of water spout.

3.3 FIXTURE TESTS

A. Test plumbing fixtures for soundness, stability of support, and operation.

B. Test fixture accessories for smooth operation of handles and hand wheels, and proper operation of flow.

C. Test flush valves for stability at the wall with no movement.

D. Test the hot water temperature at each plumbing fixture, and ensure that the correct temperature water is flowing from the system.

E. Flow all faucets and operate all flush valves until clear water is continuously observed.

3.4 WATERPROOF LINERS

A. Where waterproof liners are used with the building construction, secure to the plumbing drain body with the clamping ring, making a watertight connection.

B. Waterproof liners shall be specifically designed for shower pan construction.

C. Install liners in accordance with the manufacturer's installation instructions.

3.5 CLEANING

A. Clean plumbing fixtures and trim, and plumbing related fixtures, trim, and equipment, with a commercial grade disinfectant cleaner that will not damage the fixtures, trim, or equipment.

B. Open and clean all faucet aerators/strainers, and flush valve diaphragms/pistons of start-up film and construction debris.

END OF SECTION 224200

SECTION 224300 - DRAINAGE SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other plumbing systems are specified in other Sections of Division 22.

B. Refer to Section 220010, Plumbing General, for a list of plumbing Sections included in this specification.

C. This Section covers plumbing drainage, waste and vent systems.

1.2 QUALITY ASSURANCE

A. Conform to the following:

1. ICC A117.1-2017.
2. International Plumbing Code-2015 with South Carolina Modifications.

PART 2 - PRODUCTS

2.1 PIPING, FITTINGS, AND JOINTS

A. General:

1. Piping and fitting sizes listed are nominal inside diameter.

B. Soil, waste, vent, rainwater, and secondary rainwater, 15" and smaller, below slab-on-grade and extending to 5' outside:

1. Piping: hub and spigot cast iron, service weight, petroleum asphaltic-coated inside and out, ASTM A74-2017.
2. Fittings: hub and spigot cast iron, service weight, petroleum asphaltic-coated inside and out, ASTM A74-2017.
3. Joints: one-piece elastomeric compression gasket, ASTM C564-2014.

C. Soil, waste, vent, rainwater, and secondary rainwater, 10" and smaller, above slab-on-grade throughout the building:

1. Piping: no-hub cast iron, petroleum asphaltic-coated inside and out, ASTM A888-2018.
2. Fittings: no-hub cast iron, petroleum asphaltic-coated inside and out, ASTM A888-2018.
3. Joints:

a. Standard duty stainless steel couplings for drainage and vent piping to 4": mechanical compression type with neoprene collars conforming to ASTM C564-2014, type 301 or 304 stainless steel construction with shields (minimum 36 ga),

bands, clamps, and screws. Couplings shall conform to CISPI 310-2012 for 60 lbf·in torque and a maximum pressure test 6.0 psig.

1) Manufacturer: Ideal Standard, or Mission No-Hub Coupling.

b. Heavy duty stainless steel couplings for drainage and all rainwater piping 1.5" to 15": mechanical compression type with neoprene collars conforming to ASTM C564-2014, type 304 stainless steel construction with shields (minimum 28 ga), bands, clamps, and screws. Couplings shall conform to FM 1680-1989, Class 1 for 80 lbf·in torque and a minimum pressure test of 15 psig.

1) Manufacturer: Clamp-All 80, or Husky 4000.

D. Fixture drain connections from urinals:

1. Piping: polyvinyl chloride (PVC) DWV, ASTM D2665-2014.
2. Fittings: drainage pattern DWV PVC, ASTM D2665-2014.
3. Joints: solvent cement, ASTM D2564-2012.

E. Indirect drain, 1" and smaller:

1. Piping: copper tubing, type M, hard drawn, ASTM B306-2013.
2. Fittings: wrought copper, ASME B16.22-2017.
3. Joints: soldered with 95/5 tin/silver using a compatible flux, ASTM B813-2016 and NSF 61-2017.

F. Indirect drain, 1.25" and larger:

1. Piping: copper tubing, type DWV, hard drawn, ASTM B306-2013.
2. Fittings: drainage pattern DWV, ASME B16.29-2012.
3. Joints: soldered with 95/5 tin/silver using a compatible flux, ASTM B813-2016 and NSF 61-2017.

G. Pumped discharge from elevator and small sump pumps:

1. Piping: copper tubing type L, hard drawn, ASTM B88-2016.
2. Fittings: wrought copper, ASME B16.22-2013.
3. Joints: soldered with 95/5 tin/silver using a compatible flux, ASTM B813-2016.

H. Soil, waste, and rainwater, 4" to 15", from 5' outside the building:

1. Piping: hub and spigot cast iron, service weight, petroleum asphaltic-coated inside and out, ASTM A74-2017.
2. Fittings: hub and spigot cast iron, petroleum asphaltic-coated inside and out, ASTM A74-2017.
3. Joints: one-piece elastomeric compression gasket, ASTM C564-2014.

2.2 SPECIALTY PIPING JOINTS

A. Unions:

1. For copper piping 2" and smaller: cast bronze or cast copper with copper soldered or threaded connections.
2. For piping of dissimilar metals 2" and smaller: provide dielectric unions with solder or threaded connections, nylon insulators, minimum 600 V no flashover, and EPDM gaskets.

B. Flanges:

1. For piping 2.5" and larger: flange and gasket type. Flanges shall match connection flanges in style, material, and pressure rating.
2. For piping of dissimilar metals 2.5" and larger: provide dielectric flanges with solder or threaded pipe connections, EPDM gaskets. Flanges shall match connection flanges in style, material, and pressure rating.

2.3 P-TRAPS

A. For floor drains, and floor sinks: provide with trap primer connection in tail piece if not provided on drain body.

B. Exposed: provide with cleanout plugs.

C. For plumbing fixtures: as specified in Section 224200, Plumbing Fixtures.

2.4 CLEANOUTS

A. General:

1. Provide cleanout outlets as follows:

a. Floors above grade: no-hub, push-on or inside caulk.
b. Floors on grade: push-on or inside caulk.

B. Exterior piping: cast iron with adjustable housing, ABS cleanout plug, and round heavy duty scoriated cast iron tractor top, with "C.O." cast in and securing screws.

1. Manufacturer: Josam 56040, Smith 4245, Wade 6000-Z, or Zurn Z-1400-HD-IC.

C. Finished area floors: for piping 2" through 6", cast iron with internal cleanout plug, adjustable housing, and round polished nickel-bronze top with securing screws. For cleanouts in floors above grade, provide with flashing clamp.

1. Manufacturer: Josam 55000-I, Smith 4025, Wade 6000IC, or Zurn ZN-1400-ZN-IC.

D. Finished area floors: for piping 8" and larger, cast iron with internal cleanout plug, adjustable housing, and round polished nickel-bronze top with securing screws. For cleanouts in floors above grade, provide with flashing clamp.

1. Manufacturer: Josam 56000-22-Y, Smith 4033, or Zurn ZN-1400-NL-BP.

E. Mechanical and parking deck floors: cast iron with internal cleanout plug, adjustable housing, and nickel-bronze top. For cleanouts in floors above grade, provide with flange.

1. Manufacturer: Josam 56040, Smith 4105, Wade 6000IC-Z-1, or Zurn ZN-1400-HD-IC.

F. Wall construction: no-hub cleanout tee and tapped bronze cleanout plug, with a stainless steel wall access cover.

1. Manufacturer: Josam 58600-COT, Smith 4532-Y, Wade 8560E+8480R, or Zurn Z-1446-BP-NH.

2.5 DRAINS

A. General:

1. Outlets shall be same size as the drainage pipe.
2. Drains shall be from the same manufacturer, unless otherwise indicated.
3. Provide drain outlets as follows:

a. Drains in roofs and floors above grade: no-hub, push-on, or inside caulk.
b. Drains in floors on grade: push-on, or inside caulk.
c. Specialty drains, where specified herein, in roof and floors: threaded.

B. Finished Area Drains:

1. D1A: cast iron body, trimmed with adjustable 6" square nickel-bronze grate with vandal resistant screws, sediment bucket, trap primer connection, and reversible flashing collar.

a. Manufacturer: Josam 30000X-S, Smith 2010B, Wade 1100 G, or Zurn ZN415-S.

C. Mechanical Room Drains:

1. D2A: cast iron shallow body, trimmed with 12" round cast iron round heavy duty grate, sediment bucket, trap primer connection, and flashing clamp.

a. Manufacturer: Josam 36340X, Smith 2233, Wade 1210-27, or Zurn Z541.

2. D2B: cast iron body, trimmed with 12" square rim, nickel-bronze secured grate, 10” deep chemical resistant coated interior, dome bottom strainer, flashing clamp, and anchor flange.

a. Manufacturer: Josam 49060AS, Smith 3160, Wade 9150, or Zurn ZN1902-K.

D. Roof Drains:

1. D3A: cast iron body, trimmed with 11" round cast iron dome, combined flashing clamp and gravel stop, adjustable solid insulation extension, and under deck clamp.

a. Manufacturer: Josam 21000X, Smith 1015, Wade 3000AE, or Zurn Z100-EA.

E. Parking Deck Drains (Series D7):

1. D7A: cast iron body, trimmed with 12" round vandal resistant cast iron heavy duty grate, adjustable top, sediment bucket, seepage openings, and flashing collar.

    a. Manufacturer: Josam 31720X, Smith 2340, Wade 1240TD, or Zurn Z-521.

2. D7B: cast iron body, trimmed with 12" round vandal resistant cast iron heavy duty grate, adjustable top, sediment bucket, seepage openings, and flashing collar.

    a. Manufacturer: Josam 31720X, Smith 2340, Wade 1240TD, or Zurn Z-521.

3. D7C: cast iron body, heavy duty wide flange collar with heavy duty ADA tractor grate.

    a. Manufacturer: Smith 2624.

F. Trench Drains:

1. D10A: cast iron frame and bolt down grate, nominally 8" 10" 12" wide x 24" long, with 0.5" wide vane style grates with cross bars, machined horizontal bearing surfaces, frames with 2 side anchor flanges, meeting ADA and bicycle safety requirements, and constructed of ASTM A48/A48M-2003 (2016) class 35 gray iron. The casting shall carry AASHTO-H20 wheel loading, and the vanes shall run length wise and receive water from the width.

    a. Manufacturer: Neenah L, PM&I L, or US Foundry 57.

2.6 PUMPS

A. General:

1. Provide insulated cabling and final connections from the control panel to the pump motors, level controls, and alarms.

B. Small Capacity Sump Pumps with Oil Control Systems:

1. General: submersible type for a simplex installation with controls, wiring, piping, valves and oil control system.
2. Controls: UL labeled NEMA 4X stainless steel control panel with power on and pump running lights, high water and overload lights, and alarms with alarm silence. Provide pressure diaphragm actuated micro-switch level controls (for pump on, pump off, and high liquid level alarm) with cable wiring to control panel, and oil sensing probe interlocked with pump to prohibit operation when oil is present. Provide contactors for the building control system to signal pumps at standby, pumps running, pump failure, and oil detected.
3. Motors: submersible hermetically sealed with class F insulation for maximum 3500 rpm. Motors shall be direct connected to pumps, supplied with a minimum 20' power cord, shall have built-in thermal and overload protection with automatic reset, and rated for continuous duty submerged.
4. Pumps: close-coupled design with cast iron body, stainless steel shaft, cast iron impeller, mechanical seals, and permanently lubricated ball bearings with a minimum 14,200 hr

bearing life. The pump shall be non-overloading at any point on the pump curve and shall be statically and dynamically balanced.

5. Warranty: provide pump, controls, and equipment with a manufacturer's written one year warranty.
6. Manufacturer: Ebara, Hydromatic, Myers, Stancor, Weil, or Zoeller.

2.7 OIL INTERCEPTORS

A. Inside Oil Interceptors:

1. Fiberglass construction with inlet piping and baffle penetration, factory, SCHE 40 PVC cement welded type socket ports, or straight pipe, fitted into interceptor walls for each pipe connection.
2. Interceptors shall below slab on grade with concrete tie down pad.
3. Manufacturer: Zurn Green Turtle.

2.8 SAND INTERCEPTORS

A. Fabricated steel catch basin, gray duco coated inside and outside. Threaded inlet and outlet, cast iron grates, baffle, nonskid cover and extension.

B. Interceptors shall be located in a vault below grade with tie down pad.

C. Manufacturer: Smith 8811.

2.9 BACKWATER VALVES

A. Coated cast iron offset type, with bronze swing check assembly, bolted gasket cover, and hub and spigot connections.

B. Manufacturer: Josam, Smith, Wade, or Zurn.

2.10 TEMPERATURE MAINTENANCE CABLE

A. Self-Regulating Cable - Freeze Protection:

1. General: the system shall be UL Listed self-regulating heating cable for sanitary drain lines and p-traps, with connections, and electronic controls for maintaining the system temperature above freezing. Cable and components shall have a minimum 10 year warranty, and shall comply with IEEE 515.1-2012.
2. Cable: self-regulating heating type, manufactured for use with a controller for temperature setting of 40°F, and having a draw of 5 W per foot at full power. The cable shall consist of 2 minimum #16 AWG copper bus wires, embedded in a radiation cross-linked conductive polymer core that varies its power output to respond to temperature changes along its length. The cable shall be covered by an inner jacket, a tinned-copper braid, a color coded polyolefin outer jacket, and be field cut-to-length type with no damage to the cable or its function.

    a. Manufacturer: Nelson CLT, Raychem XL-Trace, or Thermon FLX.

3. Accessories: power connections, splices, end caps, binding tape, and identification labels reading "HEAT TRACED", as required.
4. Controllers: controllers shall be a UL listed electronic control and monitoring system, housed in a NEMA 4X stainless steel rated enclosure, and capable of providing temperature control, cable monitoring and outgoing communications. Provide the controller with on/off control, ambient sensing thermostat, display screen, panel indicator lights (power on, heater on, system failure) system test, local alarm with silence, over temperature protection set at 5°F above the system temperature, communications port with contacts and software to communicate with the building control system for cable on, high/low temperature, cable trouble, and controller trouble.

    a. Manufacturer: Nelson AP, Raychem EC-TS, or Thermon PDMP series.

2.11 ACCESSORIES

A. Bolts and nuts: ASTM A307-2014e1, Grade B.

B. Downspout nozzles: nickel-bronze body with threaded female pipe connection, wall flange, and bird screen.

1. Manufacturer: Josam 25010, Smith 1770, Wade 3940, or Zurn Z-199.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

A. General:

1. Piping shall be cut to measurements established at the site and worked into place without springing or forcing.
2. Make changes in the horizontal direction of gravity drainage piping with drainage pattern fittings.
3. Use concentric reducing fittings between different size pipe.
4. Ream steel, and copper pipe after cutting, turn on end and knock loose dirt, scale, and filings from interior of pipe.
5. Install horizontal drainage piping 3" and smaller with a slope of 0.25" per foot, and piping 4" and larger with a slope of 0.125" per foot unless otherwise noted on the Drawings.
6. Pitch/grade: piping shall be installed with sufficient pitch to ensure drainage and venting.
7. Install sway bracing and anchorage for piping as required by International Plumbing Code-2018.

B. Underground Piping:

1. Install drainage piping outside the building in trenches separate from water piping.
2. Excavation and backfill: as specified in Section 220010, Plumbing General.
3. Underground piping shall be connected to the exterior service lines, or capped or plugged if the exterior service is not in place.
4. Piping installed below the level of footings shall be installed 12" horizontally from the footing for each 12" of depth below the footing.

C. Piping Joints:

1. Solder joint connections shall be cut, deburred, cleaned and assembled in accordance with ASTM B828-2016.
2. Threaded connections: screw-thread joints shall be made with cut tapered threads. Joints shall be made tight with Teflon tape. Not more than 2 threads shall show after the joint is made tight, except no threads shall show in exposed chromium-plated piping.
3. Flanged joints: at connections to equipment, flanged joints shall be made with ring type gaskets, extending to inside of bolt holes. Flanged connections to equipment shall be made with full-face gaskets to match flanges on equipment.
4. Mechanical couplings on drainage piping: during the torque process, if any one band of the coupling breaks, replace the entire coupling.
5. Isolate joints between dissimilar metals and connections to tanks with dielectric fittings.
6. Provide adapters where copper or steel pipes connect to cast iron pipe.
7. Provide adapters where cast iron pipe connects to plastic, ductile iron, concrete, or clay pipe, or where field cuts are made in vitrified earthenware or concrete piping. Adapters shall be sized to fit into the bell of pipes with hubs, or over the barrel of pipes without hubs.

D. Coordination:

1. Pipes shall be installed to permit free expansion and contraction without damage to joints, hangers, or the building. Arrange piping to minimize stresses caused by expansion and contraction.
2. Install piping so as to preserve access to valves and equipment and to provide the maximum headroom possible.
3. Provide offsets as required to maintain ceiling height and to coordinate with other trades.
4. Install exposed piping such that when insulation is applied it will not come in contact with adjacent surfaces.
5. Provide flanges or unions at connections to valves and apparatus.
6. Piping to fixtures and equipment shall be braced so that there is no horizontal or vertical movement in the piping.
7. Pipe supports shall be isolated from copper tubing with rubber sleeves.
8. Where piping is running parallel to bar joint construction, and there is more than one pipe to be attached to bottom cord of joint, provide supplement steel supports spaced at the minimum hanger spacing, and tac-welded to joint.

3.2 PIPING, FITTINGS, AND JOINTS

A. Hub and Spigot Cast Iron Pipe and Fittings:

1. Do not use tee fittings in horizontal drainage piping.
2. Install with hubs upstream.
3. Joints and fittings may be made with compression type gaskets or caulked with white oakum and not less than 12 oz of pure lead for every in of pipe diameter.

B. No-Hub Cast Iron Pipe and Fittings:

1. Do not use tee fittings in horizontal drainage piping.
2. Extend vent piping 12" above the roof.
3. Torque coupling bolts in accordance with manufacturer's recommendations.

4. Where extra heavy duty couplings are required for underground connections, coat the stainless steel bolts with asphaltic paint sealer.
5. Install pull-out restraints on no-hub sanitary and waste drainage, and rainwater piping and fittings 5" and larger, at changes in direction and changes in pipe size greater than 2 pipe diameters, in accordance with the International Plumbing Code-2018. Provide the restraints with a minimum of 50' of thrust resistance.

C. Copper Tubing and Fittings:

1. Uninsulated piping installed in masonry construction shall be painted with 2 coats of asphaltum paint.
2. Clean, prime, and paint exposed uninsulated piping with 2 coats of glossy silver paint.

3.3 SPECIALTY PIPING JOINTS

A. Unions

1. Provide in each connection to each piece of equipment, where equipment may be removed.

B. Flanges

1. Provide in piping connections to equipment where flanges are present.

3.4 P-TRAPS

A. Set traps true and level.

B. Provide in rainwater piping connecting to combination sewers.

C. Install elastomeric trap seals in accordance with manufacturer's instructions.

3.5 CLEANOUTS

A. General:

1. Locate cleanouts so that they are accessible and in compliance with codes.
2. Install floor cleanouts flush and level with the finished floor.

B. Provide cleanouts in drainage piping as indicated on the Drawings, and as follows:

1. At the bottom of each exposed fixture trap which is not integral with the fixture.
2. At the beginning of each branch drainage line.
3. At each change of a horizontal direction greater than 45º.
4. At the foot of each stack.
5. In horizontal drain lines at intervals of not more than 50' for inside piping and 100' for outside piping.

C. Cleanouts outside the building shall extend up to grade and be set flush with finished grade in a 18" x 18" x 8" thick concrete pad.

D. Cleanouts for horizontal piping above grade located above the ceiling shall extend through the floor above, and shall be set flush with that finished floor.

E. Sanitary cleanouts shall not be installed in return air plenums.

F. Cleanouts that occur in carpeted floors shall be installed flush with the floor slab and marked with a stainless steel carpet marker.

3.6 DRAINS

A. General:

1. Cover the grate of each drain during construction to prevent entry of foreign matter. The covering shall not deface the grate's finish.
2. Remove and clean drain grate, set-screws, insides of drain bodies, and sediment buckets before substantial completion.
3. Drains shall not be field modified, except grates may be modified where required for above floor indirect drainage piping.
4. Where waterproof liners are used in the building construction, secure the liners to drain bodies with clamping rings, making watertight connections.
5. Provide trap seal protection for each drain, except equipment/fixture drains.

B. Floor Drains:

1. Set top of floor drains and floor sinks flush and level with the finished floor, unless noted otherwise on the Drawings.
2. Install drains with recessed grates and anti-splash rims, with the rims flush with the finished floor.
3. Omit grates of drains receiving piped discharge from mechanical equipment so pipes can turn down into basket, unless provided otherwise.
4. Where trap primer connections are made to drain tailpieces, cap or eliminate the trap primer connection on the drain body.
5. Set square drainage grates with sides parallel to the adjacent walls.
6. Where drains are installed in a sloping floor, install at low point.

C. Roof Drains:

1. Provide for each roof drain a sheet of 4 psf lead flashing extending at least 8" from the clamping ring in all directions, for built-up roofing.
2. The horizontal portion of scupper drains shall pitch down in the direction of flow not less than 0.25" per foot.
3. For PVC roofing, flash the PVC material a maximum of 1" into the drain body past the drain clamp.

D. Trench Drains:

1. Set top of grates flush and level at low point of finished drive.

2. The final size and location of the trench drains shall be as indicated on the Architectural Plumbing Drawings.

3.7 PUMPS

A. Coordinate final sump basin sizes for proper fit of pump and motor to be installed, and installation of accessories.

B. Sump pumps shall not be used for dewatering. If pumps are used in an emergency, replace with new units.

3.8 BACKWATER VALVES

A. Provide access for cleaning and maintenance to backwater valves:

1. For depths up to 18" use a 4" hub and spigot cast iron pipe riser with cleanout cap set flush with floor or grade. When installation is at grade level, encase top in an 18" x 18" x 8" concrete pad.
2. For depths up to 30" install the BWV in a 36" square concrete box with a flush type full size aluminum access panel set flush with the floor or grade.
3. For depths over 30" install the BWV in a 48" square concrete box with a flush type full size aluminum access panel set flush with the floor or grade.

3.9 TEMPERATURE MAINTENANCE CABLES

A. General:

1. Install cables, controllers, and components in accordance with manufacturer's instructions.
2. Test cables and electronics prior to installing piping insulation.
3. Secure cable to piping with manufacturer recommended tape on 10" centers.
4. Install power connections, splices, and end caps under the piping insulation.
5. Route power connections to a junction box located outside the piping insulation.
6. Install "Heat Trace" identification signs a maximum of 10' apart.
7. Provide 30 mA ground-fault protection for each cable circuit.

B. Installation Locations:

1. As indicated on the drawings.

3.10 ROOF PENETRATIONS

A. Vents Through Roofs:

1. Flat roofs with built-up asphaltic roofing material: flashed and soldered watertight with 2 sections of 4 psf sheet lead.

    a. The top section shall fit tightly around the upper vent, turning down at least 1" inside the vent opening, and overlapping the lower section by 2".
    b. The lower section shall fit tightly around the lower vent, extending from 2" under the top section downward to the roof, then extending 8" larger all around than the vent diameter out under the built-up roofing.

B. Roof Drains:

1. Plastic membrane roofs: flashed and sealed watertight by the membrane installer. Ensure the membrane opening inside the drain is cut large enough to allow for proper water flow and roof drainage.
2. Built-up asphaltic roof material: carefully clamp underlayment in clamping ring, taking care not to tear or puncture the underlayment.
3. Metal deck construction: provide supplemental angle iron steel on 2 sides of each drain, running perpendicular and welded to the nearest roof joists.

3.11 PIPING AND JOINTS TESTS

A. Piping and piping joints shall be leak free.

B. Test soil, waste, vent, and rainwater systems piping and joints by capping or plugging all openings, and filling each system with a 10' head of water, then allowing to stand filled for 1 hour without any leak down. Where a system is tested in sections, each section shall be subjected to the same test.

C. General:

1. Test piping and joints under floor slabs before slabs are poured.
2. Tests shall be made while piping and joints are exposed to view.
3. Submit a statement certifying that piping and joints are tight and have passed the specified test.

D. Leakage Requirements:

1. Screwed and flanged joints that leak shall be taken apart and reassembled.
2. Soldered joints that leak shall be cut-out and replaced.
3. Cast iron hub and spigot joints that leak shall be taken apart and reassembled with new joining materials.
4. Cast iron no-hub joints that leak shall be taken apart and reassembled with new couplings.

E. Flow Test:

1. Ensure a smooth and nonobstructed flow of liquid for every drainage pipe, free from construction or natural sediment debris that may have entered during construction.
2. Route clean and flush with clear water piping having an obstruction.

3.12 SUMP PUMP TESTS

A. General: pump any liquid from sump. Do not use Project's new pumps. Clean sumps, basins, pumps, and motors of construction debris.

B. Elevator Sump Pump Test:

1. Hydraulic elevators: fill sump as required with potable water and test for pump on, high water alarm, and pump off. Pump shall perform at its rated capacity. Test check valve for complete stoppage at pump shutoff. Add hydraulic elevator oil to the water and test for

pump off and oil alarm. Clean sump of oil residue. If pump or controls fail test, repair or replace units as necessary.

END OF SECTION 224300

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SECTION 224400 - WATER SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other plumbing systems are specified in other Sections of Division 22.

B. Refer to Section 220010, Plumbing General, for a list of plumbing sections included in this specification.

C. This Section covers plumbing water systems.

1.2 QUALITY ASSURANCE

A. Conform to the following:

1. ICC A117.1-2017.
2. International Energy Conservation Code-2009.
3. International Plumbing Code-2015 with South Carolina Modifications.

B. Wetted components in the potable water system, where the water is anticipated for human consumption, shall comply with the Reduction of Lead in Drinking Water Act-2011.

PART 2 - PRODUCTS

2.1 PIPING, FITTINGS, AND JOINTS

A. General:

1. Piping and fitting sizes listed are nominal inside diameter.
2. For copper pipe applications, use mechanically crimped copper joint systems, OR use solder joints and flux that comply with ASTM B828 2002, and ASTM B813 2010, respectively.
3. For water intended for human consumption:

    a. Use pipes and pipe fittings that comply with California Law AB1953, which requires that the wetted surface area have a weighted average lead content of not more than 0.25%.
    b. Solder and flux used to connect plumbing pipe on site shall meet California AB1953 standard, which specifies that solder not contain more than 0.2% lead, and flux not more than a weighted average of 0.25% lead for wetted surfaces.

B. Trap primer, underground, 2" and smaller:

1. Piping: copper tubing, type K, soft temper, ASTM B88-2016.
2. Fittings: wrought copper and/or cast bronze socket couplings, ASME B16.22-2013.

3. Joints: brazed with brazing filler metal, BcuP-3, silver-phosphorous, AWS A5.8/A5.8M-2011.

C. Cold water, underground, 2.5" and larger:

1. Piping: copper tubing, type K, hard temper, ASTM B88-2016.
2. Fittings: wrought copper, ASME B16.22-2013.
3. Joints: brazed with brazing filler metal, BcuP-3, silver-phosphorous, AWS A5.8/A5.8M-2011.

D. Cold water, hot water, hot water circulating, and trap primer, above grade, 0.5" to 2.5", except chromium-plated piping at fixtures:

1. Piping: copper tubing, type L, hard temper, ASTM B88-2016.
2. Fittings: wrought copper and/or cast bronze socket fittings, 0.5" to 2.5", ASME B16.22-2013.
3. Joints:

a. Soldered with 95/5 tin/silver or tin/antimony alloy type, with a compatible flux designed to be cold water flushable in potable water systems, ASTM B813-2016 and NSF 61-2017.

E. Cold water, and hot water, above grade, 3":

1. Piping: copper tubing, type L, hard temper, ASTM B88-2016.
2. Fittings:

a. For brazed piping joints, 3": wrought copper and/or cast bronze socket fittings, ASME B16.22-2013.

3. Joints:

a. Brazed with brazing filler metal, BcuP-3, silver-phosphorous, AWS A5.8/A5.8M-2011.

2.2 SPECIALTY PIPING JOINTS

A. Unions:

1. For copper piping 2" and smaller: cast bronze with copper soldered connections.
2. For steel piping 2" and smaller: ground joint with brass-to-iron seat.
3. For piping of dissimilar metals 2" and smaller: provide dielectric unions with solder or threaded connections, nylon insulators, and minimum 600 V no flashover.

B. Flanges:

1. For copper piping 2.5" and larger: class 150, cast bronze companion flange NSF 61-2017 lead free, with solder cup, and flat flange face. Provide a 0.125" thick EPDM NSF/ANSI 61 type rubber gasket.

2. For piping of dissimilar metals 2.5" and larger: provide dielectric flanges with solder or threaded pipe connections. Provide a 0.125" thick EPDM NSF/ANSI 61 type rubber gasket.
3. Flanges for equipment connections shall match the equipment's flange in style, material, and pressure rating. Provide a 0.125" thick EPDM NSF/ANSI 61 type rubber gasket.

C. Ball Joints:

1. Flexible ball joints less than 2.5" diameter shall be manufactured with ductile iron casings and balls. Ball joints shall permit 360° rotation and 28° minimum total angular flex.
2. Flexible ball joints with a diameter of 2.5" and larger shall be manufactured with carbon steel casings, retainers, and balls. Retainers shall be bolted to allow correct seal adjustment and disassembly for maintenance. Balls shall be protected with crack-free chromium plating. Ball joints shall permit 360° rotation and 15° minimum total angular flex.
3. Seals shall consist of inner and outer precision molded rings designed for system fluid, temperature, and pressure, without the use of additional packings or sealants. Seals shall be factory-seated with 50 psig saturated steam or equivalent thermal conditions.
4. Ball joints shall be FM approved or UL listed.
5. Manufacturer: Hyspan-Barco.

2.3 VALVES

A. General:

1. Valves shall be of the same manufacturer, except where a specific product is not available.
2. Stem packing: asbestos-free.

B. Gate Valves:

1. Gate valves 3" and larger: class 125, iron body with bronze trim, outside screw and yoke, bolted bonnet, solid wedge, renewable seats, flanged ends, 200 psig wog, MSS SP-70-2011.

    a. Manufacturer: Apollo 611F, Hammond IR1140, Milwaukee F-2885-M, or NIBCO F617-O.

C. Globe Valves:

1. Globe valves 2.5" and smaller: class 125, bronze body with threaded bonnet, integral seat, renewable bronze seat and disc, 200 psig wog.

    a. Manufacturer (solder ends): Apollo 121S-LF, Hammond UP418, or Milwaukee UP1502.
    b. Manufacturer (threaded ends): Apollo 121T-LF, Hammond UP440, or Milwaukee UP502.

D. Ball Valves:

1. For copper piping, 2.5" and smaller: 2-piece bronze or bronze alloy body, full port, with blowout-proof stem, rated for 600 psig wog. Valves shall have a stainless steel vented ball, reinforced seat, stuffing box ring, memory stop, and lever handle. Valves in insulated piping shall have 1.25" extended stems.

a. Manufacturer (soldered ends): Apollo 77CLF-240, Hammond UP8313A, Milwaukee UPBA450S, or NIBCO S-585-66-LF.
b. Manufacturer (threaded ends): Apollo 77CLF-140, Hammond UP8303A, Milwaukee UPBA400S, or NIBCO T-585-66-LF.

E. Check Valves:

1. Check valves 2.5" and smaller: class 125, bronze body, Y-pattern horizontal swing with renewable bronze disc and seat, screw cap, 200 psig non-shock cwp.

a. Manufacturer (solder ends): Apollo 161S-LF, Milwaukee UP1509, or NIBCO S-413-Y-LF.
b. Manufacturer (threaded ends): Apollo 161T-LF, Milwaukee UP509, or NIBCO T-413-Y-LF.

2. Check valves 3" and larger: class 125, iron body, horizontal swing with bronze trim, renewable disc and seat, bolted bonnet, flanged ends, 200 psig non-shock cwp.

a. Manufacturer: Apollo 910F, Hammond IR1124, Milwaukee F-2974A, or NIBCO F-918-B.

2.4 STRAINERS

A. Strainers 2.5" and smaller: class 125, bronze body, Y-pattern, with a 20 mesh type 304 stainless steel screen, threaded cap, 200 psig non-shock cwp.

1. Manufacturer (solder ends): Apollo 59LF-300, or Wilkins YBXLC.
2. Manufacturer (threaded ends): Apollo 59LF-000, or Wilkins YBXL.

B. Strainers 3" and larger: class 125, iron body, Y-pattern, with FDA coating inside and outside, type 304 stainless steel screen, bolted cap with blow-off plug and valve, flange ends, 200 psig non-shock cwp.

1. Manufacturer: Apollo 125-YF, Hammond 3030, or NIBCO F-721-A.

2.5 HOSE BIBS

A. For mechanical or equipment spaces: chromium-plated brass with 0.75" inlet, tee handle, built-in atmospheric vacuum breaker, and 0.75" hose thread outlet.

1. Manufacturer: Chicago 952 XKCP, T&S B-0722-RGH, or Zurn Z875L7.

B. For finished areas: polished chromium-plated brass with 0.75" inlet, tee handle, built-in atmospheric vacuum breaker, and 0.75" hose thread outlet.

1. Manufacturer: Chicago 952XK, T&S B-0722, or Zurn Z875L7.

2.6 HYDRANTS

A. Wall Hydrants:

1. Non-freeze type with bronze body and casing, 0.75" threaded inlet, 0.75" hose thread outlet, integral vacuum breaker, key handle, adjustable wall clamp, recessed box with hinged locking cover with the word WATER cast in, and rough bronze finish.

a. Manufacturer: Josam 71000, Smith 5509 QT, Wade 8600-175, or Zurn Z-1300.

2.7 PRESSURE REDUCING VALVES

A. Direct operating type with low capacity, bronze body, stainless steel spring, sealed spring chamber, stainless steel seat ring, composition disc, built-in bypass, and threaded ends. Provide units with isolation valves, pressure gauges, and strainers.

1. Manufacturer: Apollo PRCLF, or Wilkins 70XL.

2.8 BACKFLOW PREVENTERS

A. Reduced pressure type for cold water 0.75" to 2": with bronze body, stainless steel working parts, check modules, test cocks, relief module, and threaded ends. Provide the assembly with isolation valves, air gap drain device, and separate wye pattern strainer.

1. Manufacturer: Apollo RP4ALF, or Wilkins 975XL.

B. Reduced pressure type for cold water 2.5" to 8": with fused-epoxy coated iron body inside and out, stainless steel working parts, check modules, test cocks, relief module, and flanged ends. Provide the assembly with isolation valves, air gap drain device, and separate wye pattern strainer.

1. Manufacturer: Apollo RP40LF, or Wilkins 375XL.

C. Dual check valve type for cold water 0.25" to 0.375": with 316 stainless steel or chromium-plated bronze body, inline spring loaded dual check valves, atmospheric vent port, meeting FDA food service requirements, and complying with ASSE 1022-2017. Provide the unit with an isolation valve, and separate wye pattern strainer.

1. Manufacturer: Apollo DUC4NLF, or Wilkins 740XL.

2.9 VACUUM BREAKERS

A. Atmospheric type, for cold and hot water, 0.5" to 1": with bronze body, float disc, full flow, atmospheric vent, and operating temperature to 180°F.

1. Manufacturer: Apollo AVB1LF.

B. Pressure type, spill resistant for cold and hot water 0.5" to 1": with bronze body, check valve, replaceable valve seat, spring-loaded float disc, stainless steel springs, vent disc with isolation to the water stream, inlet/outlet isolation valves, and operating temperature to 180°F.

1. Manufacturer: Apollo SVB4WLF, or Wilkins 460XL.

2.10 TRAP PRIMERS

A. Brass construction, capacity to prime traps as indicated on the Drawings, line pressure operation, with distribution units with copper body where indicated on the Drawings.

1. Manufacturer:

a. Trap primer for flush valve lines: Precision Plumbing Produces, Prime-Rite.

B. Automatic mini trap primers: electronic trap primer with distribution unit, 1" air gap, preset 24 hour timer set for 10 second minimum operation every 24 hours, manual override switch, fuse, 120 V solenoid valve, 0.5" inlet connection, and 0.375" outlet compression fittings.

1. Manufacturer: Precision Plumbing Products Mini-Prime, or Zurn Z-1020-ETP.

2.11 WATER HAMMER ARRESTERS

A. Enclosed piston type with copper tubing enclosure, FDA approved double O-ring seals, threaded connections, ASSE 1010-2004 certified.

1. Manufacturer: Precision Plumbing Products SC series, Sioux Chief 650 series, Smith 5200 series, Watts LF15M2 series, or Wilkins 1250XL.

2.12 PRESSURE GAUGES

A. Bourdon tube type with stainless steel tube and socket, stainless steel movements with 0.5% accuracy over the full scale, and 150°F minimum operating temperature.

B. The wetted parts shall be housed in a flangeless metal case with a clear safety glass lens, stainless steel front ring, and stainless steel 0.25" NPT lower connection. Provide each gauge with a stainless steel pressure snubber and needle valve 250 psig for piping connections.

C. The dial face shall be white painted aluminum 4.5" in diameter with black graduations and letterings. The units of measure shall be in psig. The pointer shall be black painted aluminum and adjustable.

D. Gauges shall be selected where the average pressure is at the scale's midpoint, and incorporating the following as applicable:

Location	Scale Range
Inlet of pressure reducing valves	0 to 200 psig.

Outlet of pressure reducing valves	0 to 100 psig.

E. Manufacturer:

1. Dry case: Trerice 500XSS without flange, Weiss UG-2-N series, Weksler HA44-8, or Winters P3S.

2.13 THERMOMETERS

A. Blue- or green-reading organic-filled every-angle, industrial type with aluminum case, glass lens, 9" scale length, and accuracy rating of ± one scale division. Thermometers installed in insulated piping shall have 6" stems with brass thermowell, filled with heat transfer medium, and extension.

B. Scale range: 30°F to 240°F.

C. Manufacturer: Trerice BX9-SPB, Weiss A9VU, Weksler EG5L-9, or Winters 9IT.

2.14 TEMPERATURE MAINTENANCE CABLE

A. Self-Regulating Cable - Freeze Protection:

1. General: UL listed self-regulating heating cable for cold water exposed in parking deck, with connections, and electronic controls for maintaining the system temperature above freezing. Cable and components shall have a minimum 10 year warranty and shall comply with IEEE 515.1-2012.
2. Cable: self-regulating heating type, manufactured for use with a controller for temperature setting of 40°F, and having a draw of 5 W/ft at full power. The cable shall consist of 2 minimum #16 AWG copper bus wires embedded in a radiation cross-linked conductive polymer core that varies its power output to respond to temperature changes along its length. The cable shall be covered by an inner jacket, a tinned-copper braid, a color coded polyolefin outer jacket, and be field cut-to-length type with no damage to the cable or its function.

    a. Manufacturer: Nelson Type CLT, Raychem XL-Trace, or Thermon FLX.

3. Accessories: power connections, splices, end caps, binding tape, and identification labels reading, "HEAT TRACED", as required.
4. Controllers: UL listed electronic control and monitoring system, housed in a NEMA 4X coated stainless steel rated enclosure, and capable of providing temperature control, cable monitoring and outgoing communications. Controllers shall have on/off control, ambient sensing thermostat, display screen, panel indicator lights (power on, heater on, system failure) system test, local alarm with silence, over temperature protection set at 5°F above the system temperature, communications port with contacts and software to communicate with the building control system for cable on, high/low temperature, cable trouble, and controller trouble.

    a. Manufacturer: Nelson Type AP, Raychem EC-TS, or Thermon PDMP series.

2.15 WATER HEATERS

A. Commercial electric water heater, UL listed packaged unit with vertical storage tank, heating elements, ASME and CSA pressure and temperature relief valve, controls with enclosure, meeting the mandatory provisions of ASHRAE/IES 90.1-2016 and ANSI Z21.10.3-2017/CSA 4.3-2017.

1. Controls:

   a. Upper and lower immersion thermostats, temperature adjustment control, high temperature shut-off, high and low pressure shut-off, low water shut-off, magnetic contactors, control circuit transformer, control circuit switch, fuse and pilot light, fuses for each power circuit, and safety door interlock.
   b. Time sequencer.

2. Heating elements: immersion type, heavy duty, 40 W/in² maximum density, flange-mounted with incoloy sheath, maximum of 18 kW per element.
3. Tanks: polymer-lined carbon steel, designed, constructed, certified, and stamped in accordance with ASME BPVC-VIII-1-2017 for a 125 150 psig working pressure, with hand-hole cleanout, drain valve, and baffled inlet. For tanks with porous linings provide a titanium anode rod.
4. Enclosures: minimum K value of 2.17 Btu·in/(h·ft²·°F) at 80°F for tank insulation, and steel jacket with baked enamel finish.
5. Provide a manufacturer sized and installed all bronze integral circulating pump with isolation valves and controls.
6. Warranty: the complete water heater assembly shall be provided with a nonprorated warranty, in writing, by the manufacturer for a period of 1 year from heater start-up. The warranty shall include defects in the design and construction of the assembly, including parts and components. Additionally, there shall be a nonprorated 3 year warranty against tank failure due to rust, and an operational warranty for odor and discolored water due to tank rust or tank lining. The warranty shall cover all costs including parts, heaters, shipping, and labor, with no cost being incurred by the Owner. If repairs are unable to be performed, the water heater shall be replaced with an equal unit.
7. Manufacturer: Hubbell, Lochinvar, PVI, or A.O. Smith.

2.16 HOT WATER CIRCULATING PUMPS

A. Single-stage bronze inline cartridge type, fluid lubricated, with spherical rotor impeller, and magnetic drive.

1. Manufacturer: Armstrong NBF series, Bell & Gossett NBF series, or Grundfos Circulator series.

2.17 HOT WATER CIRCULATING PUMP TIMERS

A. Time switch with a 24-hour dial, day-omitting device, self-starting synchronous motor, and removable on-off trippers.

B. Provide with a NEMA 1 enclosure finished with a baked epoxy paint coating, 0.5" and 0.75" knockouts on bottom, sides and back, and provisions for locking or sealing.

C. Provide a spring-driven reserve to operate the time switch contacts for at least 16 hours after power failure. On restoration of power the time switch shall transfer to the motor drive and automatically rewind the reserve.

D. Manufacturer: Intermatic T170CR series, or Tork 7000L series.

2.18 HOT WATER CIRCULATING FLOW CONTROL FITTINGS

A. Manual Flow Control Fittings:

1. Flow regulator type fittings with brass or bronze construction, manually operated flow regulating valve, and a flow adjusting handle operable from closed to fully open. Handles shall have calibrated position indicators and memory stops. Bodies shall include 2 integrated ports for differential pressure measurement, and shall be rated for 250 psig at 250º F. Provide fittings with soldered ends.
2. Manufacturer: Armstrong CBV series, Griswold Quickset, NIBCO 1710 series, or Victaulic TA series.

2.19 HOT WATER CIRCULATING FLOW METERS

A. Inline threaded body flow meters with an accuracy of ±5%, and operating parameters of 175 psig at 200ºF. Meters shall be designed for potable water usage, able to measure flows from 0.5 gpm to 5.0 gpm and mountable in both horizontal and vertical positions.

B. Manufacturer: Ernst EFI Inflo, Kobold VKP, or Racine Federated EZ-View.

2.20 THERMAL EXPANSION TANKS

A. Inline expansion tanks shall be the bladder type with welded steel construction, primed and painted exterior, and designed for potable water. Diaphragms shall be FDA approved elastomeric, butyl rubber, designed for a maximum operating temperature of 180ºF, and a minimum of 100 psig working pressure. Tanks shall be precharged to a minimum of 40 psig.

1. Manufacturer: Amtrol Therm-X-Trol, Bell & Gossett PTA, or Watts PLT.

2.21 RELIEF VALVES

A. Temperature and pressure relief valves: 0.75" to 2", ASME rated, automatic self-closing pressure and temperature relief type with bronze or copper alloy body, stainless steel springs, non-mechanical seat-to-disc alignment, test lever, thermostat, and stainless steel or FDA approved coated temperature probe. Valves shall be in accordance with ANSI Z21.22-2015/CSA 4.4-2015, and shall be set for 80 psig pressure relief and 210°F temperature relief.

1. Manufacturer: Apollo LF18C-500, Cash Acme FVX-LF series, or Watts LF series.

2.22 MIXING VALVES

A. Building master mixing valves: high/low mixing valve assembly with bronze body, self-contained, thermostatically controlled mixing valves with adjustable setpoints, check-stop inlets, union inlet and outlet connections, dial thermometer on discharge and copper piping. High/low assemblies shall have a minimum flow rate of 0.5 gpm and include 2 mixing valves in parallel and an intermediate pressure reducing valve with pressure gauges. Assembly shall be factory assembled and tested in accordance with ASSE 1017-2009.

1. Manufacturer: Leonard TMLF Hi/Low series, Powers LFMM430 Hi/Low series, or Symmons 7 Hi/Low series.

2.23 EMERGENCY FIXTURE WATER TEMPERING VALVES

A. Single showers, shower/eye washes: thermostatic type complete with inlet checks, stops with unions, outlet thermometer, and vandal resistant temperature setting. Each valve shall be designed for use with emergency eye/face washes, and be factory set for 85°F at 20 gpm with 30 psig inlet water pressure. Units shall be designed to flow full cold in the event of hot water supply failure or thermostatic controller failure, designed to stop flow completely in the event of cold water supply failure, and conforming to ASSE 1071-2012.

1. Manufacturer: Bradley S19-2300, Lawler 911, or Leonard LFTM-600.

2.24 FLEXIBLE CONNECTORS

A. As specified in Section 220010, Plumbing General, for pressure and temperature of intended service.

2.25 WATER METERS

A. Positive Displacement Disc Meters:

1. Potable cold water meters 0.625" to 2": with bronze or copper alloy main casing, magnetic drive, remote reading, permanently sealed register, nutating disc, stainless steel trim, ±1.5% register accuracy, leak detection, and meeting AWWA C700-2015 and NSF 61-2017.
2. The meter shall measure flow and provide totals in gallons and be installable in the vertical or horizontal position.
3. Provide a factory installed electronic encoder on the meter, with probes to detect current flow, total volume to date, and leak detection. The encoder shall be wired to the BAS, and have software able to communicate the required information in digital format.
4. Manufacturer: Badger Recordall Disc series, Hersey 400 and 500 series, or Neptune T10 series.

2.26 ACCESSORIES

A. Gaskets in water piping: 0.063" thick red rubber or asbestos-free composition sheet type, selected for the pressure, temperature and service of the specific joint.

B. Bolts and nuts: ASTM A307-2014e1, Grade B.

C. Stack sleeves: coated cast iron stack sleeve, with caulking recess, flashing flange, nonpuncturing flashing clamp ring, and pressure ring.

1. Manufacturer: Josam 26450, Smith 1720, or Zurn Z-195.

2.27 TUBING AND PIPING SLEEVES

A. Underground Tubing and Piping:

1. For 0.5" to 1" noninsulated tubing and piping direct buried underground, wrap the complete length with a minimum of 4 mil virgin polyethylene sleeve conforming to ASTM D1248-2016. Sleeves for cold water shall be blue, and red for hot water.
2. Manufacturer: IPS Water-Tite, Northtown, or Oatey.

B. Tubing and Piping in Contact with Concrete:

1. For 0.5" to 1" noninsulated tubing and piping installed in contact with concrete slabs or concrete blocks, wrap the effected length with a minimum of 25 mil virgin polyethylene conforming to ASTM D1248-2016. Sleeves for cold water shall be blue and red for hot water.
2. Manufacturer: Great Bay Products, or IPS Water-Tite.

PART 3 - EXECUTION

3.1 GENERAL PIPING INSTALLATION

A. General:

1. Install all piping, fittings, and joints in accordance with the applicable manufacturer's instructions whether underground or aboveground.
2. Piping shall be cut to measurements established at the site and worked into place without springing or forcing.
3. Use concentric reducing fittings between different size pipes.
4. Ream steel, brass and copper pipe after cutting, turn on end and knock loose dirt, scale, and filings from interior of pipe.
5. Slope water piping to drain back to the mains.
6. Install piping that is to receive insulation in a manner that when the insulation is installed, the finished wall of the insulation is not crushed nor in contact with any adjacent surface or equipment.

B. Underground:

1. Install water piping outside the building in trenches separate from sewers.
2. Excavation and backfill: as specified in Section 220010, Plumbing General.
3. Underground piping shall be connected to the exterior service line, or capped or plugged if the exterior service is not in place.

4. Piping installed below a footing's bottom elevation shall be installed a minimum of 12" horizontally from the footing for each 12" of depth below the footing.

C. Aboveground:

1. Piping shall be installed to permit free expansion and contraction, as controlled by pipe anchors, without damage to joints, hangers, or the building. Arrange piping to minimize stresses caused by expansion and contraction.
2. Group exposed pipe together and arrange control valves at fixtures for ease of operation.
3. Install piping so as to preserve access to valves and equipment and to provide the maximum headroom possible.
4. Provide offsets to maintain ceiling height and to coordinate with other trades.
5. Install exposed piping such that when insulation is applied it will not come in contact with adjacent surfaces.

D. Piping Joints:

1. General:

a. Isolate joints between dissimilar metals and connections to tanks with dielectric fittings.
b. Provide flanges, grooved couplings, or unions at connections to equipment.
c. Install mechanically grooved couplings and press fittings in accordance with the manufacturer's instructions, and provide factory trained personnel for installation.

2. Solder joints: pipe ends shall be cut square, deburred, cleaned and assembled in accordance with ASTM B828-2016.
3. Threaded joints: screw-thread joints shall be made with cut tapered threads. Joints shall be made tight with Teflon tape. Not more than 2 threads shall show after the joint is made tight, except no threads shall show in exposed chromium-plated piping.
4. Flanged joints: except at connections to equipment, flanged joints shall be made with ring type gaskets, extending to inside of bolt holes.

3.2 PIPING, FITTINGS AND JOINTS

A. General:

1. Do not mix plastic pipe and fitting manufacturers. Use only the manufacturer's products approved by way of product data submittals.

B. Copper Tubing:

1. Noninsulated piping installed in masonry construction shall be painted 2 coats of asphaltum paint.
2. Clean, prime, and paint exposed noninsulated piping with 2 coats of glossy silver paint.

3.3 SPECIALTY PIPING JOINTS

A. Unions:

1. Provide in each piping connection to each piece of equipment where equipment may be removed.
2. Unions are not required where flanges or roll-grooved mechanical joint couplings are provided.

B. Flange Joints:

1. Provide in piping connections to equipment where flanges are provided.

C. Ball Joints:

1. Ball joints shall be installed in accordance with manufacturer's recommendations.
2. Where ball joints are used across building seismic joints, they shall be installed in accordance with manufacturer's recommendations and SMACNA Seismic Restraint Manual: Guidelines for Mechanical Systems-2008.

3.4 VALVES

A. General:

1. Provide an isolation valve in the cold water service line near the point of entrance into the building. On the building side and near the gate valve, install a drain leg with 0.75" hose bib.
2. Provide a valve in each water supply connection to hose bibs, wall hydrants and water using equipment.
3. Install valves in clear locations so that handles and hand wheels are easily accessible for completely opening and closing of the valves.

B. Globe Valves:

1. Provide globe valves in each water supply connection to sinks, water coolers, and any fixture provided by others, except where globe type stop valves are furnished with fixtures.

3.5 STRAINERS

A. Install in the inlet to each pump, pressure reducing valve, flow control valve, thermostatic mixing valve, backflow preventer, and as indicated on the Drawings or specified herein.

3.6 HYDRANTS

A. General:

1. Provide Owner with a loose key for each hydrant and obtain a receipt listing quantity and type of hydrant keys.

B. Wall Hydrants:

1. Install 18" above finished grade, except where building conditions and/or grade prevents the installation. Modify installation height as required, up to 36" above finished grade, where 18" will not work.

3.7 BACKFLOW PREVENTERS

A. Drain line from each unit shall be DWV copper run full size to floor drain or as indicated on the Drawings.

3.8 VACUUM BREAKERS

A. Pressure Type:

1. Install where water flow is continuous.
2. Install a minimum of 12" above the overflow level of the device being served.

B. Atmospheric Type:

1. Install where water flow is intermittent.
2. Install a minimum of 6" above the overflow level of the device being served.

C. Install where spillage of water will not cause damage to room surfaces or equipment.

3.9 TRAP PRIMERS

A. Connect trap primer lines to the drain tailpieces where field conditions prohibit connection to the trap primer connections on the drain bodies.

B. Install trap primers with a straight downward slope to allow drainage from the trap primer valve.

3.10 WATER HAMMER ARRESTERS

A. Install water hammer arresters in accordance with PDI WH201-2017.

3.11 PRESSURE GAUGES

A. Provide water filled gauges at pressure reducing valves.

3.12 THERMOMETERS

A. Thermometer stems shall be installed in pipe tees with the stem in the water way flow stream. Thermometers shall be located so as to be easily read from 4.5' above the floor.

3.13 TEMPERATURE MAINTENANCE CABLE

A. General:

1. Install cables, controllers, and components in accordance with manufacturer's instructions.

2. Test cables and electronics prior to installing piping insulation.
3. Secure cable to piping with manufacture recommended tape on 10" centers.
4. Install power connections, splices, and end caps under the piping insulation.
5. Route power connections to a junction box located outside the piping insulation.
6. Install "Heat Trace" identification signs a maximum of 10' apart.
7. Provide 30 mA ground-fault protection for each cable circuit.

B. Installation Locations:

1. Install on the domestic hot water system from the water heater to all parts of the system.
2. Install on the domestic hot water branches from the takeoffs from the circulated main.

3.14 WATER HEATERS

A. Install heaters level and stable.

B. Start-up: a factory trained representative shall start-up each water heater. The representative shall submit a start-up report to the Contractor for inclusion in the Operation and Maintenance Manual.

3.15 HOT WATER CIRCULATING PUMPS

A. Support pumps independently from piping by mounting at 48" above floor on wall with an angle iron frame.

B. Do not restrain motor from floating on frame.

3.16 HOT WATER CIRCULATING PUMP TIMERS

A. Set to turn the circulating pump on at 4 am and run for 18 hours.

B. Coordinate the day-omission setting with the Owner.

3.17 THERMAL EXPANSION TANKS

A. Support tanks with hangers independently from adjacent piping or on the floor where floor bases are provided.

3.18 MIXING VALVES

A. Connect mixing valves to the piping systems per the manufacturer's published installation recommendations.

B. Secure each mixing valve assembly to a backboard mounted on the wall.

C. Install each sensing bulb in a minimum 1" tee so that the bulb is completely washed by the flow.

3.19 EMERGENCY FIXTURE WATER TEMPERING VALVES

A. Valves shall be accessible to read thermometers and adjust temperature setting as required.

B. Install a strainer in cold and hot water supplies, and a union at each connection.

C. Locking handle ball valves shall be installed in the closest accessible proximity upstream of emergency fixture water tempering valves in both the hot and cold water supply lines. In addition, signs shall be provided and attached to the locking handles indicating that the valves shall be normally in the open position except for maintenance purposes.

D. Emergency fixture water tempering valves and emergency fixtures shall have their performance verified in accordance with the manufacturers' instructions after substantial completion but before occupancy. In addition, immediately following compliance with the manufacturers' instructions verify that the water emitted from emergency fixtures is tepid, between 60°F and 100°F.

3.20 WATER METERS

A. Install meter, piping, valves, and accessories per the manufacturer's requirements, and as indicated on the Drawings.

B. Provide isolation valves, union or flange connections, and a separate wye pattern strainer at the meter's inlet.

3.21 TUBING AND PIPING SLEEVES

A. Install sleeve over tubing or piping before installation, allowing room for expansion and turns.

B. Inspect the sleeve closely for cuts or tears. Tape any cut or tear with water proof tape, wrapped around the sleeve and tubing or piping.

C. Terminate sleeve a minimum of 10" above the floor.

3.22 PIPING AND JOINT PRESSURE TESTING

A. General:

1. Test piping and joints under floor slabs before slabs are poured.
2. Tests shall be made while piping and joints are exposed to view.
3. Screwed, flanged, and grooved joints that leak shall be taken apart and reassembled.
4. Soldered, brazed, and clamped joints that leak shall be cut out and replaced.
5. Submit a statement certifying that piping and joints are tight and have passed the specified test.

B. Piping Systems:

1. Test cold water, hot water, and hot water circulating systems piping and joints by capping all openings and applying a hydrostatic pressure of 125 psig for 1 hour without any drop in pressure. Disconnect the pump source prior to and during testing. Where a system is tested in sections, each section shall be subjected to the same test.

3.23 PIPING SYSTEM TEMPERATURE TESTING

A. Hot Water Systems:

1. Following the installation of the piping systems, energize the water heaters circulation pumps, and temperature maintenance cable, and bring the piping systems up to operating temperatures.
2. Flow the hot water systems then allow the systems to stand for one hour before beginning testing.
3. Perform hot water temperature checks at each fixture, and verify that the correct water temperature, as indicated on the Drawings, is flowing from each hot water outlet.
4. Where any fixture's hot water temperature is incorrect, make adjustments as required to the water heaters, mixing valves, balancing assemblies, circulation pumps, and temperature maintenance cable.

B. Hot Water Circulation Systems:

1. For manual balancing systems using manual flow control fittings, ball or globe valves with flow meters, make the flow adjustments for each branch as indicated on the Drawings, then verify that the accumulated flow is returning to the water heater. Where flow is lower than indicated on the Drawings, adjust the balancing assembly settings.

C. Temperature Maintenance Cable:

1. After cable installation and prior to piping insulation installation, test the temperature maintenance cable using a 2500 V DC meg-ohmmeter. Minimum electrical insulation resistance shall be 20 meg-ohms, regardless of circuit length. Both bus wires and braid shall be tested to verity the connection of splices, tees, and end caps.
2. Repair with new cable, splices, tees, and end caps, any element that does not pass the test.
3. Following the cable inspection, energizing of the water heaters, and circulation pumps, and temperature maintenance cable, flow the hot water system as controlled by the piping temperature maintenance cable, and test that the correct water temperature, as indicated on the Drawings, is flowing from each hot water outlet.
4. Make adjustments as required to the water heaters, mixing valves, and circulation pumps, and temperature maintenance cable.

D. Documentation:

1. Provide a document for the Operation and Maintenance Manual that dates, locates, and records the flow settings at each balancing station, and the temperatures recorded at each fixture.
2. Provide a copy of the meg-ohmmeter report for the Operation and Maintenance Manual.

3.24 CLEANING AND DISINFECTION

A. Domestic Water Piping:

1. Clean and disinfect inside water piping prior to placing the system in operation.
2. Purge domestic cold water, and hot water and hot water circulating piping, including heaters, pumps, tanks, and fixtures.

3. Flush the piping systems with potable water from the municipal supply system until water runs clear.
4. Fill the system with clean water with a water/chlorine solution containing a minimum 50 ppm chlorine. Isolate the piping systems and allow to stand for 24 hours.
5. Flush the systems with clean, potable water from the municipal supply system until the chlorine in the system is the same level as the municipal supply system.
6. Submit water samples for biological examination by laboratories approved by the local health authority. Samples shall be taken in the presence of the Owner.
7. Repeat the procedures and resubmit water samples as required to pass the biological test. Minimum acceptance test results shall be 0.0 colonies of coliform bacteria.
8. Provide results of tests.
9. Materials and test methods shall comply with AWWA C651-2014.

B. Strainers: after final flushing of the water system, remove strainer baskets for cleaning and disinfection. Reinstall baskets and ensure that caps are leak tight.

END OF SECTION 224400

SECTION 224500 - FUEL GAS SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other plumbing systems are specified in other Sections of Division 22.

B. Refer to Section 220010, Plumbing General, for a list of plumbing sections included in this specification.

C. This Section covers the natural gas systems.

1.2 QUALITY ASSURANCE

A. Natural gas system and gas-fired equipment shall conform to the following:

1. Canadian Standards Association (CSA) and the Canadian Gas Association (CGA) requirements.
2. International Fuel Gas Code-2015 with South Carolina Modifications-2016.
3. NFPA 54-2018.

B. Welder certification: welders shall be certified under the rules of the National Certified Pipe Welding Bureau and qualified by either the National Certified Pipe Welding Bureau or an independent testing laboratory for the procedures used on this Project.

PART 2 - PRODUCTS

2.1 PIPING, FITTINGS, AND JOINTS

A. General:

1. Piping and fitting sizes listed are nominal inside diameter.

B. Natural gas, above grade, including connections to equipment not in return air plenums:

1. Piping: black steel, schedule 40, ASTM A53/A53M-2012.
2. Fittings: standard weight malleable iron, with chamfered inlet, class 150 ASME B16.3-2016.
3. Joints: threaded.
4. Corrosion protection for any piping susceptible to rusting: cleaned, primed and painted.

C. Natural gas, above grade, in return air plenums, except connections to equipment:

1. Piping: black steel, schedule 40, ASTM A53/A53M-2012.
2. Fittings:

a. Forged steel socket weld, 1.5" and smaller, ASME B16.11-2016.

b. Standard weight black steel, butt weld, 2" and larger, ASME B16.9-2012.

3. Joints: welded.
4. Corrosion protection for any piping susceptible to rusting: cleaned, primed and painted.

D. Natural gas, underground:

1. Piping: medium density yellow polyethylene, grade PE24, ASTM D2513-2016a.
2. Fittings: socket thermal fusion type.
3. Joints: thermal fusion.

E. Flexible gas piping above grade, 0.5" to 2":

1. Piping: corrugated, semi-rigid stainless steel tubing ASTM A240/A240M-2017, jacketed with fire retardant polyethylene sleeving ASTM E84-2018, and conforming to NFPA 54-2018.
2. Fittings: brass mechanical attachment type terminating with male NPT pipe threads.
3. Joints: threaded.
4. Manufacturer: GasTite CSST, OmegaFlex Tracpipe, or Ward Wardflex.

2.2 SPECIALTY PIPING JOINTS

A. Unions:

1. For steel piping 2" or smaller: ground joint with brass-to-iron seat.
2. For copper piping 2" or smaller: cast brass or bronze with copper soldered connections.
3. For piping larger than 2", flange and gasket type. Flanges in steel piping shall be cast iron.

B. Ball Joints:

1. Flexible ball joints less than 2.5" diameter shall be manufactured with ductile iron casings and balls. Ball joints shall permit 360° rotation and 28° minimum total angular flex.
2. Flexible ball joints with a diameter of 2.5" and larger shall be manufactured with carbon steel casings, retainers, and balls. Retainers shall be bolted to allow correct seal adjustment and disassembly for maintenance. Balls shall be protected with crack-free chromium plating. Ball joints shall permit 360° rotation and 15° minimum total angular flex.
3. Seals shall consist of inner and outer precision molded rings designed for system fluid, temperature, and pressure, without the use of additional packing or sealants. Seals shall be factory-seated with 50 psig saturated steam or equivalent thermal conditions.
4. Ball joints shall be FM approved or UL listed.
5. Manufacturer: Hyspan-Barco.

C. Gas service risers: an anode-less radius riser with epoxy-coated schedule 40 steel outer jacket, an inner polyethylene (PE) radius pipe and connection to steel riser pipes. Provide gas and watertight seals on each end of the outer jacket, and provide the PE pipe with butt end, and the steel pipe with threaded cap. Assemblies shall meet ASTM D2513-2016a.

1. Manufacturer: Everett J. Prescott 800-EJP-24 HR.

2.3 VALVES

A. General:

1. Valves shall be of the same manufacturer, unless specified otherwise herein.

B. Plug Valves:

1. Lubricated plug type, 0.5" to 3": with cast iron body, wrench handle control, 100% full flow rectangular port, threaded-ends, ASTM A126-2004 (2014) Class B for 200 psig wog.

   a. Manufacturer: Homestead 601, Nordstrom 142, Resun R1430, or Walworth 2720.

2. Lubricated plug type, 4" to 8": with cast iron body wrench handle control, 100% full flow rectangular port, flanged-ends, ASTM A126-2004 (2014) Class B for 200 psig wog.

   a. Manufacturer: Homestead 602/602A, Nordstrom 143, Resun R1431, or Walworth 1700F/1725F.

C. Ball Valves - Low Pressure:

1. Ball valves 0.5" to 1": 2-piece brass body with threaded ends, standard port chromium-plated brass ball, blow-out proof stem, virgin Teflon (PTFE) seats and stem packing, and lever handle. Valves shall be rated at a minimum of 400 psig wog, and comply with CGA CR91-002 for a 5.0 psig natural gas system.
2. Manufacturer: Apollo GB-10-L, Hammond 87501, Milwaukee BA-475B, or NIBCO GB1A.

D. Earthquake Valves:

1. Horizontal or vertical earthquake sensitive gas shut-off valves, with swing check valve arrangement and acceleration sensitive triggering mechanism, with manual reset, 0.75" through 8", for inlet pressures to 60 psig. Valve bodies shall be constructed of die cast aluminum with an anodized powder coat finish, threaded or flanged ends, and site glass to view status of trip mechanism. Valves shall have a 30 year warranty, be UL listed, and meet the requirements of ASCE/SEI 25-2016.
2. Manufacturer: Pacific Seismic Products.

2.4 GAS PRESSURE REGULATORS

A. Natural Gas Pressure Regulators:

1. Self-contained direct acting service regulators with cast iron or steel valve, aluminum diaphragm housing with screened vent, balanced-diaphragm, O-ring seals, full internal pressure relief, changeable brass orifice, and adjustable color-coded spring.
2. Regulators shall have over, and under pressure protection, each with manual reset as applicable.
3. Manufacturer: Elster American, Fisher, Maxitrol, or Sensus.

2.5 ACCESSORIES

A. Gaskets in natural gas piping: aluminum, O-ring type.

B. Bolts and nuts: ASTM A307-2014e1, Grade B.

PART 3 - EXECUTION

3.1 GENERAL PIPING INSTALLATION

A. General:

1. Piping shall be cut to measurements established at the site and worked into place without springing or forcing.
2. Use concentric reducing fittings between different size piping.
3. Ream steel piping after cutting, turn on end and knock loose dirt, scale, and filings from interior of pipe.
4. Pitch natural gas piping down to the main or low point 0.5" per 10'. Take branch piping off the top of mains. Install a water leg or trap with drain valve at low points and bottoms of risers.

B. Underground:

1. Install gas piping outside the building in trenches separate from water and sewers.
2. Excavation and backfill: as specified in Section 220010, Plumbing General.
3. Underground piping shall be connected to the exterior service lines, or capped or plugged if the exterior service is not in place.

C. Aboveground:

1. Pipes shall be installed to permit free expansion and contraction without damage to joints, hangers, or the building. Arrange piping to minimize stresses caused by expansion and contraction.
2. Group exposed pipe together and arrange control valves at fixtures for ease of operation.
3. Install piping so as to preserve access to valves and equipment and to provide the maximum headroom possible.
4. Provide offsets to maintain ceiling height and to coordinate with other trades.
5. Dirt pockets shall be line size and 6" long minimum. Terminate with threaded cap or flange.

D. Piping Joints:

1. Threaded joints: screw-thread joints shall be made with cut tapered threads. Joints shall be made tight with joint compound. Not more than 2 threads shall show after the joint is made tight.
2. Welded Joints:

a. Mitering or notching pipe to form elbows and tees will not be permitted. Field and shop bevels shall be in accordance with the standards specified herein and shall be done by mechanical means or flame cutting. Where beveling is done by flame cutting, surfaces shall be cleaned of slag, scale and oxidation prior to welding.

Before welding, the component parts to be welded shall be aligned so no strain is placed on the weld when finally positioned. Height shall be aligned so that no part of the pipe wall is offset by more than 20% of the wall thickness. Flanges and branches shall be set true. This alignment shall be preserved during the welding operations. Connections larger than 6" shall be made with backing rings at welds.

b. Where the temperature of the component parts being welded reaches 32°F or lower, the material shall be heated to approximately 100°F for a distance of 3' on each side of the weld before welding, and the weld shall be finished before the material cools to 32°F.
c. Welders shall stamp each weld with his personal symbol or code number.
d. Defective welds shall either be cut out and rewelded or ground down to base metal and rewelded. Reworked welds shall be tested as specified herein.
e. A random sample of completed pipe welds may be chosen by the Engineer for visual and/or nondestructive testing by an independent testing agency, not to exceed 5% of the total welds on the Project. Costs for testing shall be borne by the Contractor. Acceptance criteria shall be as specified by ASME B31.1-2016 and ASME B31.9-2017. If any of the tested welds are unsatisfactory, additional welds may be chosen for testing at the Contractor's expense.

3. Flanged joints: flanged joints in natural gas piping shall be made with O-ring gaskets. Flanged connections to equipment shall be made with full face gaskets to match flanges on equipment.
4. Insulate joints between dissimilar metals and connections to tanks with dielectric fittings.
5. Provide flanges or unions at connections to valves and apparatus.

3.2 BLACK STEEL PIPE AND FITTINGS

A. Changes in direction shall be made with fittings, except where branches are two or more sizes less than the size of the main, the branch may be made using forged steel branch connections, weldolets, threadolets, latrolets, sweepolets, and elbolets.

3.3 POLYETHYLENE PIPING AND FITTINGS

A. Transition polyethylene piping below grade to black steel for extension to above grade. The black steel piping shall be corrosion protected with liquid epoxy coating.

B. Provide underground detectable warning tape per Section 220010, Plumbing General.

3.4 FLEXIBLE PIPING

A. Install with caution and using the manufacturers' instructions.

3.5 SPECIALTY PIPING JOINTS

A. Unions:

1. Provide in each connection to each piece of equipment, except where flanges are used.

B. Ball Joints:

1. Ball joints shall be installed in accordance with manufacturer's recommendations.
2. Where ball joints are used across building seismic joints, they shall be installed in accordance with manufacturer's recommendations and SMACNA Seismic Restraint Manual: Guidelines for Mechanical Systems-2008.

3.6 VALVES

A. General Requirements:

1. Provide a full size valve in the main gas line inside the building for the building shutoff.

2. Provide a full size valve to control each gas main, branch line, and supply line to gas using equipment.

B. Plug Valves:

1. Provide a minimum of 4 gas valve wrenches per size of gas valve operating nuts.
2. Valves shall be lubricated before shipment.

C. Earthquake Valves:

1. Install earthquake valves only in series as shipped from the factory: for horizontal valves, the horizontal position; and for vertical valves, the vertical position.

3.7 GAS PRESSURE REGULATORS

A. General:

1. At building startup and testing, provide additional regulator orifices, springs, and accessories, to make any adjustments and setting changes required to ensure that each regulator is functioning properly for its full equipment load.
2. Install regulators with vent openings facing down.
3. Supply pipes shall not be more than one pipe size larger than the regulator's pipe connection size.
4. Adjust the regulator springs with a minimum 5% system's designed flow, flowing. Select the spring with the system's operating pressure not at the spring's minimum or maximum pressure settings.

B. Engine Generators:

1. When the regulator serves an engine-generator, the distance from the regulator outlet to the engine-generator inlet connection shall not exceed 10'.
2. Provide the regulator at 150% of the generator’s full load requirement.

C. Regulator Vent Piping:

1. Gas pressure regulator vents: provide vent piping to a point outside the building at least 10' above finished grade, 10' from any outside air intake, and minimum 5' from any building

opening. Each vent connection to a regulator shall be increased 1 pipe size, and routed independently outside.

2. Water heater and boiler gas pressure regulator vents: provide vent piping to a point outside the building at least 10' above finished grade, 10' from any outside air intake, and minimum 5' from building opening. Each vent connection to an appliance regulator, and block and vent valve, shall be increased 2 pipe sizes, and routed independently outside.
3. Vents from normally open solenoid vent valves shall be increased 2 pipe sizes, and routed independently outside.
4. Terminate vent piping with down-turned elbows, and secure insect screens to the open ends.

3.8 CORROSION PROTECTION

A. Above grade ferrous piping, fittings, and valves, exposed where moisture can produce rust shall be cleaned, primed, and painted with 2 coats of exterior grade silver paint.

3.9 GAS RELATED EQUIPMENT

A. General:

1. After gas related equipment has been installed, provide piping, isolation valves, and accessories as specified herein, and make final connections.
2. The location and number of connections shown on the Drawings is approximate. Determine the exact number, location, and rough-in requirements from the equipment drawings and specifications.

B. Equipment:

1. For gas piping, rough-in each at 6" from wall or 6" above floor, unless otherwise indicated on the Drawings, with a valve and cap.

3.10 PIPING AND JOINT TESTS

A. Test natural gas system piping by capping openings and applying an air pressure of 100 psig for 2 hours without any leaks. Disconnect the air source prior to and during testing. Where the system is tested in sections, each section shall be subjected to the same test.

B. Piping General:

1. Test piping under floor slabs before slabs are poured.
2. Tests shall be made while piping and joints are exposed to view.
3. Submit a statement certifying that piping and joints are tight and have passed the specified test.

C. Piping Test General:

1. Screwed and flanged joints that leak shall be taken apart and reassembled.
2. Brazed joints that leak shall be taken down and replaced.
3. Thermal fused joints that leak shall be taken down and replaced.

END OF SECTION 224500

SECTION 230010 - HVAC GENERAL

PART 1 - GENERAL

1.1 DESCRIPTION

A. These heating, ventilating and air conditioning (HVAC) provisions specified herein apply to all Sections of Division 23.

B. Refer to the General and Supplementary Conditions and Division 01 for special requirements and conditions which apply to all Sections of Division 23.

C. This Section includes responsibilities and obligations in support of the performance verification specified in Section 230090, HVAC Performance Verification

1.2 QUALITY ASSURANCE

A. Conform to the following:

1. International Energy Conservation Code-2009.
2. International Mechanical Code-2015 with South Carolina Modifications.
3. NFPA 90A-2018.

B. Codes, standards and regulations specified herein refer to the edition date. Revisions and addenda to these codes, standards and regulations shall be part of these specifications. Provisions of referenced codes, standards, and regulations do not create duty or responsibility by the Architect or the Owner, unless otherwise specified herein.

C. Codes, standards and regulations referred to are minimum standards. Where the requirements of these specifications or drawings exceed those of the codes, standards and regulations, the drawings or specifications shall govern.

D. HVAC/Electrical Design Coordination:

1. The power ratings of motors and other HVAC equipment and the electrical characteristics of electrical systems serving them, as specified herein and indicated on the Drawings, have been established as minimums which will allow that equipment to satisfactorily function while producing the required capacities. These power ratings include a safety factor deemed appropriate to accommodate common differences between design parameters and field construction practices. Under no circumstances shall equipment with power ratings less than those indicated on the Drawings or specified herein be provided.
2. Reasonable efforts have been made to coordinate the electrical requirements of the HVAC equipment with the electrical systems serving that equipment. Differences among manufacturers of HVAC equipment make it impossible to produce a single electrical design which will satisfy the varying electrical requirements of those manufacturers. Consequently, the Contractor shall coordinate the electrical requirements of the HVAC equipment actually furnished on this Project and provide the electrical systems required by that equipment. This coordination effort shall be completed prior to the installation of either the HVAC equipment or the electrical systems serving that equipment. Electrical system

revisions required to coordinate with the HVAC equipment actually furnished shall be provided at no additional cost to the Owner.

E. Adhesives and Sealants:

1. Adhesives, sealants, and sealant primers used inside the building (defined as inside the weatherproofing envelope and applied on site) shall comply with SCAQMD Rule 1168-2017 for volatile organic compound content limits.
2. Aerosol adhesives shall comply with GS 36-2013 for volatile organic compound content limits.

F. Paints and Coatings:

1. Anticorrosive and antirust paints applied to interior ferrous metal shall not exceed a volatile organic compound content limit of 250 g/L per GS 11-2015.

1.3 SPACE CONDITIONS

A. Drawings are diagrammatic in nature and, unless explicitly dimensioned, indicate approximate locations of apparatus, equipment, ductwork and piping. Changes in the location, and offsets, of same which are not shown on the Drawings but are necessary in order to accommodate building conditions and coordination with the work of other trades, shall be made during the preparation of coordination drawings and prior to initial installation, without additional cost to the Owner.

B. Provide access to equipment and apparatus requiring operation, service or maintenance throughout the life of the system.

C. Piping, equipment, or ductwork shall not be installed in electrical equipment rooms, elevator equipment rooms, or elevator shafts unless specifically indicated on the Drawings. In addition, piping, ductwork, or mechanical equipment shall not be installed in the space equal to the width and depth of switchgear, switchboards, panelboards, and motor control centers from floor to structure above nor within the working space in front, rear and/or side (where rear and/or side access is required to work on equipment) of electrical equipment (switchgear, switchboards, panelboards, motor control centers, variable frequency drives, transformers, and starters). Dimensions of the working space shall be a minimum depth of 42" horizontally, the width of the equipment or 30", whichever is greater, and the height of the equipment or 78", whichever is greater. Minimum depth shall be increased to 60" for equipment rated over 600 V.

1.4 ASBESTOS MATERIALS

A. Materials containing asbestos or any trace of asbestos related materials shall not be used on this Project.

1.5 DEFINITIONS

A. Exposed piping, conduit, or ductwork is that which can be seen when the base building and tenant fit-up is complete without opening or removing access doors or panels or accessible ceiling components.

B. Other piping, conduit, and ductwork is considered to be concealed.

1.6 RELATED WORK DESCRIBED IN OTHER DIVISIONS

A. Installation of access panels in wall and ceiling construction.

B. Cutting, coring, waterproofing, and patching of walls, floors, ceilings, roofs and structure of existing buildings.

C. Painting, except as specified herein.

D. Electric power, interlock, and control wiring, except as specified herein.

E. Installation of starters, contactors, thermal overload switches, and remote push buttons, except as specified herein.

F. Fire alarm initiating devices, control modules, and monitoring modules.

G. Curbs, flashing, and pitch pockets for equipment on roof, except as specified herein.

H. Motor control centers.

I. Pipe trenches with grates.

J. Masonry plenums.

K. Vehicle washing equipment.

L. Concrete pump pits.

M. Manhole construction.

N. Door undercuts.

O. Structural supports for the heat rejection equipment and roof-mounted equipment.

P. Engine-generator sets, including silencers.

Q. Louvers and screens.

R. Subway grating and frames.

1.7 SUBMITTALS

A. After notice to proceed, submit a schedule indicating the proposed submission date of each submittal specified herein. Schedule shall anticipate the submittal review time, the possible need for resubmittals, and the time required for fabrication, shipping and integration into the construction sequence. Architect will advise of any conflicts in reviewing submittals that the proposed schedule presents.

B. Submittals shall be prepared in a line-by-line format corresponding to these Specifications and shall indicate compliance with each requirement specified herein and indicated on the Drawings.

1. In addition to any other transmittals or cover sheets used, fill out and attach to each individual submittal a copy of the Cover Sheet for Submittals to Newcomb & Boyd included at the end of this Section.
2. Indicate manufacturer's installation instructions.
3. Indicate deviations, if any, including any from the manufacturer's installation instructions.
4. Reproductions or electronic versions of design drawings shall not be used in the preparation of shop drawings.
5. Resubmittals that are required to address review comments shall include a cover transmittal with a written explanation of how each review comment has been addressed.
6. Submittals not specifically required, or not complying with the format requirements, will be returned unreviewed.
7. Shop drawings and submittals shall be provided in portable document format (PDF). PDF files containing multiple drawings or components shall include an index of the file contents and electronic bookmarks.

C. Shop drawings shall include the following:

1. Trade shop drawings (i.e., HVAC equipment room drawings, HVAC piping system drawings, HVAC sheet metal system drawings, and electrical main feeder raceway drawings) shall be submitted within 30 days after award of contract.
2. Approved trade shop drawings shall be utilized as the basis for the coordination drawings. Coordination drawings shall be submitted within 30 days after approval of trade shop drawings.
3. Coordination drawings shall utilize either manual or electronic means of analyzing the work of each trade in spatial relationship with other trades. Locations of conflicts between trades, and the proposed resolution for each conflict, shall be noted on the coordination drawings submitted.
4. No work shall be fabricated and/or installed prior to receipt by the Contractor of approved trade shop drawings without specific written authorization from the Architect. No change orders will be approved or design assistance provided for remedial field coordination activities for work fabricated and/or installed prior to receipt by the Contractor of approved trade shop drawings.

D. HVAC submittals shall include the following:

1. Performance Verification Supervisor qualifications.
2. Coordination drawings, with dimensions and elevations, of HVAC work, including ductwork, equipment, piping with fittings, valves, dampers, accessories and sleeves coordinated with the work of other trades, including plumbing, fire suppression, electrical, structural, and architectural, minimum 1/4" = 1'-0" scale.
3. Insulation.
4. HVAC underground preinsulated piping systems, including drawings with dimensions and bury depths, fittings, valves, accessories, thrust blocks, expansion loops, factory-prepared calculations of thrust and expansion, coordinated and shown with the work of other trades including plumbing, civil, fire suppression, electrical, structural and architectural, minimum 1" = 20'-0" scale.

5. Vibration isolation, including spring data, manufacturer's equipment operating weight, actual load distribution and actual deflection at each loading point for each piece of isolated equipment.
6. Air-cooled condensing units.
7. Air handling units with coil, fan, and filter data, and fan curves.
8. Automatic temperature controls with information as specified in Section 23 80 00, Automatic Temperature Controls. Each control device, software, sequence of operation, and control schematic and I/O summary submittal shall be cross-referenced to a specific requirement in these Specifications and Drawings.
9. Chillers.
10. Coils.
11. Ductless split systems.
12. Electric heating coils, including diagrams showing arrangement of circuits to prevent stratification of hot and cold air for coils controlled at 3 stages or more.
13. Fans and fan curves.
14. Finned tube radiation.
15. Fire dampers, including static pressure drop for each damper.
16. Grilles, registers and diffusers, including performance data.
17. Infrared heaters.
18. HVAC equipment room drawings, with dimensions and elevations, showing equipment, coil and tube pull areas, sheet metal work and piping with locations of valves, thermometers, thermometer wells, gauges and needle valves, minimum 1/4" = 1'-0" scale.
19. Precision air conditioning units.
20. Pumps and pump curves.
21.
22. Sheet metal system drawings, showing air distribution equipment, including required clearances around control panels, coils, filters, return air openings, and other components, ductwork, fittings, dampers, plenums, elevations, dimensions, offsets, and transitions coordinated with piping, building conditions, and other trades, minimum 1/4" = 1'-0" scale.
23. Terminal units.
24. Unit heaters.
25. Valves and strainers.
26. Variable frequency drives, including harmonic analysis study and report.

1.8 EQUIPMENT AND INSTALLATION REQUIREMENTS

A. Equipment and materials shall, unless otherwise specified herein, be new and shall be of the customary standard and quality furnished by the designated manufacturer for that catalogue number.

B. Materials and equipment shall be UL listed, and shall bear the UL listing mark on products for which standards have been established and for which listing is regularly furnished by UL.

1. In lieu of the UL listing, or where standards have not been established by UL and UL listing is not regularly furnished, materials and equipment shall be listed by a laboratory recognized under the OSHA Nationally Recognized Testing Laboratory Program or by a laboratory accredited by International Accreditation Service. Examples include:

a. Canadian Standard Association.
b. ETL Testing Laboratories, Inc.
c. MET Electrical Testing Company, Inc.

C. Mechanical equipment that is not covered by NAECA-2015 shall carry a permanent label installed by the manufacturer stating that the equipment complies with the requirements of ASHRAE/IES 90.1-2016.

D. In addition to the 1 year warranty specified in General Conditions, an additional 4 year warranty shall be extended on the compressors of rooftop and split system air conditioning units.

PART 2 - PRODUCTS

2.1 HANGERS AND SUPPORTS

A. Hangers:

1. General: complete with rods and supports proportioned to the size of piping or equipment to be supported.
2. For steel pipe: steel or malleable iron, unless specified otherwise herein.
3. For copper piping 4" and smaller: copper-plated; Anvil CT-69, B-Line B3170 CT, or ERICO 101.
4. For black steel piping 2" and smaller: Anvil 69, B-Line 200, or ERICO 115.
5. For copper piping over 4": copper-plated; Anvil CT-65, B-Line B3104 CT, or ERICO 401.
6. For chilled water piping 3" and larger, and piping insulated to prevent sweating: galvanized; Anvil 260, B-Line B3100, or ERICO 401.
7. For PVC piping: vee-bottom type; B-Line B3106, PHD 450V, or RHK K3106.

B. Hanger Rods:

1. One-piece steel type, threaded as required.
2. Sizes, unless specified otherwise herein, shall be as follows:

Pipe Size	Rod Diameter
2" and smaller	0.375"
2.5" and 3"	0.5"
4"	0.625"
6"	0.75"
8" and larger	0.875"

3. Sizes for gang or multiple hangers: calculated for the combined weight of the piping and accessories.
4. Sizes for equipment hangers: calculated for the weight of the equipment supported.

C. Inserts:

1. Adjustable type: Anvil 282, B-Line B3014, or ERICO 355.
2. Continuous type: Anvil PS-5000, B-Line B32I, or ERICO CON.

D. Expansion Anchors:

1. In concrete: wedge, self-drilling, or drilled flush type.
2. In masonry: sleeve type.
3. Manufacturer: Hilti, ITW Ramset/Red Head, or Rawl.

E. Clamps for piping in bar joist construction: Anvil 92 or 93, B-Line B3031 or B3033, or ERICO 300.

F. Insulation protectors: Anvil 167, B-Line B3151, or ERICO 125.

G. Channel strut systems: 14 gauge minimum galvanized steel, with factory-punched attachment holes. Straps shall be designed so that the attachment nut is captive on the shoulder of the strap when tightened. Attachment nuts shall be designed to provide a surface on the turned down edge while making positive contact with the side walls of the channel. Nuts, bolts, straps, and accessories shall be protected with same finish as channels.

1. Manufacturer: B-Line, Kindorf, Midland-Ross, or Unistrut.

2.2 VALVE TAGS

A. Minimum 19 gauge polished brass, 1.5" minimum size. Tags shall be square. Stamped numbers and letters shall be not less than 0.75" high, and filled with black paint.

2.3 IDENTIFICATION MATERIALS

A. Pipe identification shall be 5 mil thick, self-adhering vinyl plastic tape. Tape and legend shall be as follows:

Diameter (Including Insulation)	Width	Size of Legend Letters
0.75 - 1.25"	8"	0.5"
1.5 - 2"	8"	0.75"
2.5 - 6"	12"	1.25"
8 - 10"	24"	2.5"
Over 10"	32"	3.5"

1. Legends shall be in full or abbreviated form, in contrasting color to background color.

B. Nameplates and signs: laminated plastic, engraved with white letters. Background color shall be:

System	Color
Equipment served by emergency power	Red
Other equipment	Black

C. Duct identification shall be strap-on type vinyl markers, minimum size 32" x 6" with minimum 3.5" lettering.

2.4 SLEEVES

A. Sleeves shall be standard weight steel pipe except sleeves for concealed piping through floors not in structural members, and through interior drywall construction may be formed from 26 gauge galvanized sheet metal lapped and pop riveted.

2.5 PENETRATION SEALS

A. Firestops:

1. Refer to Architectural Specification Section 078400, Firestopping.

B. Expansion Seals:

1. Waterproof, modular, mechanical expansion type consisting of synthetic rubber grommets or interlocking links shaped to continuously fill the annular space between the penetrating item and the opening. Sizing of links and sleeve shall be determined by the manufacturer.
2. Manufacturer: Calpico Pipe Linx, Metraflex MetraSeal, or Thunderline Link Seal.

2.6 MOTORS

A. General:

1. Motors shall be dripproof, unless otherwise specified herein or indicated on the Drawings, and in compliance with NEMA MG 1-2016. Refer to Electrical Drawings for exact characteristics of motors. Dripproof and totally enclosed fan-cooled motors shall be rated on a 50°C and 55°C temperature rise basis, respectively, unless otherwise specified herein.
2. Dripproof and totally enclosed: 1800 rpm, induction type with a 1.15 service factor, unless otherwise specified herein.
3. Motors indicated on the Drawings as being controlled by variable frequency drives shall be:

    a. Designed in accordance with Part 31 of NEMA MG 1-2016 for use with variable frequency drives.
    b. Provide with factory-installed shaft grounding rings, which shall consist of a circumferential ring of conductive microfibers that discharge shaft voltages to ground.

        1) Manufacturer: AEGIS SGR.

4. Motors not furnished with equipment shall be by: Baldor, Century, Delco, GE, Marathon, Reliance, or Siemens.

B. Efficiency:

1. NEMA premium efficiency type, in accordance with NEMA MG 1-2016, for heating, ventilating, and air conditioning equipment 1 hp and larger.
2. Totally enclosed or weather protected type 1 for cooling towers and outside condenser water pumps air-cooled condensers and air-cooled condensing units.

2.7 STARTERS

A. General:

1. Manual reset, Class 20, thermal type overload protection for each phase, in accordance with NEMA ICS 2-2000 (R2005).
2. NEMA 3R enclosures for exterior application.

3. Equipment furnished with factory-installed starters shall also be equipped with individual motor disconnect and thermal magnetic circuit breakers or fuses as specified herein with lugs sized to receive a feeder as indicated on the Electrical Drawings.
4. 120 V secondary control power transformer with fused primary and secondary circuit in the enclosure.
5. Starters located in motor control centers are specified in Division 26.
6. Unused auxiliary contacts (installed on each contactor): 1 normally open, and 1 normally closed.
7. Starters and contactors not furnished with equipment shall be provided by: ABB, Allen-Bradley, Crouse-Hinds, Cutler-Hammer, GE, Square D, Furnas, Joslyn Clark, or Siemens-ITE.

B. For 3-phase motors, unless otherwise specified herein:

1. Combination magnetic type and fused disconnect switch:

a. Fuses having type and UL class rating as specified in Division 26, providing Type 2 protection.
b. External operating handle capable of being locked in the off or open position.
c. Hand-off-automatic switch on the face for each fan and pump, except those manually controlled.
d. Solid state motor winding heater package, fused, for motors over 40 hp installed outdoors.

C. For 3-phase, 2-speed, unless otherwise specified herein:

1. Combination magnetic type and fused disconnect switch :

a. Overload protection for each speed.
b. Fuses having type and class rating as specified in Division 26, providing Type 2 protection.
c. External operating handle capable of being locked in the off or open position.
d. Hand 2-hand 1-off-automatic switch on the face, except those manually controlled.
e. Low speed deceleration relay.
f. Solid state motor winding heater package, fused, for motors over 40 hp installed outdoors.

D. For 1-phase, unless otherwise specified herein:

1. Manual starting switch with thermal overload protection and pilot light.
2. Hand-off-automatic switch, except for manually controlled equipment.

2.8 VARIABLE FREQUENCY DRIVES

A. Variable frequency AC motor controllers shall be designed for use with motors as specified in Paragraph 2.6, Motors

B. Variable frequency drives in air handling units mounted on the roof shall be installed in accordance with the manufacturer's recommendations and shall include provisions for removing excess heat. Manufacturer shall fully warrant the installation as specified herein and indicated on the Drawings. Coordinate with the air handling unit manufacturer.

C. Controllers:

1. NEMA 1 enclosure, wall- or floor-mounted, UL 508C-2016 listed, with integral power disconnect with door interlock, completely factory-wired, ready for field connection of incoming and outgoing power, and control signal, in compliance with NEMA ICS 1-2000 (R2005, R2008, R2015), NEMA ICS 6-1993 (R2001, R2006, R2011, R2016), and NEMA ICS 7.1-2014. Drives shall be rated a minimum of 100,000 A RMS symmetrical AIC.
2. Controllers shall be of the pulse width modulation type, and shall have the following features and functions contained in the cabinets unless otherwise specified herein:

    a. Current limiting fuses or semi-conductor protection on the incoming line side.
    b. Speed regulation within 3% accuracy.
    c. Integral manual bypass complete with interlocked contactors to completely isolate the controller when in the bypass mode, face-mounted controller-off-bypass switch with pilot lights, solid state motor overload relays with phase loss protection for motor protection in both the controller and bypass modes, auxiliary relays to allow remote start-stop commands in both modes, and door interlocked lockable disconnect switch to provide means of disconnecting power to both bypass circuitry and controller. Manual bypass components shall mount within the controller enclosure or enclosure extension. A separate starter shall not be required to operate the motor in the bypass mode. Power supply to the bypass contactors and relays shall be provided by a single-phase power conditioner with sufficient rating and capacity to prevent contactor dropout during power sags.
    d. Serial communications capability for transmitting operating data and receive commands through a single connection to the building automation system. Provide hardware and software for BACnet, LonWorks, or Modbus communication, as coordinated with building automation system supplier.
    e. Interface connections for remote controls shall be wired to terminal strips as follows:

        1) Dry contacts for remote enable/disable.
        2) Process transducers for 4-20 mA speed adjustment signal.
        3) Terminals for connection of normally closed remote safety devices.
        4) Dry contact for external alarm, to open on internal drive fault, power supply fault, process transducer signal fault, or operation of remote safety devices.

    f. Harmonic Distortion Control:

        1) The variable frequency drive manufacturer shall perform a harmonic analysis study in accordance with IEEE 399-1997. The study shall establish the requirements for harmonic distortion control. Harmonic analysis study report shall be submitted concurrently with the variable frequency drive submittals and shall include variable frequency drives factory-installed on equipment, such as chillers.
        2) Variable frequency drive design shall be such that the maximum contribution from all variable frequency drives does not exceed the following:

            a) IEEE 519-2014 voltage and current distortion limits at the point of common coupling.
            b) 5% total demand distortion (total harmonic current distortion in percent of maximum demand load current) and 3% total harmonic voltage distortion at the building service.

c) Variable frequency drives shall limit the harmonic distortion imposed on the building electrical system to voltage and current distortion limits as defined above by utilizing DC link chokes and/or integral 3-phase AC input line reactors with minimum impedance of 3%.

3. Where specified herein, controllers shall be provided with damped low pass DV/DT drive output filters. Filters shall have K-rated line reactor, gapped iron core, inductor, copper windings and 40ºC ambient temperature rating with a 155ºC maximum operating temperature. Filters shall allow mounting of variable frequency drives up to 3000' from motor loads by filtering voltage spikes.
4. Controllers shall have the following internal protective functions for the protection of the controller modules and motors:

    a. DV/DT (voltage transient) and DI/DT (short circuit) protection.
    b. Inverse time overcurrent protection.
    c. Full time current limit to limit maximum speed for prevention of overload.
    d. Phase sequence (if phase sensitive), phase loss, overvoltage, undervoltage, electronic thermal overload, abnormal temperature, DC overvoltage, and internal fault protection.
    e. Motor winding ground fault.
    f. Motor and variable frequency drive overtemperature protection.
    g. Input power line surge protective device.

5. Integral EMI/RFI filter. Controllers shall be designed to avoid RF interference with other electronic equipment internal or external to the building.
6. Diagnostic module shall identify faults as they occur, storing them in nonvolatile memory for recall, including:

    a. Overcurrent.
    b. Overvoltage.
    c. Undervoltage.
    d. Ground fault.
    e. Electronic motor overload, UL listed for this function.

7. Operator panels shall include digital display and keyboard for entry of set-up parameters, recall of faults from diagnostic module, and display of current operating values including:

    a. Output frequency.
    b. Motor speed.
    c. Motor current.
    d. Output voltage.
    e. Analog input values.
    f. Digital input status.
    g. Elapsed time meter.
    h. Power on indication.

8. Provide nameplate engraved with system identification and hand-off-automatic switch. The hand position shall start the drive and shall have a manual means of speed adjustment. In the automatic position, the drive shall be started and adjusted remotely.
9. Controller design shall permit operation at full load with ambient conditions between 0°C and 40°C, with capacity to handle 110% overload torque for 1 minute. Printed circuit

boards shall be tested under full rated load at 10°C above rated ambient temperature for at least 20 hours, and failures corrected prior to shipment.

10. When enabled by remote controls, controller shall start at zero speed and ramp to the current speed setting. Speed range shall be adjustable between 0 Hz and 66 Hz, with separately adjustable maximum and minimum speeds, and adjustable rate of acceleration and deceleration. Provide at least 2 lockout speed ranges with adjustable minimum and maximum speed settings to prevent operation at driven equipment resonant vibration frequencies.
11. Controllers shall restart automatically upon restoration of stable electric service after power supply faults, with adjustable time delay before restart. Operating parameters shall be stored in nonvolatile memory. Controllers shall continue to operate at the minimum speed setpoint on loss of remote control signal, and activate the remote alarm contact.
12. Variable frequency drives shall be designed for starting into a spinning motor. The variable frequency drive shall be able to determine the motor speed in any direction and resume operation without tripping. If the motor is spinning in the reverse direction, the variable frequency drive shall start into the motor in the reverse direction, bring the motor to a controlled stop, and then accelerate the motor to the preset speed.
13. Drive displacement power factor shall be between 0.95 and 1.0 lagging over the entire operating speed range.
14. Drive efficiency shall be greater than 96% at 100% speed full load.

D. Start-up service: as specified in Section 230090, HVAC Performance Verification.

E. Service: manufacturer shall maintain a parts and service facility within 4 hours of this Project, which shall have inventory to cover not less than 80% parts service within 24 hours, and 95% within 48 hours. Further, the facility shall have a factory-trained service representative to furnish installation, test, and start-up supervision necessary for final approval and acceptance, as well as to perform maintenance and repairs on components.

F. Warranty: in addition to other warranties specified herein, equipment shall be guaranteed against defective parts and workmanship under terms of the manufacturer's standard warranty, but in no event shall it be for a period of less than 2 years from date of initial start-up of the system and shall include labor and travel time.

G. Manufacturer: ABB, AC Tech, Allen-Bradley, Baldor, Danfoss, Eaton, Emerson, Fuji, GE, Hitachi, Johnson Controls/York, Siemens, Square D, Toshiba, Trane, US Drives, or Yaskawa.

2.9 VIBRATION ISOLATION

A. Apparatus shall be by one manufacturer, except where herein specified otherwise.

B. Vibration bases for fans shall have adjustable motor slide rails, and shall accommodate motor overhang. Bases shall be of welded construction with cross members to form an integral support platform. Steel members shall be designed to match supported equipment. Bases for exterior use shall be completely corrosion resistant.

1. Height-saving brackets or welded steel pockets shall be incorporated to ensure a 2" minimum clearance under each inertia base.

C. Where isolators are exposed to weather, springs shall be powder- or neoprene-coated and other parts hot-dipped galvanized or zinc-plated.

D. Isolators:

1. Type FS - Free-standing, laterally stable, unhoused spring type with leveling bolts for bolting to the equipment. Spring diameter shall be not less than 0.8 of the compressed height of the spring. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Springs shall be complete with neoprene or fiberglass noise isolation pads, minimum 0.25" thick, bonded to the baseplate.

    a. Manufacturer: Kinetics Noise Control FDS, Mason SLF, Vibration Eliminator OST, VMC Group AW/AWH, or Vibro-Acoustics FS.

2. Type NH - Double-deflection neoprene or natural rubber hanger type, with neoprene or natural rubber grommet between hanger rod and housing. Neoprene or natural rubber element shall have neoprene- or natural rubber-coated metal surfaces.

    a. Manufacturer: Kinetics Noise Control RH, Mason HD, Vibration Eliminator C, VMC Group HR, or Vibro-Acoustics NH.

3. Type NS - Sandwich pad type, with minimum 0.25" thick ribbed or waffled neoprene pad bonded to each side of 16 gauge plate. Isolator pads shall be selected for less than 80% maximum rated load.

    a. Manufacturer: Kinetics Noise Control RSP, Mason WSW, Vibration Eliminator P, VMC Group Multi-Layer Shear-Flex, or Vibro-Acoustics 400 NP.

2.10 CONCRETE

A. Normal weight concrete (145 pcf) using Type I Portland Cement, 1" maximum size coarse aggregate to provide a minimum 28 day compressive strength of 3000 psi.

2.11 GROUT

A. Nonshrink type, conforming to ASTM C1107/C1107M-2017 when tested at fluid consistency. Grout shall exhibit zero bleeding at every age when mixed to fluid consistency. Minimum 28 day compressive strength, when mixed to fluid consistency, shall be 7000 psi.

B. Manufacturer: Cormix, or Master Builders.

2.12 ACCESS PANELS - BUILDING

A. Refer to Architectural Specification Section 083100, Access Doors and Panels.

2.13 ESCUTCHEONS

A. Split hinged type, constructed of chromium-plated steel or cast brass, sized to fit over insulation and to cover sleeve.

2.14 UNDERGROUND WARNING TAPE

A. Tape shall be acid- and alkali-resistant polyethylene film tape, 6" wide with minimum thickness of 0.004", specifically designed for marking and locating of underground utilities.

B. Tape shall be manufactured with integral wires, foil backing or other means to enable detection by a metal detector when the tape is buried up to 3' deep. The metallic core of the tape shall be encased in a protective jacket or provided with other means of corrosion protection.

C. Tape color shall be as specified below and shall bear a continuous printed inscription describing the specific utility:

Utility	Color
Chilled water	Blue

D. Manufacturer: Brady, Boddingtons, Carlton Industries, Seton, or Thor Enterprises.

2.15 PAINTING

A. Paint for high temperature piping and equipment shall be high temperature resistant, designed for the temperatures at which the system will operate.

PART 3 - EXECUTION

3.1 PROTECTION OF EQUIPMENT AND MATERIALS DURING CONSTRUCTION

A. Provide protective covers, skids, plugs or caps to protect equipment and materials from damage or deterioration during construction.

B. Store equipment and material under cover, and off the ground or floors exposed to rain.

C. For outdoor storage, protective covers of 10 mil thick black sheet plastic shall be fitted over equipment and materials. Covers shall be reinforced to withstand wind and precipitation. Set equipment and material on skids or platforms of height to avoid damage or deterioration from spattering and ground water.

D. Protect coils against damage by installing temporary closure panels over exposed coil faces. Panels shall be minimum 24 gauge sheet metal or 0.375" plywood.

E. Close open ends of fans, terminal units, air handling units, and ductwork with temporary closures of sheet plastic taped in place.

F. Plug ends of pipes when work is stopped to prevent debris from entering the pipes.

G. Provide dust and debris protection for ductwork, coils, fans, equipment, motors, and bearings operated during construction up to date of substantial completion.

H. Cover open ends of exhaust and return ducts with temporary filter media while fan systems are operating.

3.2 EQUIPMENT AND INSTALLATION REQUIREMENTS

A. Air systems shall operate without aerodynamic noise generated from the faulty installation of ductwork or any component of the air distribution system.

B. Equipment shall be installed and connected as specified herein or indicated on the Drawings in accordance with the manufacturers' instructions and recommendations for this Project. Furnish and install auxiliary piping, water seals, valves, and electrical connections recommended by the manufacturer for operation.

C. Refer to manufacturer's or equipment supplier's shop drawings for exact type, number, location, dimensions and size of connections to equipment including, but not limited to:

1. Car washing equipment.

D. Motor quantities, sizes and equipment wattage ratings specified herein or indicated on the Drawings are the minimum requirements, unless noted otherwise. Motor quantities, sizes and equipment wattage ratings less than those specified herein or indicated on the Drawings are not acceptable. Larger motor sizes and equipment wattage ratings may only be provided if necessary to meet the prescriptive requirements specified herein or indicated on the Drawings. Where multiple motors or motor sizes or equipment wattage ratings larger than specified herein or indicated on the Drawings are furnished, provide and coordinate the corresponding increased number or capacity of feeders and other electrical equipment serving them, at no additional cost to the Owner.

E. Fans, drive sheaves, motors, and pumps shall be statically and dynamically balanced and shall have steady state radial vibration levels which do not exceed the following:

Equipment	Peak-to-Peak Displacement (mils)
Fans, drive sheaves, and motors	
under 600 rpm	4
600 to 1000 rpm	3
1000 to 2000 rpm	2
over 2000 rpm	1
Pumps and motors	
over 1800 rpm	1
under 1800 rpm	2

F. Field-installed equipment controls or sensor wiring shall be installed in conduit. Low voltage control and sensor wiring shall be installed in conduits separate from line voltage control wiring and power wiring.

G. Where connection sizes at equipment vary from the pipe size indicated on the Drawings, provide appropriate reducers/increasers directly adjacent to the pipe-equipment unions. Unless otherwise specified herein or indicated on the Drawings, the size of the valves and accessories dedicated to the equipment shall not be less than the pipe size to which they are connected.

3.3 HANGERS AND SUPPORTS

A. Where several pipes run parallel and in the same plane:

1. 2.5" and smaller: may be supported on gang or multiple hangers. Separate copper tubing from ferrous supports with copper-plated steel or 4 psf sheet lead.
2. 3" and larger: support independently, parallel, and equally spaced.

B. Supports for steel pipe and for copper tubing shall not be more than 10' apart. Supports for copper tubing 1.25" and smaller shall be not more than 5' apart. Supports for PVC piping shall be not more than 4' apart. Pipes shall be supported within 1' of each elbow and tee, and for piping 2.5" and larger at each valve and strainer or each close-coupled group of valves, traps, and strainers.

C. Hangers and supports for insulated piping shall bear on outside of insulation. Hangers shall be sized for uncompressed insulation thickness.

D. Provide insulation protectors.

E. Support piping independently of equipment.

F. Adjust hangers and supports so that loading is uniform.

G. Hanger rods shall be suspended from the structure. Do not suspend from other piping, equipment, or ductwork.

H. Inserts:

1. Use for piping 2.5" and larger .
2. Where the weight to be supported by an insert exceeds 50% of its rated load, install 2 No. 3 reinforcing rods, 3' long through each yoke of insert.

I. Expansion Anchors:

1. Use for piping 2" and smaller.

3.4 SLEEVES

A. Provide where pipes pass through walls, floors and roofs, except in the following circumstances:

1. Concealed wall openings of the required diameter in non fire- or smoke-rated construction.
2. Concealed floor openings formed by the use of plastic forming devices providing a circular opening of the required diameter.
3. Core drilled concealed openings. Openings in roofs shall not be core drilled. Obtain written permission prior to core drilling.
4. Openings in concrete floor slabs on grade.

B. Sleeves shall be placed into position prior to wall, floor, or roof construction. Sleeves shall be tight-fitting and cut smooth.

C. Floor sleeves shall be cast in place, shall be watertight, and shall extend from the bottom of the slab to 2" above the finished floor.

D. Wall sleeves shall extend 1" on each side of walls.

E. Make sleeves through outside walls above and below grade watertight.

F. Size sleeves for insulated pipes penetrating nonrated construction to allow full thickness insulation.

G. Sleeves in nonrated construction shall be sized to provide clearance all around pipe, including insulation, to accommodate thermal movement. Clearance shall be minimum 0.75".

3.5 PENETRATION SEALS

A. General:

1. Install in accordance with the manufacturer's published instructions to achieve ratings and classifications specified herein. A copy of these instructions shall be maintained and available on site.

B. Exterior Wall Seals:

1. Piping without insulation: use expansion seals between pipes and sleeves. Where walls exceed the width of expansion seals, use two seals, one being flush with the inside sleeve face and the second with the outside sleeve face. Fill the annular void space between the two seals.
2. Piping with insulation: pack center annular space between the insulation and the sleeve with fiberglass, then caulk 1" deep from each face to the fiberglass with nonhardening sealant. Smooth sealant with face of sleeve.

3.6 IDENTIFICATION OF PIPING

A. Identify piping specified under this Division in accordance with ASME A13.1-2015.

B. Legends shall be on the lower quarters of the pipe except where such location would be obscured. Arrow tape shall be wrapped completely around the pipe at each end of the legend with arrows pointing in the direction of flow.

C. Locate pipe identification as follows:

1. In equipment rooms:

a. Within 18" of each valve or valve assembly.
b. Within 36" of each 90º elbow, connection to equipment or vessel, point where pipe enters shafts and pierces outside walls.
c. On not over 20' intervals along exposed piping.

2. Above suspended ceilings:

a. Within 18" of each valve or valve assembly.
b. At tees within 36" of both main and branch.
c. Within 36" of each 90º elbow.

d. Identify at not less than 1 point each piping run visible in each room with identification on not over 20' intervals.
e. On not over 20' intervals.

3. Piping concealed in chases or shafts:

a. Each pipe visible through an access door or panel.

4. Piping exposed in rooms other than mechanical equipment areas:

a. Omit identification of piping 0.5" and smaller exposed at connections to equipment.
b. With the above exception, identify at not less than 1 point each piping run visible in each room with identification on not over 20' intervals.

D. Schedule of Piping Identification:

Piping System and Contents	Tape Color	Legend	Abbreviated Legend
Chilled Water	Green	Chilled Water	CHS & CHR

E. Piping with temperature maintenance cable shall be labeled Electronically Traced on the outside of the insulation jacket.

F. Quench vent piping shall be labeled along its entire length: "Extremely Cold Helium Gas-Authorized Personnel Only".

3.7 VALVE TAGS AND SCHEDULES

A. Provide numbered brass tags on valves, except at unit heaters, fan-coil units, terminal unit coils, finned tube radiation, and convectors. Attach tags to valve stems with brass S-hooks or brass chain.

B. Provide for each system a typewritten schedule of valves giving number, location (room number), and function of each with a small scale diagram outlining general piping layout and location of each numbered valves.

3.8 IDENTIFICATION OF EQUIPMENT

A. Identify equipment. Identification shall consist of upper case letters.

B. Each starter, variable frequency drive, contactor, push button station, control switch, disconnect, and thermal overload switch shall be appropriately identified by nameplates with 0.25" high letters.

1. Identification shall include the equipment designation and device function, e.g., CT-1 Water Level Control Disable.

C. Each piece of equipment and access door shall be stenciled with its equipment number in a prominent location with minimum 2" high letters.

D. Access panels and doors in ductwork and plenums shall be stenciled with minimum 1" high letters to indicate the type of devices accessible therein and the system or fan identification number associated with that ductwork or plenum.

E. Ceiling tile grid shall be stenciled with minimum 1" high letters containing terminal unit tag to indicate terminal unit accessible through the adjacent acoustic ceiling tile.

3.9 IDENTIFICATION OF DUCTWORK

A. Markers shall be secured to ductwork with draw bands.

B. Legends shall be on the underside of the duct except where such location would be obscured. Legends shall include name of air handling unit or fan system and arrows pointing in the direction of flow.

C. Concealed ductwork shall be labeled with identification materials specified herein. Exposed ductwork shall be stenciled with minimum 3.5" uppercase letters.

D. Supply ductwork downstream of terminal units shall not be labeled.

E. Locate duct identification as follows:

1. Mechanical Equipment Rooms:

   a. Within 36" of each elbow, connection to equipment, and point where duct enters a shaft.
   b. On not over 20' intervals along exposed ductwork.

2. Above Suspended Ceilings:

   a. Within 18" of each terminal unit.
   b. At branch connections within 36" of both main and branch.
   c. Within 36" of each elbow and point where duct enters a shaft.
   d. On not over 40' intervals.

3. Ductwork Concealed in Chases or Shafts:

   a. Each duct visible through an access door or panel.

F. Schedule of Ductwork Identification:

Duct System and Contents	Background Color	Legend	Legend Color
Outside Air	Green	Outside Air	White
Supply Air	Blue	Supply Air	White
Return Air	Red	Return Air	White
Toilet or Janitor Closet Exhaust	Yellow	Toilet Exhaust	White

3.10 MOTORS

A. Provide motors for equipment covered in Division 23 unless otherwise specified herein. Select motors for operation not exceeding a 1.0 service factor and within the nameplate amperage and nominal power rating.

3.11 STARTERS

A. Provide starters, push buttons, thermal overload switches, and contactors for equipment covered in Division 23 unless otherwise specified herein. Installation of starters, push buttons, and thermal overload switches, not factory installed, is specified under Division 26.

B. Provide 120 V secondary control power transformers for control circuits where equipment is served at 208 V or higher.

3.12 FUSES

A. Provide fuses in equipment furnished under this Division of the specifications.

B. Provide 3 spare fuses of each size, UL class, and voltage rating furnished under this Division of the specifications and turn over to the Owner. Obtain a receipt for same.

3.13 VARIABLE FREQUENCY DRIVES

A. Installation is specified under Division 26.

B. Start-up shall be performed under the supervision of a technical service employee of the manufacturer. Set minimum speed at 20%, and calibrate the control input to match the operating conditions and the automatic temperature control system. Submit written certification, upon completion, that components have been installed correctly in accordance with the manufacturer's recommendations, are operating correctly, and that operation and set-up has been coordinated with the automatic temperature control systems.

C. Test each fan from minimum to maximum speed to determine the resonant frequencies. Once the resonant speeds have been determined, adjust the frequency lock-out feature to eliminate fan operation at those speeds.

D. Install DV/DT drive output filters where load lead length is 50' and greater.

3.14 VIBRATION ISOLATION

A. General:

1. Select and locate vibration isolation equipment for uniform loading and deflection, according to weight distribution of equipment.
2. Vibration isolators shall be installed and connected as specified herein or indicated on the Drawings in accordance with the manufacturer's written instructions and certified submittal data.
3. Installation of vibration isolation equipment shall be supervised by an authorized, factory-trained manufacturer's representative.

4. There shall be no direct contact of isolated piping, ductwork, or equipment with shaft walls, floor slabs, structural elements, conduits, or any other nonisolated item.
5. Prior to startup, clean out foreign matter between bases, isolators, equipment, and mounting surfaces. Verify that there are no rigid connections between equipment and building structure.
6. Where recommended by the manufacturer, isolator baseplates shall be bolted to the structure or foundation. Bolting shall incorporate neoprene bushings and washers.
7. Installed Type FS isolators shall not incorporate a leveling bolt of greater length than that supplied with the isolators.
8. Isolator hangers shall be installed with housings a minimum of 2" below but as close to the structure as possible.
9. Absence of Type SR isolators scheduled on Drawings shall not preclude their use. Coordinate with the manufacturer if installation conditions warrant their use once specific equipment selection is finalized.
10. Vibration isolators shall not cause any change in position of equipment, piping, or ductwork resulting in stresses or misalignment.
11. Conflicts with other trades that will result in direct contact with isolated equipment, piping, or ductwork, shall be brought to the attention of the Architect prior to installation.
12. Discrepancies between the specifications and the field conditions, or changes required due to specific equipment selection shall be brought to the attention of the Architect prior to installation.
13. After installation, manufacturer shall verify that vibration isolation systems are installed and operating properly, and shall submit a certificate so stating. Verify that isolators are adjusted, with springs perpendicular to bases or housing, adjustment bolts are tightened up on equipment mountings, and hangers are not cocked.

B. Equipment Isolation:

1. Isolated equipment mounting systems shall permit equipment motion in all directions.
2. Mount fans, as indicated on the Drawings, on structural steel vibration bases common to both fan and motor.
3. Mount equipment, as indicated on the Drawings, on concrete-filled inertia bases. Inertia bases shall be arranged with spring isolator locations such that a horizontal plane passing through the top of the isolators will pass through or above the center of gravity of the equipment and base. There shall be a minimum operating clearance of 2" between each inertia base and its foundation.

C. Piping Isolation:

1. Extent of Piping Isolation:

   a. Chilled water piping in the air handling unit room shall be supported with vibration isolators.
   b. Different sections of piping requiring the same type of isolator with the same minimum static deflection may be supported on a common trapeze support that is isolated with the same type of isolator.

2. Chilled and Condenser Water Piping:

   a. Piping shall be suspended with Type SH isolators with a minimum 1" static deflection.

3.15 EQUIPMENT AND EQUIPMENT ROOMS

A. Remove dust, dirt, rust, stains, and temporary covers.

B. Foreign matter shall be blown, vacuumed, flushed, or cleaned out of and from new equipment, piping, ductwork, pumps, fans, motors, bearings, devices, switches, controls, and panels.

C. Clean and polish identification plates.

D. In equipment rooms, clean equipment, ductwork, insulation, piping, conduit, and room surfaces from dust and dirt and maintain in a clean condition from date of substantial completion until final completion of work and corrective work.

E. Remove excess material from the Project site.

3.16 FOUNDATIONS

A. Provide concrete foundations for the following floor-mounted equipment:

Equipment	Foundation
Air handling units	4" high pad

1. Foundation height shall accommodate condensate P-traps, but shall be not less than the minimum specified above.

B. Foundations shall be continuous and shall have beveled edges and smooth float finish. Foundations shall be reinforced with No. 3 bars a maximum of 12" on center each way, and held in place with dowel rods at each corner anchored in the slab. Dowel rods shall not penetrate through the slab.

C. Roughen and clean exposed slabs before pouring foundations. Apply bonding agent to surfaces in contact.

D. Foundations shall extend a minimum of 6" beyond the equipment footprint or 1.5 times the seismic anchor embedment depth from the point of anchoring (whichever is larger) in all directions, including appurtenances, vibration isolators, base elbow supports, and motors.

E. Equipment attached directly to foundations or inertia bases; bases provided with grout holes; and bases consisting of a structural frame shall have voids filled with grout after attachment to foundation.

F. Fill voids between baseplates and foundations, and level equipment, with grout.

G. Provide exterior foundations for air-cooled chiller on grade.

1. Exterior foundations shall be minimum 8" thick pads, minimum 4" above surrounding grade. Pads shall be reinforced with No. 4 bars, 16" on center each way.
2. Exterior foundations shall be supported on natural ground with organic material under pad removed. The subgrade shall be compacted to 90% modified proctor maximum dry density, ASTM D1557-2012e1, to a depth of 12". If the compaction density cannot be achieved with the existing soil, the existing subgrade shall be removed to a depth of 12" and replaced

with clean backfill and compacted as specified above. A 4" thick granular subbase of sandy gravel or crushed stone shall be compacted with vibratory compactors. Dampen the subbase prior to concrete placement. At the time of placement, the subbase shall not contain standing water.

3.17 ACCESS PANELS - BUILDING

A. Where HVAC work is concealed by walls or ceilings, or is inaccessible, provide an access panel to provide access for service and maintenance.

B. HVAC work located above ceilings is considered accessible if the ceiling is the accessible type and is arranged for access to the equipment.

C. Fire-rated access panels shall be provided in fire barriers with ratings to match the construction fire rating.

D. Access doors providing access to ductwork access doors shall allow for service and maintenance of the intended equipment.

E. Installation of access panels is specified under another Division.

3.18 ESCUTCHEONS

A. Provide escutcheons where exposed piping passes through walls, floors and ceilings in finished areas.

3.19 UNDERGROUND WARNING TAPE

A. During backfill, install tape continuously along length of piping, 12" to 18" above the piping for:

1. Chilled water.

3.20 PAINTING

A. Except where otherwise specified herein, painting shall be done under another Division. Surfaces shall be left clean and free from oil.

B. Equipment factory finishes damaged or deteriorated during construction shall be repaired to match original finish.

C. Where galvanizing is broken during fabrication or installation, recoat exposed areas with zinc-rich paint.

D. Exterior ferrous equipment, piping and supports shall be painted with 2 coats of rust preventive paint, color selected by the Architect.

E. Exposed interior uninsulated black steel piping, and exposed nongalvanized ferrous accessories, hangers, rods, inserts, and mechanical supports shall be prepared and painted with 1 coat of rust preventive paint prior to other painting or identification, or 2 coats of rust preventive paint if no other painting is specified.

F. Ductwork, conduits, insulation, pipe and structure visible through architectural return air openings, grilles, registers and diffusers shall be painted flat black.

3.21 EXCAVATION AND BACKFILLING

A. Install underground piping outside the building with 36" minimum cover, unless specified otherwise herein.

B. Determine exact location of existing underground utilities before excavation.

C. Excavations shall be no longer or deeper than necessary. Backfill material shall be free from rocks and debris.

D. Compact backfill as the excavation is filled.

E. Excavation, shoring, bracing, backfilling, and compaction, cutting and patching of hardscape, and restoration of landscape shall conform to Division 31, Earthwork.

3.22 COORDINATION

A. Provide offsets, transitions, and fittings to coordinate the work of each trade with that of other trades, including plumbing, fire protection, electrical, structural, and architectural.

3.23 PHASING

A. Install work in phases as required by the Architectural Documents.

3.24 OPERATION AND MAINTENANCE MANUALS

A. These operation and maintenance manual requirements supplement operation and maintenance manual documentation requirements of other Sections of these specifications.

B. Operation and maintenance documentation, in hardback 3-ring loose-leaf binders except full size drawings and CDs, shall cover the HVAC and automatic temperature control systems. Documentation shall include an operations and maintenance documentation directory, emergency information, operating manual, maintenance manual, test reports, and construction documents.

C. The operation and maintenance documentation package shall be submitted as one comprehensive package to the Architect Owner 3 months before systems start-up, and shall be updated, revised and completed at completion of construction.

D. Compile and coordinate the documentation for equipment and systems installed. Documentation shall be typewritten and shall contain, at a minimum, the following information.

1. Introduction:

    a. Project name, contractors' and subcontractors' names, addresses, and telephone and facsimile numbers. Indicate the portion of the work for which each subcontractor was responsible.
    b. Index.

2. Operation and Maintenance Documentation Directory:

    a. Explanation of the identification system used, including lists of systems, equipment, and component identifiers and names.

3. Emergency Information:

    a. Information for technical and nontechnical personnel about actions recommended during emergency situations to protect life and property and to minimize disruption to the building occupants. Emergencies shall, at a minimum, include:

        1) Fire.
        2) Security breach.
        3) Water outage.
        4) Power failure.
        5) Refrigerant release.
        6) Heating failure.
        7) Cooling failure.

4. Operation Manual:

    a. General Information:

        1) Building function.
        2) Building description.
        3) Operating standards and logs.

    b. Technical Information:

        1) System description.
        2) Operating routines and procedures.
        3) Seasonal start-up and shutdown.
        4) Special procedures.
        5) Basic troubleshooting.

5. Maintenance Manual:

    a. Descriptions (specifications) of the equipment and components.
    b. Description of function, as applicable: the function of the equipment, procedures before start-up, functional parameters (input, output) at the design load and at part loads, and performance verification procedures.
    c. Recommended maintenance and lubrication procedures and their recommended frequency for this Project.
    d. Recommended list of spare parts, part numbers, and the place(s) from which they can be obtained.
    e. Original purchase order number; date of purchase; name, address, and the telephone number of the vendor; and warranty information.
    f. Name and address of at least one service agency capable of providing maintenance.
    g. Installation information.
    h. Other information needed for the preparation of documents supporting the management of operation and maintenance programs.

6. Test Reports and Certifications:

   a. Copies of tests and certifications performed during manufacture and construction, including but not limited to the following:

      1) Certification of installation of vibration isolation.
      2) Receipt for spare fuses.
      3) Receipt for instruction of operating personnel.
      4) Certification of installation of HVAC underground preinsulated piping systems.
      5) Certification of hydronic system cleaning.
      6) Certification of chiller installation and safety and control check-out.
      7) Certification of ductwork testing results.
      8) Seasonal adjustment reports.
      9) Certificate of refrigerant piping dehydration test.

7. Construction Documents:

   a. Record drawings.
   b. Approved submittals, including revised shop drawings indicating as-installed conditions.
   c. Equipment identification charts and schedules.
   d. Warranty certificates.
   e. Inspection certificates.
   f. Test, adjust and balance report.
   g. Performance verification report.

E. Submit a receipt signed by the Owner acknowledging receipt of the operation and maintenance documentation package.

3.25 RECORD DRAWINGS

A. A record of field and as-installed conditions shall be maintained at the site, shall be kept current throughout the Project, and shall be used in the preparation of the final record drawings. Field and as-installed conditions shall be recorded on design drawings and shall be marked to include addenda, change orders, field changes and selections made during construction.

3.26 DIAGRAMS

A. Frame and mount the following information:

Information	Location
HVAC diagrams, start-stop procedures, and valve schedules.	Appropriate mechanical rooms.
Automatic temperature control diagrams and sequences.	Adjacent to each control panel.

Information	Location
Appropriate control and interface drawings, including a simplified guide to local programming through the digital display unit, a directory of I/O points connected to that panel, and variables which may be displayed.	Posted on the inside cover of each BCS panel.

B. Diagrams shall be type written or computer generated.

C. Diagrams shall be as-built, and shall include interfaces and interlocks with other equipment.

D. Diagram framing system: 0.125" thick acrylic with satin finish aluminum frames.

3.27 MAINTENANCE

A. Equipment operated prior to the date of substantial completion shall be maintained in accordance with manufacturer's recommendations. In addition, provide complete water treatment for hydronic systems operated prior to date of substantial completion.

B. Prepare and submit a lubrication chart listing for each piece of equipment:

1. Points requiring lubrication.
2. Recommendations for a single manufacturer's lubricants with brand name and designation.
3. Frequency of lubrication required.

C. Lubricate each item of apparatus requiring lubrication prior to start-up in accordance with the manufacturer's recommendations.

3.28 INSTRUCTION OF OPERATING PERSONNEL

A. Provide the designated Owner's personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of equipment specified in Division 23. Conduct 2 formal instruction sessions for operating personnel. The first session shall be conducted at the time of start-up and check-out, and the second session shall be approximately 2 months later. Sessions shall be a minimum of 2 days for basic HVAC systems, and as specified herein for specialty systems and equipment. Sessions shall be conducted at the site.

B. Prepare and submit a syllabus describing an overview of the proposed training program, describing how the training program will be conducted, when and where meetings are to be held, names and company affiliations of lecturers, description of contents and outline for each lecture, and recommended reference material and outside reading. Obtain direction from the Architect Owner on which operating personnel shall be instructed in each system. Proposed training schedules, materials, and lesson plans shall be submitted to the Owner for review of the content and adequacy of the training of the Owner's personnel.

C. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor, or manufacturer's representative. More than one party may be required to execute the training. The training program shall include the following, as appropriate for the system or equipment:

1. Training shall normally start with classroom sessions followed by hands-on training for each piece of equipment, which shall illustrate the various modes of operation, including start-up, shutdown, fire/smoke alarm modes, and power failure.
2. During any demonstration, should the system fail to perform in accordance with the requirements of the operation and maintenance manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
3. The controls contractor shall attend training sessions for each type of equipment or system controlled by the automation system, to discuss the interaction of the automation system as it relates to the equipment or system, in addition to the training required for the automation system.
4. Training shall include:

    a. Use of the printed installation, operation and maintenance instruction material included in the operation and maintenance manuals.
    b. A review of the written operation and maintenance instructions emphasizing safe and proper operating requirements, preventative and routine maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover, and any emergency procedures.
    c. Discussion of relevant health and safety issues and concerns.
    d. Discussion of warranties and guarantees.
    e. Common troubleshooting problems and solutions.
    f. Explanatory information included in the operation and maintenance manuals and the location of plans and manuals in the facility.
    g. Discussion of any peculiarities of equipment installation or operation.
    h. Classroom sessions shall include the use of overhead projections, slides, video/audio-taped material as appropriate.
    i. Specific operating and maintenance procedures for:

        1) Chillers.

    j. Factory-trained technicians shall give instruction on the following specialty systems and equipment:
    k. BCS training: as specified in Section 23 80 00, Automatic Temperature Controls.

5. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance for all pieces of equipment.
6. Explain and demonstrate the operation, function and overrides of local packaged controls not controlled by the central control system.
7. Training shall occur after testing is complete, unless approved otherwise by the Architect. Owner.
8. Provide DVD format video recordings of training sessions and a complete record copy of training materials, handouts, and other printed materials used in each training session.

9. Obtain a receipt acknowledging completion of each item of instruction.

END OF SECTION 230010

COVER SHEET FOR

SUBMITTALS TO NEWCOMB & BOYD

Project: _____ Date: _____

Item: _____ Submittal Number: _____

Manufacturer: _____ Model: _____

Specification Paragraph and/or Drawing Number: _____

Capacity: _____

Electrical Characteristics (including identification of all separate connections or services required): _____

_____

_____

_____

Accessories: _____

_____

_____

_____

Options: _____

_____

_____

_____

Deviations (if any; if none, state so): _____

_____

General Contractor Approval: _____

SECTION 230090 - HVAC PERFORMANCE VERIFICATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other HVAC systems are specified in other Sections of Division 23.

B. Performance verification is ongoing process and shall be performed throughout construction. Performance verification verifies that systems are operating in a manner consistent with the Construction Documents.

C. This Section covers HVAC systems performance verification, as required to demonstrate that the equipment and systems of Division 23 are ready for safe and satisfactory operation, as defined by the Construction Documents. Performance verification shall include, but shall not be limited to, identification of piping and equipment, cleaning, lubrication, start-up, check-out, and testing, adjusting, and balancing of systems, preparation of equipment and systems documentation and of maintenance and operation manuals, Owner training, and preparation of record drawings.

D. Performance verification shall conclude with the completion of required deferred testing, training, and system documentation as specified herein and required to demonstrate the proper operation of the HVAC equipment and systems provided by this Division.

E. Verify, at a minimum, the performance of the following systems and equipment and witness the following tests:

1. Section 230010, HVAC General:

    a. Seismic restraints.
    b. Variable frequency drives.
    c. Vibration isolation.

2. Section 231000, Piping, Valves and Accessories:

    a. Automatic air vents.
    b. Expansion tanks.
    c. Flow meters.
    d. Water pressure reducing valves.
    e. Water pressure relief valves.
    f. Water storage tanks.

3. Section 231500, HVAC Underground Preinsulated Piping Systems:

    a. Underground chilled water system.

4. Section 236000, Equipment:

    a. Air handling units.
    b. Air-cooled chillers.
    c. Ductless split systems.

d. Electric heating coils.
e. Gas-fired infrared heaters.
f. Precision air conditioning units.
g. Pumps.
h. Rooftop air conditioning units.
i. Terminal units.

5. Section 237000, Air Distribution:

a. Carbon monoxide exhaust systems.
b. Centrifugal fans.
c. Centrifugal inline fans.
d. Filter pressure gauges.
e. High velocity low speed fans.

6. Section 238000, Automatic Temperature Controls:

a. BCS.
b. BCS acceptance.
c. BCS start-up and checkout.
d. BCS training.

7. Section 230095, Testing, Adjusting, and Balancing:

a. Certified test reports.
b. Ductwork leakage tests.
c. Hydrostatic pressure tests.

1.2 QUALITY ASSURANCE

A. Provide a HVAC Performance Verification Supervisor with ten years experience in HVAC contracting. The HVAC Performance Verification Supervisor shall become familiar with the Owner's project requirements and the requirements of the performance verification process as defined in this Section. The HVAC Performance Verification Supervisor shall coordinate and execute the required performance verification activities.

B. The HVAC Performance Verification Supervisor shall review submittal data for conformance with the requirements of the Project, shall monitor compliance with the requirements specified herein for storage and protection of equipment during construction, shall authorize the initial starting of equipment and systems in a manner to avoid damage to equipment, shall oversee start-up, testing and balancing, and shall document that the scheduled and specified performance requirements of each system have been accomplished.

C. Refer to ASHRAE Guideline 0.2-2015, Commissioning Process for Existing Systems and Assemblies, ASHRAE Guideline 1.1-2007, The HVAC+R Technical Requirements for the Commissioning Process, and Guideline 4-2008 (RA 2013), Preparation of Operating and Maintenance Documentation for Building Systems.

1.3 PERFORMANCE VERIFICATION RESPONSIBILITIES

A. The HVAC Performance Verification Supervisor shall be responsible for scheduling, supervising, and coordinating and executing the start-up, testing, and performance verification activities as specified herein. Include and itemize the cost of performance verification in the contract price, and in each purchase order or subcontract written, include requirements for submittal data, performance verification efforts and documentation, operations and maintenance data, and training as specified herein.

B. HVAC Performance Verification shall take place in three phases. Performance verification requirements for each phase are as follows:

1. Construction Phase:

a. Attend a performance verification scoping meeting and additional such meetings, initially scheduled monthly until prefunctional testing of equipment and systems begins, and weekly thereafter during the construction phase to facilitate the performance verification process. The HVAC Performance Verification Supervisor shall coordinate meeting attendance.
b. Report in writing to the Architect, at least as often as performance verification meetings are scheduled, concerning the status of mechanical activities as they affect the performance verification process, the status of each discrepancy identified the prefunctional and functional testing process, explanations of any disagreements with the identified deficiencies, and the proposed resolution and schedule for correction of the deficiency.
c. Provide documentation of installed systems and equipment, and develop functional testing procedures. This documentation shall include detailed manufacturer installation, start-up, operating, troubleshooting and maintenance procedures; full details of any Owner-contracted tests; fan and pump curves; full factory testing reports, if any; and full warranty information, including responsibilities of the Owner to keep the warranty in force. In addition, the installation, start-up and check-out materials that are actually shipped inside the equipment and the actual field check-out sheet forms to be used by the factory or field technicians shall be submitted to the Owner.
d. Develop and submit to the Owner for review and comment, prior to equipment or system start-up, a complete start-up and initial check-out plan using manufacturer's start-up procedures and prefunctional checklists for the performance of the equipment to be verified.
e. Assist in clarifying the proposed operation and control of equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
f. Prepare the specific functional test procedures as specified herein and review the proposed functional test procedures to ensure feasibility, safety, and equipment protection, and provide necessary written alarm limits to be used during the tests. Obtain Owner approval for proposed functional test procedures.
g. Prepare a preliminary schedule for performance verification activities, including pipe and duct system pressure and leakage testing, flushing and cleaning, equipment start-up, and testing, adjusting and balancing start and completion, and update the schedule during the construction period, as appropriate. Notify the Owner immediately when the performance verification activities not yet performed or not yet scheduled will delay construction.
h. HVAC equipment start-up shall not be initiated until completion of pressure and leakage testing and cleaning as specified in other Sections of Division 23.

i. Provide start-up and prefunctional testing for equipment, including the building automation control system, and execute the HVAC-related portions of the prefunctional checklists for the verification of the performance of all the equipment during the start-up and initial check-out process.
j. Perform and document start-up and system operational check-out procedures, providing a copy to the Owner.
k. Correct noncompliance items before beginning functional performance testing. Air and water testing, adjusting and balancing shall be completed with discrepancies and problems remedied before functional testing of the respective air- or water-related systems.

2. Acceptance Phase:

a. Place equipment and systems into operation and continue their operation during each working day of the testing, adjusting and balancing, and performance verification activities, as required.
b. For each system or area, have required prefunctional checklists, calibrations, start-up and prefunctional tests of the mechanical systems and associated controls completed prior to beginning the testing, adjusting and balancing process.
c. Provide sheaves and belts as required to achieve required equipment performance, as measured by the testing, adjusting and balancing work.
d. Provide skilled technicians to execute starting and prefunctional testing of equipment and to execute the functional tests for each individual piece of equipment and system. Technicians shall be available and present during the agreed upon scheduled tests and for sufficient duration to complete the necessary tests, adjustments and problem-solving.
e. Perform functional testing for specified equipment and interpret the test data, as necessary.
f. Correct deficiencies (differences between specified and observed performance) as identified by the HVAC Performance Verification Supervisor, and interpreted by the Architect and retest the equipment, as required to demonstrate proper operation and performance.
g. Prepare operation and maintenance manuals as specified herein, including clarifying and updating the original sequences of operation to as-built conditions.
h. Maintain marked-up record drawings and produce final record drawings of Project drawings and contractor-generated coordination drawings. List and identify on these record drawings the locations of control system components, airflow stations, and sensor installations that are not equipment mounted.
i. Provide specified training of the Owner's operating personnel.
j. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

3. Warranty Period:

a. Execute seasonal or deferred functional testing.
b. Correct deficiencies and make necessary adjustments to operations and maintenance manuals and as-built drawings system or equipment modifications made during the warranty period and those identified in any deferred functional performance testing.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Standard testing equipment required to perform start-up, initial check-out, prefunctional, and required functional testing shall be provided for the equipment or system being tested.

B. Test equipment shall be of the quality and accuracy required to test and/or measure system performance with the tolerances specified and shall have been calibrated within the last 12 months, or as specified herein. Equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates available on request.

1. Temperature sensors and digital thermometers shall have a certified calibration within the past 12 months and a resolution of ±0.1ºF. Accuracy of temperature test equipment shall be at least twice that of the instrumentation being tested.
2. Humidity sensors shall have a certified calibration within the past 6 months and a resolution of ±1%. Accuracy of humidity test equipment shall be at least twice that of the instrumentation being tested.
3. Pressure sensors shall have a certified calibration within the 12 months and a resolution of 0.05% of sensor range. Accuracy of pressure test equipment shall be at least twice that of the instrumentation being tested.
4. Accuracy of other sensors shall be at least twice that of the instrumentation being tested.

PART 3 - EXECUTION

3.1 SUBMITTALS

A. Submit additional documentation as required to support the performance verification process. This additional submittal documentation shall include, at a minimum, the proposed start-up and initial check-out procedures, and prefunctional checklists.

3.2 START-UP PLAN AND PREFUNCTIONAL TESTING

A. Prefunctional testing shall be required for each piece of equipment to ensure that the equipment and systems are properly installed and ready for operation, so that functional testing may proceed without delays. Follow the approved start-up, initial check-out, and prefunctional testing procedures. Sampling strategies shall not be used for prefunctional testing. The prefunctional testing for equipment and subsystems of a given system shall be successfully completed and documented prior to functional testing of the system.

B. Procedures for performance verification shall include:

1. Start-up and initial check-out plan: develop the detailed start-up and prefunctional testing plans for equipment and systems that are to be performance verified, as specified herein. Review the proposed procedures and prefunctional testing documentation to ensure that there is written documentation that each of the manufacturer-recommended procedures have been completed.

2. The start-up and initial check-out plan shall consist, as a minimum, of the following:

   a. The manufacturer's standard written start-up and check-out procedures copied from the installation manuals and manufacturer's normally used field check-out sheets. The plan shall include checklists and procedures with specific boxes or lines for recording and documenting the checking and inspections of each procedure and a summary statement with a signature block at the end of the plan.
   b. First-run checklist for equipment, including:

      1) Equipment properly set.
      2) Alignment of shafts and couplings.
      3) Adjustment of vibration isolators.
      4) Piping and equipment properly connected.
      5) Completion of initial lubrication procedures.
      6) Clean filters in place, as appropriate.
      7) Wiring properly connected.
      8) Electrical overload relays appropriate for load.
      9) Electrical accessories properly installed and adjusted.
      10) Controls, safeties, and time switches properly set.
      11) Verification of direction of motor rotation after final electrical connections by jogging motor.
      12) Verification of proper belt tension.
      13) Measurement of ampere draw of electric motors and comparison with nameplate rating and with overload heater ratings.
      14) Monitoring of temperature build-up in motors and bearings.

   c. Contractor-developed prefunctional checklists.

3. Identify which trade is responsible for executing and documenting each of the line item tasks and note that trade on the form. Each form may have more than one trade responsible for its execution.

C. Four weeks prior to start-up, schedule equipment and systems start-up and check-out and notify the Architect in writing. The execution of the prefunctional checklists, start-up and check-out shall be directed and performed by the Contractor, in accordance with manufacturer's published procedures. The Architect shall be present for the start-up, check-out, and prefunctional testing of the first unit of each type of equipment, and any other tests he designates.

D. Sensor calibration: calibration of sensors associated with a given piece of equipment or system shall be included as part of the prefunctional testing and listed on the appropriate test checklists and reports for the system. This requirement may be met during the prefunctional testing of the temperature control or automation system, but shall also be documented with the functional testing procedures.

E. Completed start-up, check-out, and prefunctional test forms shall be completed and submitted to the Architect for review. List outstanding items of the initial start-up and prefunctional procedures that were not completed successfully, at the bottom of the procedures form or on an attached sheet. The procedures form and any outstanding deficiencies shall be provided to the Architect within 2 days of test completion. The Architect shall review the Contractor's start-up and prefunctional testing reports and shall submit either a noncompliance report or an approval form to the Contractor. The Contractor shall correct items that are deficient or incomplete in the checklists and tests in a timely manner, and shall notify the Architect as soon as outstanding items

have been corrected and resubmit an updated start-up report and a statement of correction on the original noncompliance report. When requirements are completed, the Architect shall recommend approval of the start-up and prefunctional testing of each system and schedule the functional testing of the equipment or system.

F. Complete start-up and prefunctional testing for a system before functional test of that system may proceed.

G. Do not operate HVAC systems in a mode that would induce unconditioned, humid outside air into the building.

3.3 RETESTING OF EQUIPMENT AND/OR SYSTEMS

A. Provide labor and materials required for retesting of any functional test found to be deficient.

B. Prior to retesting, submit required data indicating that the deficient items have been completed and/or corrected to the Architect for approval and rescheduling of the functional test. If during the retesting it becomes apparent that the deficient items have not been completed and/or corrected as indicated in the data provided by the Contractor, the retesting shall be stopped. Costs for the design team to further supervise the retesting of a functional test shall be the responsibility of the Contractor.

3.4 DEFERRED TESTING

A. Schedule and coordinate, with the approval of the Architect, any required seasonal testing, tests delayed until building construction is completed, required building occupancy or loading, weather, or other conditions are suitable for the demonstration of equipment or system's performance, as specified herein. Deferred testing shall be executed, documented, and deficiencies corrected as specified herein for functional testing. Adjustments or corrections to the operations and maintenance manuals and as-built documents required by the results of the testing shall be made before the seasonal testing process is considered complete.

3.5 SEASONAL ADJUSTMENTS

A. The HVAC Performance Verification Supervisor shall schedule, coordinate and complete the seasonal adjustment process. During this effort the HVAC Performance Verification Supervisor shall:

1. Check and verify the calibration of temperature control devices and thermostats. Test and verify control sequences for proper operation for the season.
2. Check the operation, performance, and balance of air and hydronic systems to provide uniform distribution and comfort conditions.

B. Where deficient operation or defective equipment is discovered, provide corrective measures.

3.6 TESTING DOCUMENTATION, NONCONFORMANCE, AND APPROVALS

A. List outstanding items of the initial start-up and prefunctional procedures that were not completed successfully, at the bottom of the functional test procedure forms or on an attached sheet. The functional test procedure forms and any outstanding deficiencies shall be provided to the

Architect within 2 days of test completion. The Architect shall review the Contractor's start-up and prefunctional testing documentation and shall submit either a noncompliance report or an approval form to the Contractor. Work with the Architect to correct and retest deficiencies or uncompleted items. Correct items that are deficient or incomplete in a timely manner, and notify the Architect as soon as outstanding items have been corrected and resubmit an updated start-up report and a statement of correction on the original noncompliance report. When requirements are completed, schedule the functional testing of the equipment or system.

B. As functional performance testing progresses and deficiencies are identified, work with the Architect to resolve the issues.

3.7 OPERATION AND MAINTENANCE MANUALS

A. The HVAC Performance Verification Supervisor shall compile and prepare documentation for equipment and systems covered in Division 23 and deliver this documentation for inclusion in the operation and maintenance manuals prior to the training of the Owner's personnel.

3.8 INSTRUCTION OF OPERATING PERSONNEL

A. The HVAC Performance Verification Supervisor shall schedule, coordinate and assemble, and deliver the documentation of training required by Division 23.

3.9 FUNCTIONAL TESTS

A. Functional test requirements for the demonstration of proper system and equipment operation shall be defined by the HVAC Performance Verification Supervisor. Execution of these test and demonstration of the required performance shall be the responsibility of the Contractor.

B. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems or subsystems at the discretion of the HVAC Performance Verification Supervisor. Beginning system testing before full completion of construction shall not relieve the Contractor from fully completing the system, including prefunctional checklists.

C. Functional testing shall be completed and test documentation approved by the Architect before the Project will be considered substantially complete.

END OF SECTION 230090

SECTION 230095 - TESTING, ADJUSTING AND BALANCING

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other mechanical systems are specified in other Sections of Division 23.

B. This Section covers testing, adjusting, and balancing work specified herein, and also indicated on the Drawings, and is defined to include, but is not limited to, air distribution systems, hydronic distribution systems, and associated equipment and apparatus of the new HVAC work. The work consists of setting speed and flow, adjusting facilities provided for systems, recording data, conducting tests, preparing and submitting reports, and recommending modifications to work as indicated on the Drawings or specified herein.

C. Component types of testing, adjusting, and balancing specified in this Section include the following as applied to HVAC equipment:

1. Air handling units.
2. Chillers.
3. Coils.
4. Ductless split systems.
5. Ductwork systems.
6. Fans.
7. Grilles, registers, and diffusers.
8. Piping systems.
9. Pumps.
10. Terminal units.

D. This Section includes responsibilities and obligations in support of the performance verification specified in Section 230090, HVAC Performance Verification.

1.2 QUALITY ASSURANCE

A. Work shall be performed by a firm certified by the National Environmental Balancing Bureau (NEBB), or the Associated Air Balance Council (AABC) in testing and balancing for this type of project, but who is not in any other way associated with work on this Project.

B. Conform to:

1. NEBB-2015 (Errata 2017), Eight Edition Procedural Standards for Testing, Adjusting, and Balancing of Environment Systems, or AABC MN-1-2016, as applicable to mechanical air and hydronic distribution systems and associated equipment and apparatus.
2. ASHRAE recommendations pertaining to measurements, instruments and testing, adjusting and balancing, except as otherwise specified herein.

1.3 SUBMITTALS

A. Within 30 days after the award of the contract, submit an organizational chart and proof of current certification identifying current certified supervisors in the trade that they are certified.

B. Immediately upon award of the contract, review the construction documents to determine that:

1. The required testing, adjusting, and balancing devices, e.g., balancing dampers and balancing valves, are included.
2. The design intent of the systems and their operation to the extent necessary to perform the work is clear.
3. The systems are capable of being tested, adjusted, and balanced as designed.

a. Upon completion of the review, submit a report summarizing the findings, and including any recommendations.

C. Submit a testing, adjusting and balancing plan that provides a detailed description of the methodology that will be implemented to accomplish the testing, adjusting, and balancing for this Project. Include:

1. Schedule for the Project, with timeline.
2. Specific testing, adjusting and balancing procedures proposed for each system, tailored to the requirements of the Project. The procedures shall include all "shall" and "should" requirements of the NEBB TAB Procedural Standards.
3. Instruments that will be used and copy of their latest certification.
4. Sample testing, adjusting, and balancing report forms proposed for each system.
5. Single-line schematic flow diagram for each system.
6. Proposed pitot tube traverse locations.

D. Submit certified test, adjust and balance reports signed by the supervisor who performed the testing, adjusting, and balancing work, complying with the requirements of this Section and Section 230090, HVAC Performance Verification. Include the following information:

1. Include identification and types of instruments used, their most recent calibration dates, and methods of testing and balancing each system and piece of equipment.
2. A final test and balance report including all "shall" and "should" requirements of the NEBB TAB Procedural Standards, Chapter 5, Standards for Reports and Forms.
3. Include AABC or NEBB test forms containing installation data, design data, equipment data, and operating data for systems and equipment, including air handling unit pressure profiles for each unit and duct traverse forms showing all measurements taken at traverse locations.
4. Include copies of readings with piping layouts and duct layouts showing where readings were taken.
5. Identification of the index device for each air and hydronic system, and the minimum static or differential pressures required to achieve design flows for those devices.
6. Include terminal unit correction factors and BCS controller calibration constants for terminal devices and flow measuring installations.

1.4 PROJECT CONDITIONS

A. Do not proceed with testing, adjusting and balancing work until:

1. Deficiencies in the systems and controls that would prevent complete and accurate testing, adjusting and balancing have been corrected.
2. Work is complete and systems, including automatic temperature controls, are operable.
3. Cleaning, flushing, lubrication, and start-up specified in other Sections has been accomplished.

PART 2 - PRODUCTS

2.1 PATCHING MATERIALS

A. Instrument test ports: as specified in Section 237000, Air Distribution.

PART 3 - EXECUTION

3.1 TESTING, ADJUSTING AND BALANCING:

A. Examine installed work and conditions under which testing is to be done to ensure that work has been completed, cleaned and is operable. Submit a detailed report documenting deficiencies of systems and controls that prevent complete testing, adjusting and balancing. Do not proceed with testing, adjusting and balancing work until unsatisfactory conditions have been corrected.

B. Provide materials, equipment, labor, and power to test, adjust, and proportionally balance new heating, ventilating, refrigeration, and air conditioning systems and components as indicated on the Drawings and as specified herein. Verify functioning of operating devices and equipment. In addition, the following specific testing, adjusting and balancing shall be performed.

1. Ductwork Leakage Testing:

a. For ductwork with static pressure classification of 4" wg, 6" wg, or 10" wg, a leakage test shall be made after installation of the first representative sample of ductwork of each classification. The test sample shall incorporate at least: 5 transverse joints, typical seams, one elbow, 2 typical branch connections, and for riser ducts or other systems that include multiple fire dampers, one fire damper and one access door. After satisfactory results for the test sample, additional ductwork shall be tested totaling no less than 25% of the total duct area for each pressure class.
b. For ductwork with static pressure classification of 3" wg, a leakage test shall be made after installation of the first representative sample of ductwork. The test sample shall incorporate at least: 5 transverse joints, typical seams, one elbow, 2 typical branch connections, and for riser ducts or other systems that include multiple fire dampers, one fire damper and one access door. After satisfactory results for the test sample, additional ductwork shall be tested totaling no less than 25% of the total duct area.
c. Prior to testing, submit drawings indicating sections of ductwork to be tested, including area calculations.
d. Leakage testing shall be performed in accordance with SMACNA HVAC Air Duct Leakage Test Manual-2012.

e. Test pressure shall equal the static pressure classification for the duct.
f. Leakage in each type of ductwork shall not exceed:

1) Rectangular Ductwork:

Static Pressure Classification, wg	Leakage Class
0.5", 1", 2"	16
3"	8
4", 6", 10"	4

2) Round and Flat Oval Ductwork:

Static Pressure Classification, wg	Leakage Class
0.5", 1", 2"	8
3"	4
4", 6", 10"	2

g. Submit a report certifying ductwork testing and results.
h. In addition to the tests specified herein, test ductwork located outdoors in accordance with the criteria specified herein for the pressure classification of the ductwork.
i. Ductwork failing tests shall be reconstructed and retested until satisfactory, before additional ductwork is installed and before ductwork is concealed.
j. Positive pressure testing may be used for negative pressure ductwork.

2. Air Systems Balancing, General:

a. Test, adjust, and balance systems to achieve operation and design air quantity, temperature differential, and pressure drop through ductwork, equipment, and components.
b. Variable frequency drives for fans shall be set up so that a 100% input signal to the variable frequency drive does not overload the fan motor and produces the design fan total static pressure at design airflow. If necessary, fan total static pressure shall be simulated. Adjustment of design airflow shall be accomplished by providing the proper motor sheave.
c. Balance air handling units such that duct static pressures are maintained as low as possible while maintaining minimum inlet static pressure and airflow requirements at each terminal unit.
d. Total supply, return and outside air airflow for each air handling unit shall be measured using pitot tube duct traverses. Where the outside air inlet configuration is insufficient for a pitot tube duct traverse, the outside air shall be calculated as the difference between the supply and return.
e. Determine the minimum and maximum supply duct static pressure setpoints, as described in the air handling unit controls sequences on the Drawings.
f. Adjust pattern adjustment devices in diffusers for horizontal discharge, unless otherwise indicated on the Drawings.
g. Calibration of BCS flow elements shall be verified through the use of duct traverses or flow hoods, as appropriate for the device being calibrated. BCS flow elements shall not be used for balance adjustments prior to the verification of their calibration. Use a 3-point calibration method to calibrate terminal units. Perform 3-point

calibration for airflow measurement systems that will experience variable flow, using the lower and upper airflow limits as two of the calibration points.

h. Test, adjust and balance outside air balancing, minimum outside air and return dampers to produce the quantity of minimum outside air indicated on the Drawings when each air handling unit is operating at its maximum supply air quantity. Return air dampers shall be adjusted to a less than fully open position only if required to achieve the minimum outside air quantity indicated on the Drawings. Return and minimum outside air damper linkages shall be adjusted to position their respective dampers at full stroke. Permanently mark damper linkage adjustments. Measure, record and adjust the mixing plenum static pressure setpoints, including associated lower and upper limits, as necessary to achieve the required outside air quantity described in the air handling unit controls sequences on the Drawings.

3. Hydronic Systems Balancing, General:

   a. Test, adjust, and balance systems to achieve operation and design flow, pressure, temperature differential, and pressure drop through equipment, piping and components.

4. Hydronic Systems - Variable Flow, Variable Speed Pumps:

   a. Operate the system pumps under control and balance terminal devices for design flow with control valves wide open. Record the pump operating data and piping loss data. Do not throttle the pump discharge. Calculate the pump differential pressure setpoint needed to obtain full flow at the worst case load and set the pump controller to that value.
   b. Variable frequency drives for pumps shall be set up so that a 100% input signal to the variable frequency drive does not overload the pump motor and produces the design total head pressure at design flow. If necessary, system total head shall be simulated.
   c. Balance pumps that are controlled in parallel such that the pump suction and discharge pressures are the same for each pump. The balancing valve associated with each pump shall be adjusted to equalize those pressures.
   d. Balance hydronic systems such that distribution system differential pressures are maintained as low as possible while maintaining the minimum differential pressure and volume requirements at connected loads.
   e. For systems with diversity, with the pump under control and loads nearest to the pump closed off to simulate diversity, verify design flow through each terminal device. Diversity shall be calculated as the ratio of the total system capacity to the total connected load.

5. Hydrostatic Pressure Testing:

   a. Test piping systems in accordance with the ASME standards specified in Section 23 10 00, Piping, Valves and Accessories and Section 23 15 00, HVAC Underground Preinsulated Piping Systems.
   b. Test shall be held for 4 hours, minimum, with compensation made for temperature change.
   c. No pressure change allowed.

C. Submit report of system deficiencies, leaks, or defects that must be corrected to successfully pass tests.

D. Patch holes in insulation, vapor barriers, ductwork, and housings, which have been cut or drilled for test purposes.

E. Position and secure memory stops on valves used for balancing.

F. Mark equipment settings, including damper control positions, valve indicators, memory stop positions, and controls and devices, to show final settings at completion of testing, adjusting, and balancing work. Provide markings with paint or permanent identification materials.

G. Prior to the date of substantial completion, after balancing is complete, furnish labor, equipment and materials to verify a random 20% selection of all conditions.

H. Pressure and leakage tests of the piping and ductwork systems shall be made in the presence of the Owner.

3.2 SEASONAL ADJUSTMENTS

A. Assist the HVAC Performance Verification Supervisor with the seasonal adjustment process. During this effort the HVAC Performance Verification Supervisor will:

1. Check the operation, performance, and balance of air and hydronic systems to provide uniform distribution and comfort conditions.
2. Where deficient operation or defective equipment is discovered, Contractor shall provide corrective measures as required by the warranty provisions of these specifications and shall assist the Performance Verification Supervisor in the correction of these deficiencies.

END OF SECTION 230095

SECTION 231000 - PIPING, VALVES AND ACCESSORIES

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other mechanical systems are specified in other Sections of Division 23.

B. This Section covers piping, fittings, valves and accessories for heating, ventilating, and air conditioning systems, and, except as otherwise specified herein, does not cover fuel, plumbing, or fire protection systems.

C. Testing, adjusting, and balancing is specified in Section 230095, Testing, Adjusting and Balancing.

D. This Section includes responsibilities and obligations in support of the performance verification specified in Section 230090, HVAC Performance Verification.

1.2 QUALITY ASSURANCE

A. Piping systems shall meet ASME B31.9-2017, Building Services Piping.

B. Components of the same type shall be products of the same manufacturer.

C. Welder certification: welders shall be certified under the rules of the National Certified Pipe Welding Bureau and qualified by either the National Certified Pipe Welding Bureau or an independent testing laboratory for the procedures used on this Project.

D. Welding procedures: in accordance with ASME B31.9-2017, for the service involved. Welds shall be full penetration type, accomplished by proper beveling and spacing of pipe ends. Where backing rings are specified herein, root pass shall penetrate into the backing ring.

E. Pressure/temperature ratings of components and accessories shall meet or exceed design conditions for the system in which they are installed. Components and accessory items shall be designed for operating conditions of not less than:

System	Rating
Boiler feedwater	300 psig swp
Chilled water	125 psig and 200ºF
Other services	125 psig and 200ºF

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

A. Pipe:

Service	Joints	Material
Chilled water, 2.5" through 10"	Welded	Black steel, schedule 40, Grade B, ASTM A53/A53M-2012
Chilled water, 2" and smaller	Soldered	Copper tubing, type L, hard drawn ASTM B88-2016
Refrigerant	Brazed	Copper tubing, type ACR, hard drawn, ASTM B280-2016
Engine-generator set exhaust	Welded	Black steel, schedule 40, ASTM A53/A53M-2012
Cold water make-up	Soldered	Copper tubing, type L, hard drawn, ASTM B88-2016
Hot and chilled water chemical treatment systems	Threaded	Black steel, schedule 40, ASTM A53/A53M-2012
Miscellaneous atmospheric vents	Threaded	Black steel, schedule 40, ASTM A53/A53M-2012
Miscellaneous drains, overflows, and vents, 2" and smaller	Soldered	Copper tubing, type L, hard drawn, ASTM B88-2016
Miscellaneous drains and overflows, 2.5" and larger	Threaded	Galvanized steel, schedule 40, ASTM A53/A53M-2012
Coil condensate drain	Soldered	Copper tubing, type L, hard drawn, ASTM B88-2016
Quench vent	Welded	Stainless steel, S/10S, type 304, ASTM A312/A312M-2017

B. Fittings for type L copper 2" and smaller shall be wrought copper, solder joint fittings, ASME B16.22-2013.

1. Solder joint fitting manufacturer: Elkhart, Mueller, or NIBCO.
2. Press joint fitting manufacturer: NIBCO Press, Victaulic Vic Press, or Viega Pro Press.

C. Fittings for black steel schedule 40 pipe, 2" and smaller, shall be standard weight black malleable iron.

D. Fittings for black steel pipe 2.5" and larger shall be black steel ASTM A234/A234M-2017 Grade WPB of a service class to match the adjacent pipe, except that connections to valves and equipment shall be made with ASTM A105/A105M-2014 flat face welding neck flanges.

E. Branch connections: forged steel, welding nipple type.

1. Manufacturer: Bonney Forge, Capital, or WFI.

F. Elbows: long radius type, except where space conditions do not permit.

G. Solder: 95/5 tin/silver or tin/antimony alloy type.

H. Flux: ASTM B813-2016.

I. Brazing Alloys:

1. For copper-to-copper joints: AWS A5.8/A5.8M-2011, Classification BCuP-5, 15% silver brazing alloy with a melting point range of 1300ºF to 1500ºF.
2. For dissimilar metal joints: AWS A5.8/A5.8M-2011, Classification BAG-1, 45% silver brazing alloy with a melting point of 1145ºF to 1400ºF.
3. Flux: approved by brazing alloy manufacturer.
4. Manufacturer: Airco, Handy & Harman, or Harris.

2.2 VALVES AND STRAINERS

A. Body construction, unless specified otherwise herein:

1. 125 psig service and lower: cast iron.

B. Gate valves: solid wedge-disc type, conforming to ASME B16.34-2017. Valves 2" and smaller shall be threaded bronze body with rising stem, union bonnet, conforming to MSS SP-80-2013. Valves 2.5" and larger shall be flanged body with bronze mountings, outside screw and yoke with bolted bonnets, conforming to MSS SP-70-2011.

1. Manufacturer: Crane, Milwaukee, or Stockham.

C. Globe valves: straight or angle type as indicated on the Drawings, with teflon or composition discs. Valves 2" and smaller shall be threaded bronze body with union bonnet conforming to MSS SP-80-2013. Valves 2.5" and larger shall be flanged iron body with bronze mountings, outside screw and yoke with bolted bonnets, conforming to MSS SP-85-2011.

1. Manufacturer: Crane, Kitz, Milwaukee, NIBCO, or Stockham.

D. Butterfly valves: lug type with cast or ductile iron body, EPT (EPDM) seat designed for service at 200ºF, type 304, 316, or 416 stainless steel stem, and conforming to MSS SP-67-2017. Shaft bushings shall be permanently lubricated bronze, TFE-coated stainless steel, nylon, or acetal. Operators shall be the lever and quadrant type with memory stops for valves 6" and smaller and valves used for balancing. Operators shall be the manual handwheel gear type for valves 8" and above. Butterfly valves shall be factory hydrostatically tested at 150% of the pressure rating specified herein, and shall be factory-tested bubbletight at 150 psi disc differential. Butterfly valves shall be 2.5" size and larger.

1. Manufacturer: Apollo, Bray, Crane, Keystone, Kitz, Milwaukee, NIBCO, or Stockham.

E. Ball valves: bronze body, full port, chromium-plated brass ball, TFE seals and seats, blowout-proof stem, and soldered or threaded ends conforming to MSS SP-110-2010. Ball valves shall be 2" size and smaller. Ball valves in insulated piping shall be provided with extended lever or stem. Ball valves used for balancing shall have memory stops.

1. Manufacturer: Apollo, Crane, Kitz, Milwaukee, NIBCO, or Stockham.

F. Check valves installed in horizontal pipe: swing-type with full flow area. Valves 2" and smaller shall be threaded bronze body with Teflon or composition discs conforming to MSS SP-80-2013. Valves 2.5" and larger shall be flanged body with Teflon, cast iron, or composition discs conforming to MSS SP-70-2011. Check valve hanger pins shall be supported at both ends by removable side plugs.

1. Manufacturer: APCO, Hammond, Kitz, Milwaukee, NIBCO, or Wheatley.

G. Check valves installed in vertical pipe and at pump discharges: spring-loaded silent-type. Seats, discs, and guides shall be bronze or stainless steel with stainless steel or bronze return spring. Disc shall be fully guided top and bottom. Valves shall have an open area equal to 10% more than the related pipe size area. Valves 2" and smaller shall be threaded bronze body. Valves 2.5" and larger shall be flanged conforming to MSS SP-125-2010.

1. Manufacturer: APCO, Hammond, Kitz, Milwaukee, NIBCO, or Wheatley.

H. Control valves: as specified in Section 23 80 00, Automatic Temperature Controls.

I. Strainers: Y-type, flanged body with removable type 316 stainless steel or monel screens. Strainers 2.5" and larger shall be provided with a plugged gate valve and nipple the full size of the strainer blowdown outlet. Strainers 2" and smaller shall be threaded, bronze body type. Strainers 2.5" and larger shall be flanged.

1. Water Service:

Pipe Size	Strainer Perforation Size
0.75" to 1.5"	20 mesh
2" to 3"	0.062"
4" and above	0.125"
Chiller inlet (all sizes)	20 mesh

J. Suction diffusers: angle type body with inlet vanes and combination diffuser strainer-orifice cylinder with 0.188" diameter openings. Unit shall be equipped with disposable fine mesh start-up strainer. Strainer free area shall be no less than 5 times the section area of the pump connection. Unit shall be provided with adjustable support foot.

K. Balancing valves: plug, nonlubricated type with resilient coated plugs, or lubricated type with nonresilient coated plugs. Port area shall not be less than 80% of full pipe area. Body and plug shall be semi-steel. Valves 6" and smaller shall be wrench operated with memory stops. Valves 8" and larger shall be gear operated. Valves 2" and smaller shall be threaded. Valves 2.5" and larger shall be flanged. Provide wrench set for each valve size and turn over to the Owner.

1. Manufacturer: Resun, or Xomox.

L. Water pressure relief valves: bronze body construction with a steel spring. Valves for hot water applications shall be ASME rated.

1. Manufacturer: Aquatrol, Kunkle, Watts, or Wilkins.

M. Water pressure reducing valves: bronze body construction with a stainless steel spring, and renewable seat.

2.3 ACCESSORIES

A. Unions:

1. Unions in black steel piping 2" and smaller, except as specified herein, shall be black malleable iron, ground joints, bronze seated of the service class to match the adjacent piping, with screwed end connections.
2. Unions in copper piping shall be cast brass or bronze with copper soldered connections.

B. Dielectric fittings: threaded, flanged, brazed, or soldered to match adjacent piping. Metal parts of the union shall be separated so that the electrical current is below 1% of the galvanic current which would exist with metal-to-metal contact.

1. Manufacturer: Bolt-Pak, Epco (with high temperature gasket), Perfection Clearflow, or Watts.

C. Automatic air vents: float-operated automatic type with cast iron body, stainless steel trim, 0.75" piping connections, and minimum 175 psig water working pressure.

1. Manufacturer: Anderson, Armstrong, or Hoffman.

D. Pressure gauges: bourdon tube type with metal case, 4.5" dials, accuracy within 1% of full scale range, equipped with snubbers and needle valves. Gauges at pumps and chillers shall be liquid-filled.

Service	Range
Chilled water pumps	0/100 psig
Evaporators of chillers	0/100 psig
Condensers of chillers	0/60 psig

1. Manufacturer: Ashcroft, Marsh, Trerice, Weiss, or Weksler.

E. Needle valves: brass with 0.25" connection.

F. Dial thermometers: bimetallic element, dial type with minimum 3" dials, stainless steel case, angle or straight as required. Thermometers installed in uninsulated piping shall have 4" stems with brass separable sockets. Thermometers installed in insulated piping shall have 6" stem with brass separable socket with extension neck equal to thickness of insulation. Thermometers installed in ducts shall have 6" stems with duct mounting flanges.

Service	Range
Chilled water	0º/150ºF

1. Manufacturer: Ashcroft, Marsh, Palmer, Taylor, Trerice, Weiss, or Weksler.

G. Thermometer test wells: brass construction with brass plug and chain, designed for use with partial immersion laboratory type test thermometers. Test wells in insulated piping shall have an extension neck equal to thickness of insulation.

1. Manufacturer: Ashcroft, Moeller, Taylor, Trerice, Weiss, or Weksler.

H. Manual Flow Control Valves:

1. Valves 2" and smaller shall have soldered or threaded ends with brass or bronze body; and 2.5" and larger shall have flanged ends with iron body. Valves shall have brass or bronze ball, Teflon or carbon-filled TFE seats, memory stop, meter connections with built-in check valves or pressure/temperature test plugs, and shall be designed for balancing and positive shut off.
2. Valves shall have calibrated orifice or venturi. Provide flow capacity characteristic curves or tables for each valve size. Calibrated orifice devices shall have integral pointer and calibrated nameplate.
3. Provide one portable meter set, including checking hoses, check seal and carrying case. Wetted parts of the meter shall be corrosion resistant. Meter shall be diaphragm type with variable pulsation damping control, zero adjustment control, and bleed valves. Meter shall be designed for system velocities and temperatures.
4. Manufacturer: Bell & Gossett, Flow Design, Gerand, Griswold, MEPCO, Taco, or Tour & Andersson.

I. Automatic Flow Control Valves:

1. Valves 2" and smaller shall have soldered or threaded ends with brass or bronze body; and 2.5" and larger shall have flanged ends with iron body. Valves shall have pressure/temperature test plugs for verifying the pressure differential across the assembly and system temperature.
2. Valves shall automatically control flow rates within ±5% accuracy over an operating pressure differential range of at least 14 times the minimum required for control. At least 2 operating pressure ranges shall be available with the minimum range requiring less than 3 psig to activate the mechanism. Provide flow capacity characteristic curves or tables for each valve size.
3. Valve internal control mechanisms shall consist of a corrosion resistant cartridge with segmented port design and full travel linear coil spring. Valves shall have Y-body housing or other means to provide access to internal control mechanism without removing the valve.
4. Manufacturer shall provide certified independent laboratory test verifying accuracy of performance.
5. Provide one portable meter set, including checking hoses, check seal and carrying case. Wetted parts of the meter shall be corrosion resistant. Meter shall be diaphragm type with variable pulsation damping control, zero adjustment control, and bleed valves. Meter shall be designed for system velocities and temperatures.
6. Manufacturer: Flow Design, Griswold, or Kates.

J. Expansion Tanks:

1. Expansion tanks shall be bladder type, welded steel, designed, constructed, certified, and stamped in accordance with ASME BPVC-VIII-1-2017 for a working pressure of 125 psig. Bladders shall be replaceable elastomeric butyl rubber type, designed for a maximum operating temperature of 240ºF.
2. Manufacturer: Bell & Gossett, MEPCO, Taco, Wessels, or Wheatley.

K. Combination Pressure and Temperature Test Plugs:

1. Combination pressure and temperature test plugs may, at the Contractor's option, be used on pipe sizes 2" and smaller, for maximum 150 psig service, in lieu of the needle valves and thermometer test wells specified herein or indicated on the Drawings. Plugs shall not be used at locations specified herein or indicated on the Drawings to have a pressure gauge or thermometer permanently installed. Plugs shall have brass bodies, and internal valve seat material designed for specific system operating temperature and pressure. Plugs shall be provided with adaptors to connect pressure gauges or thermometers identical to those used elsewhere on the Project.
2. Manufacturer: Fairfax, Flow Design, Peterson, or SISCO.

L. Inline air separators: centrifugal inline tank type, capable of handling the water flow indicated on the Drawings, and constructed for 125 psig working pressure.

1. Manufacturer: Armstrong, Bell & Gossett, Taco, Thrush, or Wheatley.

M. Gaskets: 0.063" thick, conforming to ASME B16.5-2017, asbestos-free, selected for the pressure, temperature and service of the specific joint.

N. Bolting Materials:

1. For maximum system ratings of 250ºF and 160 psig:

a. Bolts and studs: ASTM A307-2014e1, Grade B, zinc-plated.
b. Nuts: ASTM A563-2015, Grade A, heavy hex, zinc-plated.

PART 3: EXECUTION

3.1 GENERAL

A. Before erection, clean interior and exterior of pipe and fittings of slag, spatter, rust, dirt and debris by wire brushing and swabbing.

B. Workmanship: pipe shall be cut to measurements established at the Project site and worked into place without springing or forcing. Pipes shall be installed to permit free expansion and contraction without damage to joints, hangers, or the building.

C. Changes in direction shall be made with fittings, except where branches are two or more sizes less than the size of the main, the branch may be made using branch connections, weldolets, threadolets, latrolets, sweepolets, and elbolets.

D. Pitch/grade: piping shall be installed with sufficient pitch to ensure drainage and venting.

E. Solder joint connections shall be cut, deburred, cleaned and assembled in accordance with ASTM B828-2016.

F. Threaded connections: screw-thread joints shall be made with cut tapered threads. Joints shall be made tight with Teflon tape unless otherwise specified herein. Not more than 2 threads shall show after the joint is made tight. Pipes shall have burrs removed by reaming cut end.

G. Welding:

1. Mitering or notching pipe to form elbows and tees will not be permitted. Field and shop bevels shall be in accordance with the standards specified herein and shall be done by mechanical means or flame cutting. Where beveling is done by flame cutting, surfaces shall be cleaned of slag, scale and oxidation prior to welding. Before welding, the component parts to be welded shall be aligned so no strain is placed on the weld when finally positioned. Height shall be aligned so that no part of the pipe wall is offset by more than 20% of the wall thickness. Flanges and branches shall be set true. This alignment shall be preserved during the welding operations. Connections larger than 6" shall be made with backing rings at welds.
2. Where the temperature of the component parts being welded reaches 32ºF or lower, the material shall be heated to approximately 100ºF for a distance of 3' on each side of the weld before welding, and the weld shall be finished before the material cools to 32ºF.
3. Welders shall stamp each weld with their personal symbol or code number.
4. Current welder certifications for welders performing welding on this Project (on or off-site) shall be maintained at the Contractor's site office and shall be readily available for review.
5. A random sample of completed pipe welds may be chosen by the Engineer for visual testing by an independent testing agency, not to exceed 5% of the total welds on the Project. Costs for testing shall be borne by the Contractor. Acceptance criteria shall be as specified by ASME B31.9-2017. If any of the tested welds are unsatisfactory, additional welds may be chosen for testing at the Contractor's expense.
6. Defective welds shall either be cut out and rewelded or ground down to base metal and rewelded. Reworked welds shall be tested as specified herein.

H. Flanged joints in water piping shall be made with ring type gaskets, extending to inside of bolt holes. Flanged connections to equipment shall be made with full face gaskets to match flanges on equipment.

I. Install piping so as to preserve access to valves, air vents, and equipment requiring access, and to provide the maximum headroom.

J. Provide offsets to maintain ceiling height and to coordinate with other trades.

K. Install piping such that when insulation is applied it will not come in contact with adjacent surfaces.

L. Provide reducing fittings for changes in pipe sizes.

M. Provide extra heavy pipe for nipples: where unthreaded portion of pipe is less than 1.5" long, and where size is less than 0.75" x 6".

N. Dirt pockets: line size, 4" long minimum. Terminate with threaded cap or blind flange, and provide clearance for access to cap or flange.

O. Perform pressure tests required by Section 230095, Testing, Adjusting and Balancing before work is concealed or buried.

P. Piping failing the tests specified in Section 230095, Testing, Adjusting and Balancing shall be repaired until satisfactory.

3.2 VALVES AND STRAINERS

A. Valves in horizontal piping shall be installed with stems at or above the pipe centerline.

B. Butterfly valves may be used in lieu of the gate and balancing valves indicated on the Drawings for 125 psig and 200ºF chilled, water service.

C. Ball valves may be used in lieu of the gate and balancing valves indicated on the Drawings.

D. Butterfly valves adjacent to equipment shall be functional when equipment is removed.

E. Control valves: install in accessible locations, with room for actuator removal and service. Adjust the actuators to provide tight closure. Provide valve stem travel indicators and adjust to indicate proper travel. Where butterfly valves are used, permanently mark the end of the valve shafts to indicate valve position.

F. Strainers in water piping shall be installed with blowdown outlets at the low point.

G. Strainers in horizontal steam piping shall be installed on the side.

H. Suction diffusers: install at the inlet of end suction pumps, in lieu of the strainer indicated on the Drawings.

3.3 ACCESSORIES

A. Pressure Gauges:

1. Install a gauge at the highest point of each closed hydronic system.
2. Install as indicated on the Drawings, unless otherwise specified herein.

B. Needle valves: install as indicated on the Drawings, unless otherwise specified herein.

C. Dial thermometers: install as indicated on the Drawings, unless otherwise specified herein.

D. Thermometer test wells: install as indicated on the Drawings, unless otherwise specified herein. Fill with a thermally conductive material.

E. Thermometers and thermometer test wells shall be installed on a 45° angle in vertical piping and vertically in horizontal piping.

F. Thermometers, needle valves, pressure gauges, and thermometer test wells shall be installed so as to not be obscured by piping, building structure, or equipment.

G. Install siphons for needle valves and pressure gauges in steam piping and equipment.

H. Flow meter connections with isolation valves shall be extended and attached to the wall 5' above the floor with channel struts. Wall-mounted meters shall be mounted 5' above the floor.

I. Manual flow control valves may be used in lieu of balancing valves indicated on the Drawings but the flow control valve meter connections may not be a substitute for pressure gauges or needle valves indicated on the Drawings.

J. Install control valves, thermometers, and valved pressure taps provided under Section 23 80 00, Automatic Temperature Controls.

K. Temperature Maintenance Cable:

1. Install and test before insulation is applied, in accordance with manufacturer's recommendations.
2. Install on exterior chilled water supply and return piping.
3. Secure cable to the piping with cable ties or fiberglass tape.

L. Inline Air Separators:

1. Provide a 0.75" drain with valve on the separator tank.
2. Support from the floor on an angle iron frame or prefabricated base.
3. Support with hangers independently from the adjacent piping.

M. Bolting Materials:

1. Lubricate bolt and stud threads with molybdenum disulfide anti-seize compound.
2. Bolts and studs, when installed, shall extend not less than 2 full threads through nuts when tightened to the required torque.
3. Install washers under bolt heads and nuts.

3.4 UNIONS AND FLANGES

A. Provide unions or flanges for disconnecting pipe from valves and equipment, and as indicated on the Drawings.

B. Dielectric fittings shall be used for connections between ferrous piping or equipment and nonferrous piping or equipment, except that brass and bronze valves shall not be isolated in predominantly steel piping systems.

3.5 WATER SUPPLY AND RETURN PIPING

A. Arrange piping for the venting of air and for drainage of the entire system.

B. Changes in size of vertical piping shall be made with concentric reducers, and in horizontal piping shall be made with eccentric reducers to maintain uniform top elevation of pipe.

C. Extend drain piping from chilled water pump drain pans to floor drain. Route pipe tight to equipment foundations and avoid obstructing access paths and maintenance areas.

D. At each low point of the system, provide a 0.75" drain valve with hose thread, and at each high point and in every drop in the direction of flow of supply and return mains provide an automatic air vent valve, unless otherwise indicated on the Drawings or specified herein.

3.6 CLEANING

A. Chilled Water Piping:

1. Fill and flush with clean water.

2. Refill with clean water, then add cleaning/degreasing detergent.

    a. Approved by local, state and federal authorities for the intended use.
    b. With nonfoaming wetting agent.
    c. Concentration of the detergent shall be 2% of the active ingredients of the chemicals used for cleaning.
    d. Supplied and supervised by water treatment company.

3. Circulate water, using temporary pumps as required, in each system at respective design flow rates, minimum, for three 8 hour periods.

    a. At the end of each 8 hour period: remove and clean strainers. Blow-off low points.

4. After third period of pumping, drain entire system of cleaning solution.

    a. Clean out cooling tower basins and hose down.

5. Refill systems with clean water and circulate for an additional 8 hour period. Remove and clean strainers. Drain and refill with clear water. Continue to circulate water.
6. Test for alkalinity, not more than 200 ppm in excess of alkalinity of rinsing water.
7. Repeat process described above until 200 ppm in excess of alkalinity of rinsing water, or less is maintained for 10 days.
8. Protect against damage from freeze-up or discharge of water.
9. When cleaning is completed, fill systems with clear water, and circulate with appropriate water treatment chemicals to protect pipe and equipment until the date of substantial completion.
10. Immediately prior to the date of substantial completion, remove and clean strainers.
11. Use and disposal of chemicals shall comply with local, state, and federal regulations.

3.7 PIPING SYSTEMS

A. Manually operate relief valves and verify that discharge openings and piping are clear and free flowing.

B. Open air vents until air is removed from the systems.

3.8 ENGINE-GENERATOR SET EXHAUST PIPING

A. Install silencer and flexible fittings provided under Division 26.

B. Extend engine-generator set exhaust piping from silencer to the exterior as indicated on the Drawings.

END OF SECTION 231000

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SECTION 231500 - HVAC UNDERGROUND PREINSULATED PIPING SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other mechanical systems are specified in other Sections of Division 23.

B. This Section covers HVAC underground preinsulated piping systems, including chilled water.

C. Testing, adjusting and balancing is specified in Section 230095, Testing, Adjusting and Balancing.

D. This Section includes responsibilities and obligations in support of the performance verification specified in Section 230090, HVAC Performance Verification.

1.2 QUALITY ASSURANCE

A. Piping systems shall meet ASME B31.9-2017, Building Services Piping.

B. Pressure/temperature ratings of components and accessories shall meet or exceed design conditions for the system in which they are installed. Components of the same type shall be products of the same manufacturer. Components and accessory items shall be designed for operating conditions of not less than:

System	Rating
High pressure steam, condensate, and pumped condensate	150 psig swp
Medium and low pressure steam, and condensate	125 psig swp
Chilled water	125 psig and 200 °F
Other services	125 psig and 200°F

C. Welder certification: welders shall be certified under the rules of the National Certified Pipe Welding Bureau and qualified by either the National Certified Pipe Welding Bureau or an independent testing laboratory for the procedures used on this Project.

D. Welding procedures: in accordance with ASME B31.9-2017, for the service involved. Welds shall be full penetration type, accomplished by proper beveling and spacing of pipe ends. Where backing rings are specified herein, root pass shall penetrate into the backing ring.

PART 2 - PRODUCTS

2.1 UNDERGROUND CHILLED WATER SYSTEMS

A. General:

1. Underground chilled water, piping shall be the preinsulated type consisting of a carrier pipe, insulation, and protective jacket. The carrier pipe shall be insulated with polyurethane foam and enclosed with a protective jacket of FRP, PVC, or HDPE. Straight sections, fittings, anchors and accessories shall be factory prefabricated to site dimensions and designed to minimize the number of field welds.
2. Straight sections and fittings shall be supplied with 6" to 8" of piping exposed at each end for field-insulating the joints. Ends of straight sections and fittings shall be fitted with end seals for moisture protection. Additionally, end seals shall be provided for ends terminating at wall and slab penetrations in manholes, tunnels, concrete trenches, and the floor slab of the finished building.

B. Insulation:

1. Straight sections and fittings shall be prefabricated and pre-insulated at the factory with polyurethane foam. The foam shall completely fill the annular space between carrier pipe and protective jacket, and shall have the following properties: minimum 2 pcf density, 90%-95% closed-cell content, and maximum K-value of 0.16 Btu·in/(h·ft²·°F) at 75°F.
2. The minimum insulation thickness shall be as follows:

Piping	Insulation Thickness
Chilled water	1"

3. Joints shall be field-insulated by pouring polyurethane foam into the field joint area and sealing with heat shrink wrap, or by securing preformed polyurethane sections to the field joint area and sealing with a sleeve and heat shrink tape. Field-insulated areas shall be watertight and have a continuous seal with the prefabricated sections.
4. The insulation and jacket at fittings shall be the same thickness and quality as for the straight sections.

C. Protective Jackets:

1. Protective jackets shall be filament wound, polyester resin/fiberglass reinforcement composite (FRP); seamless polyvinyl chloride (PVC), Type 1, Grade 1, conforming to ASTM D1784-2011; or high-density polyethylene (HDPE), Type III, Class C conforming to ASTM D1248-2016.
2. The minimum wall thickness for FRP jackets shall be as follows: for jacket diameter up to 15.5", 0.055"; jacket diameter between 15.6" and 24.5", 0.085"; jacket diameter between 24.6" and 31.0", 0.110"; and jacket diameter between 31.1" and 40.0", 0.140".
3. The minimum wall thickness for PVC jackets shall be as follows: for jacket diameter up to 5", 0.060"; 6" jacket diameter, 0.070"; jacket diameter greater than 6", 1% of diameter.
4. The minimum wall thickness for HDPE jackets shall be as follows: for jacket diameter up to 12", 0.125"; jacket diameter between 12.1"and 24", 0.15"; jacket diameter greater than 24", 0.175".

D. Prefabricated plate anchors: 0.5" thick steel plates welded to the carrier pipe.

E. Underground chilled water, systems shall be shipped from the factory with plastic pipe end covers installed with tape on the piping.

F. Manufacturer: Perma-Pipe/Ricwil, Rovanco, Thermacor, or Thermal Pipe Systems.

2.2 MATERIALS

A. Chilled Water:

1. Pipe, fittings, and accessories: as specified in Section 23 10 00, Piping, Valves and Accessories.

PART 3 - EXECUTION

3.1 GENERAL

A. HVAC underground preinsulated piping systems shall be installed in a coordinated manner, at the same time, and in the same proximity as other site utilities defined in other Divisions.

B. Piping, insulation, protective jackets, and other materials required for a complete HVAC underground preinsulated piping system shall be furnished by the manufacturer and installed in accordance with manufacturer's installation instructions.

C. Excavation and backfill: as specified in Section 230010, HVAC General.

D. Changes in direction shall be made with fittings, except where branches are two or more sizes less than the size of the main, the branch may be made using branch connections, weldolets, latrolets, sweepolets, and elbolets.

E. Welding:

1. Mitering or notching pipe to form elbows and tees will not be permitted. Field and shop bevels shall be in accordance with the standards specified herein and shall be done by mechanical means or flame cutting. Where beveling is done by flame cutting, surfaces shall be cleaned of slag, scale and oxidation prior to welding. Before welding, the component parts to be welded shall be aligned so no strain is placed on the weld when finally positioned. Height shall be aligned so that no part of the pipe wall is offset by more than 20% of the wall thickness. Flanges and branches shall be set true. This alignment shall be preserved during the welding operations. Connections larger than 6" shall be made with backing rings at welds.
2. Where the temperature of the component parts being welded reaches 32°F or lower, the material shall be heated to approximately l00°F for a distance of 3' on each side of the weld before welding, and the weld shall be finished before the material cools to 32°F.
3. Welders shall stamp each weld with their personal symbol or code number.
4. A random sample of completed pipe welds may be chosen by the Engineer for visual testing by an independent testing agency, not to exceed 5% of the total welds on the Project. Costs for testing shall be borne by the Contractor. Test criteria shall be as specified by ASME B31.1-2016. If any of the tested welds are unsatisfactory, additional welds may be chosen for testing at the Contractor’s expense.

5. Defective welds shall either be cut out and rewelded or ground down to base metal and rewelded. Reworked welds shall be tested as specified herein.

F. Provide reducing fittings for changes in pipe sizes.

G. Cleaning: as specified in Section 231000, Piping, Valves and Accessories.

3.2 UNDERGROUND CHILLED WATER SYSTEMS

A. Plastic end covers shall not be removed until field joint is ready to be made.

B. Immediately after installation in the ditch, a partial backfill shall be made in the middle of each length leaving joints exposed for inspection.

C. At anchor locations, field-insulate exposed carrier pipe and seal to the protective jacket per manufacturer's recommendations.

D. Concrete anchor blocks shall be cast over the anchor plates and piping. The concrete shall be 30" minimum length and shall extend a minimum of 12" beyond the top and bottom of each anchor plate.

E. After anchor blocks are poured and cured, a hydrostatic test of 125 psig shall be required for a period of 4 hours.

F. After hydrostatic test, a backfill of selected earth shall be hand placed and hand tamped in 4" layers to 12" minimum over the top of the jacket. Remainder of the backfill shall be free of rocks over 6" in diameter, frozen earth or foreign matter, and shall be completed in accordance with Division 31, Earthwork, with the exception that tracked or wheeled vehicles shall not be used for tamping.

G. Minimum bury depth for preinsulated piping system mains shall be 4' to top of outer jacket. Minimum bury depth for preinsulated piping system branches to buildings shall be 3' to top of outer jacket.

H. Unload, install, and test under the supervision of a factory installation supervisor. On completion of the installation, submit a certificate from the manufacturer stating that the installation has been accomplished in accordance with the manufacturer’s recommendations.

3.3 FLANGES

A. Provide flanges for disconnecting pipe from valves and as indicated on the Drawings.

3.4 WATER SUPPLY AND RETURN PIPING

A. Arrange piping for the venting of air and for drainage of the entire system.

B. Changes in size of vertical piping shall be made with concentric reducers, and in horizontal piping, shall be made with eccentric reducers to maintain uniform top elevation of pipe.

END OF SECTION 231500

SECTION 232500 - HVAC INSULATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other HVAC systems are specified in other Sections of Division 23.

B. This Section covers thermal insulation for equipment, ductwork and piping specified in Division 23.

C. Items not to be insulated:

1. Vents from pressure relief valves.

D. This Section includes responsibilities and obligations in support of the performance verification specified in Section 230090, HVAC Performance Verification.

1.2 DEFINITIONS

A. Exterior piping, ductwork, or equipment is exposed to outdoor temperature.

1.3 QUALITY ASSURANCE

A. Conform to the following:

1. International Energy Conservation Code-2009.
2. International Mechanical Code-2015 with South Carolina Modifications.
3. NFPA 90A-2018.

B. Products of the manufacturers listed will be acceptable for use for the specific functions specified herein. Materials shall be compatible with the materials to which they are applied, and shall not corrode, soften or otherwise attack such material in either the wet or dry state.

C. Materials shall be applied subject to their temperature limits. Methods of application of insulating materials or finishes not specified in detail herein shall be in accordance with the particular manufacturer's published recommendations.

D. Insulation shall be applied by experienced workers regularly employed for this type of work.

1.4 RATINGS

A. Insulation and accessories, unless specifically excepted herein, shall have a maximum composite flame spread rating of 25 and a maximum smoke developed rating of 50. Materials that are factory-applied shall be tested as assembled. Materials which are field-applied may be tested individually. No fugitive or corrosive treatments shall be employed to impart flame resistance.

B. Flame spread and smoke developed ratings shall be in accordance with ASTM E84-2017a. Products or their shipping cartons shall bear a label indicating flame spread and smoke developed ratings.

C. Treatment of pipe jackets and duct facings to impart flame and smoke safety shall be permanent. The use of water-soluble treatments is prohibited.

D. Vapor retarders shall have a maximum permeance of 0.02 perm at 73.4°F.

1.5 ALTERNATE THICKNESSES

A. Specified thicknesses may be increased or reduced for insulation materials having thermal resistivity, K-values, different from those listed. Submit calculations in accordance with ASHRAE/IES 90.1-2016, and documentation of product performance.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Fiberglass Pipe, Duct and Equipment Insulation:

1. Maximum K-value for preformed pipe insulation: 0.23 Btu·in/(h·ft²·°F) at 75°F.
2. Maximum K-value for board insulation: 0.23 Btu·in/(h·ft²·°F) at 75°F.
3. Minimum R-value for blanket insulation shall be as specified herein and shall be based on an installed condition with 25% compression of the specified nominal thickness at 75°F.
4. Manufacturer: CertainTeed, Johns Manville, Knauf, Owens Corning, or Manson Insulation.

B. Adhesives, Sealants, Coatings, and Mastics:

1. Weather barrier breather mastics (white) for above ambient pipe and duct service only.

    a. Manufacturer: Childers CP-10/11 Vi-Cryl Coating, Foster 46-50 Weatherite Coating, or Pittsburgh Corning Pittcote 404.

2. Vapor barrier mastic (white) for below ambient pipe and duct service only. Water vapor permeance shall comply with ASTM E96/E96M-2016, 0.08 perms or less at 45 mils dry.

    a. Manufacturer: Childers CP-34, Foster 30-65, or Vimasco 749.

3. Lagging adhesive and coating.

    a. Manufacturer: Childers Chil-Seal CP-50A MVI, Foster 30-36 Sealfas, or Vimasco 136.

4. Insulation joint sealant for cellular glass, phenolic, and polysocyanurate.

    a. Manufacturer: Childers Chil Byl CP-76, Foster Flextra 95-50, or Pittsburgh Corning Pittseal CW.

5. Elastomeric adhesive.

    a. Manufacturer: Armaflex 520 BLV, Childers CP-82, Foster 85-75, or Kflex 720-LVOC.

6. Elastomeric insulation coating.

    a. Manufacturer: Armacell WB Finish, or Kflex 374.

7. Aluminum jacketing sealant, and flexible butyl elastomer based vapor barrier sealant.

    a. Manufacturer: Childers Chil-ByL CP-76, Foster 95-44, or Pittsburgh Corning PC 444N.

C. Preformed Fittings:

1. Equal thickness and composition to adjacent pipe insulation.
2. Manufacturer: Extol, Performance Insulation Fabricators, or Specialty Products & Insulation.

D. Insulating Cement:

1. Mineral wool type, asbestos free, maximum K-value of 0.20 Btu·in/(h·ft²·°F) at 75°F.
2. Manufacturer: Industrial Insulation Group CalCoat-127, or Ramco Ramcote 1200.

E. PVC Fitting Covers:

1. Preformed insulated PVC covers for pipe fittings. Insulation thickness shall match adjacent piping, and shall be increased to limit insulation outer surface temperature to 150°F.
2. Manufacturer: Johns Manville Zeston 2000, Proto Corporation, or Speedline Corporation.

F. Asphalt Cutback Mastic:

1. Fibrated.
2. Manufacturer: Childers CP-22/24, Foster 60-25/60-26, or Koppers Bitumastic 50.

G. Flexible Elastomeric Sheet, Tubing and Tape:

1. Closed-cell.
2. Maximum K-value: 0.25 Btu·in/(h·ft²·°F) at 75°F.
3. Manufacturer: Aeroflex Aerocel, Armacell AP Armaflex, or K-flex.

H. Calcium Silicate:

1. Asbestos free, maximum K-value of 0.38 Btu·in/(h·ft²·°F) at 100°F.
2. Designed for continuous operation at 1200°F.
3. Manufacturer: Industrial Insulation Group.

I. Polyisocyanurate:

1. Maximum aged 180-day K-value: 0.19 Btu·in/(h·ft²·°F) at 75°F.
2. Minimum density: 2 pcf.

3. Manufacturer: Hitherm HT 300, or ITW Trymer 25-50.

J. Phenolic:

1. Maximum K-value: 0.18 Btu·in/(h·ft²·°F) at 75°F.
2. Minimum density: 2.5 pcf.
3. Manufacturer: ITW Trymer Supercel, or Resolco International Insul-phen.

K. Removable Insulation Blankets and Pads:

1. Rated for 500°F continuous service.
2. Fiberglass, ceramic fiber, or mineral wool insulation enclosed in glass fiber cloth or knitted stainless steel mesh. Stitching shall be PTFE (Teflon) coated glass fiber thread or stainless steel wire. Attachment shall be by lacing and hooks, straps and buckles, or self-adhering fabric.
3. Manufacturer: Coverflex, M.I.T. International, or Thermal Energy Products.

L. Glass fabric: 10 x 10 construction white fiberglass scrim fabric.

M. Tape: pressure sensitive, foil-scrim-kraft backed.

N. Staples: outward clinching type.

O. Rigid inserts: cellular glass or 5 pcf phenolic. Rigid inserts shall be same length as insulation protectors, 360° pipe coverage, and same thickness as adjacent insulation. Where polyisocyanurate is specified herein, rigid inserts may be polyisocyanurate, minimum 2 pcf for piping 6" and smaller and minimum 3 pcf for pipe 8" and larger. Where fiberglass is specified herein, rigid inserts may be premolded minimum 20 pcf fiberglass blocks with 180° pipe coverage. Where flexible elastomeric is specified herein, rigid inserts may be rigid foam designed for the supported weight without compression. Provide jacketing, joint sealing, and weatherproofing as specified for the pipe service. Fiberglass inserts shall be selected for a maximum 10% compression when loaded. Polyisocyanurate inserts shall be selected such that compressive load does not exceed 33% of the compressive strength of the insert.

P. Self-adhering Flexible Exterior Covering:

1. Self-adhering, flexible, sheet type protective membrane with a 10-year product warranty. Inner surface shall be pressure sensitive rubber or asphaltic adhesive designed to cover rigid insulation on ductwork with no mechanical fastening required. Covering shall be designed to be applied down to 35°F and to maintain integrity, flexibility and adhesion after installation between -10°F and 120°F ambient temperature.
2. Composite material shall have a maximum permeance rating of 0.01 per ASTM E96/E96M-2016, a maximum 25/50 flame/smoke rating per ASTM E84-2017a, and a minimum average tear strength of 660 grams per ASTM D1424-2009 (2013)e1.
3. Outer surface shall be UV resistant and shall be white or aluminum color as directed by the Architect.
4. Manufacturer: Alumaguard, FlexClad, Foster 62-05, or VentureClad 1577CW.

PART 3 - EXECUTION

3.1 GENERAL

A. Surfaces to be insulated shall be clean, dry, and free of foreign material, rust, scale and dirt when insulation is applied. Perform pressure and leakage tests and submit results required by other Sections before applying insulation.

B. Where existing insulation is damaged due to the new work, repair damage to match existing work or replace damaged portion with insulation specified for new work.

3.2 MATERIAL SELECTIONS

A. Where multiple insulation materials are specified herein for the same service, one of the specified materials shall be applied and used consistently throughout the project, subject to the requirements of these specifications.

3.3 INSULATION FOR HOT PIPE

A. Insulate the following pipe with calcium silicate or mineral wool pipe insulation, 3" thick for pipe 2.5" through 4", and 4" thick for pipe 5" and larger:

Engine-generator set exhaust.

1. Secure insulation with 16 gauge nonferrous wire or stainless steel bands 9" on center.
2. Insulate fittings and flanges with preformed or mitered fittings. Wire fittings in place.
3. Insulate piping from discharge flange to exhaust pipe termination.
4. Provide 0.016" aluminum jacket secured with 0.375" aluminum bands 12" on center.

3.4 INSULATION FOR COLD PIPE

A. Insulate the following pipe with preformed phenolic or polyisocyanurate pipe insulation of the thickness indicated with a vapor retarder and all service jacket with self-sealing lap:

Insulation Thickness, Inches

	Pipe Sizes		
	Through 1.25"	1.5" - 12"	14" and over
Chilled water supply and return	1	1	1.5
Exterior chilled water supply and return	1	1.5	1.5

1. Seal longitudinal and end joints with sealant and mastic as recommended by the manufacturer to achieve the permeance rating specified herein. Install insulation with jacket drawn tight with side-laps and end joint butt strips secured. End joint butt strips shall be same material as jacket, not less than 3" wide.
2. Insulate fittings, flanges, strainers, unions, and valves with preformed or mitered phenolic or polyisocyanurate fitting sections. Secure fittings in place, seal joints and contour mitered

sections with insulating cement, and finish with a layer of glass fabric embedded between 2 coats of vapor barrier mastic. Glass fabric shall overlap adjoining insulation at least 2".

3. Where temperature maintenance cable is specified herein or indicated on the Drawings, piping shall be insulated after application of temperature maintenance cable.
4. Provide vapor stops consisting of glass fabric and vapor barrier mastic over the entire end of butt joints at control valves, strainers, and equipment requiring access.

B. Insulate the following pipe with preformed flexible elastomeric insulation, 1" thickness:

Refrigerant suction.
Refrigerant liquid.
Condensate drain.

1. Insulation shall be slipped on before pipe joints are completed. Hold back from hot joints until cool. Cement insulation joints with adhesive applied to both ends.
2. Insulate fittings, flanges, unions, and valves with fabricated fittings, same thickness as piping.

3.5 INSULATION FOR COLD EQUIPMENT

A. Insulate chiller evaporator end plates and water boxes, and suction pipe couplings on chillers; and flanged ends of strainers; with 1" thick flexible elastomeric sheet. Insulation shall be secured with adhesive, except pieces covering strainer flanges and other components requiring access shall be designed for removal and reinstallation without damage to insulation.

B. Insulate chilled water pumps with 1" thick flexible elastomeric sheets. Insulation shall be adhered to inside of 18 gauge aluminum casings. Casings shall be fabricated in a minimum of 2 sections, with flanged and bolted joints or operable latches and hinges. Hardware shall be galvanized or cadmium-plated steel. Casings shall be designed for removal to allow access for maintenance without damaging insulation. Seal penetrations of casings.

C. Insulate chilled water expansion tanks, chilled water buffer tanks, and inline air separators as specified herein for chilled water pipe.

D. Insulate chilled water and refrigerant piping appurtenances, thermowells, thermometer test wells, gauge cocks, valve stems, and hangers and supports subject to sweating with flexible elastomeric tape.

3.6 INSULATION FOR DUCT SYSTEMS

A. Insulate the following concealed duct systems with flexible, fiberglass insulation, nominal 2.2" thickness, minimum R-value at the installed condition of 6.0 $h \cdot ft^2 \cdot °F/Btu$, with foil-scrim-kraft facing:

Supply ductwork and plenums.
Outside air ductwork and plenums.
Intake, exhaust and relief plenums.

1. Overlap edges 3" and secure 12" on center with copper-clad, stainless steel or galvanized steel wire.
2. Seal joints, breaks, and punctures with tape.

3. On ducts over 24" wide, insulation shall be secured to the underside with mechanical fasteners maximum 18" on center each way.
4. Insulation shall be installed with 25% or less compression of the nominal thickness.

B. Insulate the following exposed duct systems with 2" thick rigid fiberglass board, 6 pcf minimum density, with foil-scrim-kraft facing:

Supply ductwork and plenums.
Return ductwork below roofs or exposed plaza areas.

1. Secure with welded pins or clips set in adhesive 18" on center each way with 2 rows per panel minimum.
2. Seal joints and clips with tape.

C. Finish insulation with glass fabric, set in white lagging adhesive. Insulate the following duct systems with 2" thick polyisocyanurate rigid insulation with polyvinylidene chloride (PVDC) vapor retarder film:

Exterior supply and return ductwork and plenums.

1. Insulation shall be shipped to the jobsite with the vapor retarder film secured with adhesive at the fabricator's shop.
2. Secure insulation with welded pins or clips set in adhesive 12" on center each way with 2 rows per panel minimum. Seal longitudinal and end joints with 3" wide PVDC tape. Clip or bend pins and seal punctures with PVDC tape.
3. Contour mitered sections on radius elbows, non-rectangular ductwork, and fittings and secure with adhesive. Seal joints and gaps with joint sealant. Mitered sections shall be maximum 3" wide.
4. Horizontal surfaces shall be built up and sloped to shed water.
5. Finish insulation with weatherproofing as specified herein.

3.7 INSTALLATION

A. Insulation shall be clean and dry during installation and during application of any finish.

B. Provide removable and replaceable covers on pumps, equipment, and removable ends of strainers requiring insulation that must be opened periodically for inspection, cleaning, or repair.

C. Install insulation materials with smooth and even surfaces, jackets drawn tight and cemented down smoothly at longitudinal and end laps. Do not use scrap pieces of insulation where a full length section will fit.

D. Install insulation, jackets and coatings continuous through openings and sleeves in nonrated construction. For penetrations of fire- or smoke-rated construction, insulation shall be butted tightly against firestops specified in Section 230010, HVAC General. Tape and seal butt joints.

E. Banding wires shall have the twisted terminals turned down toward the insulation without damaging the vapor barrier.

F. Install layered insulation with layer joints staggered. Wire inner layer 9" on center; apply outer layer and finish as specified herein.

G. Finish open ends of pipe insulation as specified herein for fittings.

H. Provide rigid inserts at each insulation protector location for piping 1.5" and larger.

I. Fill hollow steel pipe covering protection saddles with fiberglass insulation.

J. Standing seams and projections in ductwork or casings shall have insulation applied so that at least 0.25" of insulation will cover such projections.

K. Insulation and vapor barrier shall be continuous around and under standoff brackets used for mounting balancing and control devices on ductwork.

L. Where equipment is furnished with other components and adjoining piping factory-assembled on a skid or other common platform, such equipment and piping shall be insulated as specified herein.

3.8 WEATHERPROOFING

A. Protect insulation on ductwork and equipment exposed to weather outside the building with self-adhering flexible exterior covering. Junctions of horizontal and vertical surfaces shall have a minimum of 3" vertical overlap. Horizontal seams shall have a minimum of 6" overlap in roof shingle fashion. Install as recommended by the manufacturer.

B. Protect insulation, except flexible elastomeric, on piping exposed to weather outside the building with 0.016" thick corrugated aluminum jacketing with factory-applied moisture retarder protective film on the inner surface. Provide 2" overlap at joints with sealant as recommended by the manufacturer. Locate longitudinal joints to shed water. Secure jacketing with aluminum bands every 12" and at end joints.

C. Protect exterior flexible elastomeric insulation with UV resistant white acrylic latex coating.

3.9 ALTERNATE METHODS

A. In lieu of banding wires, staples, installed 3" on center, may be used on fiberglass blanket insulation joints.

END OF SECTION 232500

SECTION 236000 - EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other HVAC systems are specified in other Sections of Division 23.

B. This Section covers HVAC systems and equipment.

C. Testing, adjusting and balancing is specified in Section 230095, Testing, Adjusting and Balancing.

D. This Section includes responsibilities and obligations in support of the performance verification specified in Section 230090, HVAC Performance Verification.

1.2 QUALITY ASSURANCE

A. Conform to the following:

1. International Energy Conservation Code-2009.
2. International Mechanical Code-2015 with South Carolina Modifications.
3. National Electrical Code-2014 with South Carolina Modifications-2016.
4. NFPA 90A-2018.

B. Pressure/temperature ratings of components and accessories shall meet or exceed design conditions for the system in which they are installed. Refer to Section 231000, Piping, Valves and Accessories, and requirements specified herein.

C. Provide a complete parts and labor warranty, including refrigerants and lubricants, for 1 year after date of substantial completion, for the following equipment:

1. Air-cooled chillers.

PART 2 - PRODUCTS

2.1 COILS

A. Copper tubes, and nonferrous fins with belled collars mechanically bonded to the tubes.

B. Supply and return connections shall be on the same end.

C. Performance shall be in accordance with AHRI 410-2001 (with Addendum).

D. Minimum working pressure rating shall be equal to that specified herein for the piping system in which the coil is installed. Coils shall be tested at the rated working pressure plus 50%.

2.2 AIR-COOLED CHILLERS

A. Packaged, air-cooled type, designed and constructed in accordance with ASHRAE 15-2016, complete with refrigerant, compressors, motors, evaporator, condenser, insulation, controls, motor controller, control panel, mounting base, enclosure, and associated equipment.

B. Rating certification: capacity rating shall be certified in accordance with AHRI 550/590-2015 Addendum 1. Submit chiller performance data directly from the manufacturer's selection software annotated with a statement of AHRI compliance and including software version number, chiller model number, refrigerant, net refrigeration capacity, water flow rate, pressure drop, entering and leaving water temperatures, power input, ambient condition, fouling factors, and voltage. Performance shall be provided at the full load design condition and each of the NPLV part load conditions.

C. Compressors shall be one of the following types:

1. Scroll type, including centrifugal oil pump. Compressors shall cycle to meet demand. Chillers greater than 35 tons shall have a minimum of 2 refrigerant circuits.
2. Digital scroll type, including solenoid valve and variable cycle time to allow continuous capacity reduction from 100% to 10% load.
3. Rotary screw type, complete with positive pressure oil lubrication system, oil heater, and automatic capacity reduction system with automatic unloading on start-up. Compressors shall fully modulate from 100% to 10% of design capacity.

D. Evaporators: shell and tube or brazed-plate constructed for 150 psig waterside rating, covered with 1.5" thick flexible elastomeric sheet, vapor barrier insulation; protected against freeze-up by a thermostat-controlled temperature maintenance cable wrapped around the shell under the insulation. Fouling factor shall be 0.0001 $ft^2 \cdot °F \cdot h/Btu$.

1. Evaporators for variable chilled water flow shall be certified by the manufacturer to operate with the minimum chilled water flow indicated on the Drawings.

E. Refrigerant circuits: high side pressure relief valve, service isolation valves, filter drier, moisture indicating sight glass, liquid line solenoid valves, insulated suction lines, and thermal expansion valves.

F. Condensers: vertical discharge with safety guard. Coils shall have copper tubes and aluminum fins, or single piece aluminum construction.

G. Motor controllers: across-the-line motor starter. Controllers and components, excluding evaporator heater, shall be factory-wired for a single-point field power connection.

1. Controllers shall include:

a. Non-fused disconnect switch or non-automatic circuit breaker, with door interlocked externally-operable handle, capable of being pad locked. Electrical lugs shall be sized for the incoming power wiring.
b. Short-circuit rating of 10,000 A.
c. Control power transformers for controls and accessories.
d. Short circuit, motor overload, and ground fault protection.
e. Phase failure and low voltage protection.

2. Variable frequency drives shall include harmonic filters to limit total demand distortion from current and the total harmonic distortion from voltage each to a maximum of 5% at the input terminal of the variable frequency drive. Coordinate with the supplier of other variable frequency drives on this project and provide data for a harmonic analysis performed in accordance with IEEE 399-1997.

H. Control panels: unit-mounted in a weather-tight enclosure with microprocessor-based operating and safety controls, graphic display and keypad, with monitoring capabilities, programmable setpoints, and building automation system interface. Panels shall include the manufacturer's standard control package with accessories as required to provide the following functions:

1. Leaving chilled water temperature control.
2. Graphic display of the following items, including factory-wired devices and sensors:

    a. Chilled water temperature entering and leaving evaporator.
    b. Evaporator refrigerant pressure and temperature.
    c. Condenser refrigerant pressure and temperature.
    d. Ambient temperature.
    e. Oil pressure.
    f. Oil temperature.
    g. Motor current % of rated load amperes.
    h. Input power (kW).
    i. Operating hours.
    j. Diagnostic messages.

3. Communication interface to transmit operating data and receive commands through a single connection to the building automation system. The interface shall include hardware and software coordinated with the building automation system that allows monitoring and control of data and alarms available at the control panel from the BCS. Communication protocol shall be BACnet, LonWorks, or Modbus as coordinated with the building automation system supplier. Information transmitted and received shall include:

    a. Digital inputs from the building automation system:

        1) Chiller enable/disable.

    b. Analog inputs from the building automation system:

        1) Chilled water reset.
        2) Electric power demand limit.

    c. Digital outputs to the building automation system:

        1) Chiller status.
        2) Chiller master alarm indicating shutdown due to safety controls.

    d. Analog outputs to the building automation system:

        1) Running amperes as a percentage of rated load amperes.
        2) Chilled water setpoint.
        3) Current limit setpoint.

I. Evaporator differential pressure switches: opposed-diaphragm type, with magnetically actuated adjustable switches, dial type differential pressure readout, and isolation and null valves, selected to operate in the top 80% of the range at the differential pressure corresponding to minimum allowable evaporator flow. Switch shall not drop out at differential pressures that exceed the range. Maximum line pressure shall exceed the operating pressure of the installed system.

1. Manufacturer: Orange Research 1516 DGS series.

J. Chiller manufacturer shall coordinate and approve controls provided in Section 23 80 00, Automatic Temperature Controls, and shall indicate such approval in writing on the control shop drawing submittal.

K. Written instructions and control diagrams showing wiring and programming for building automation system interfaces shall be furnished by the manufacturer to be incorporated in the control diagrams specified in Section 23 80 00, Automatic Temperature Controls.

L. Manufacturer: Trane.

2.3 TERMINAL UNITS

A. Casings:

1. Minimum 24 gauge galvanized steel.
2. Acoustical lining: minimum 0.5" thick, 1.5 pcf density coated fiberglass. Lining shall meet erosion test method described in UL 181-2013 and shall have a flame spread rating of not more than 25 and a smoke developed rating of not more than 50 in accordance with NFPA 90A-2018.
3. Access doors: sealed, flush type for access to internal parts for service or maintenance.
4. Enclosure: removable type for control components.
5. With four angle or heavy gauge hanger brackets for units indicated on the Drawings to be suspended with vibration isolators.
6. Casing leakage rate of less than 3% at 4" wg.
7. Inlet velocity shall not exceed 2200 fpm.

B. Control Motors:

1. Factory-installed on units by unit manufacturer.
2. Coordinated with automatic control system manufacturer; see Section 238000, Automatic Temperature Controls.

C. Airflow sensors: averaging multipoint type, with taps for field calibration, minimum ±5% accuracy with 90° elbow at inlet.

D. Volume Regulators:

1. Factory preset: minimum and maximum air quantity. Air volumes and unit size shall be indicated on the regulator.
2. Gauge taps and calibrated means of adjustment to permit field adjustment of air quantities without unit disassembly.
3. Pressure independent, capable of maintaining constant volume, ±5%, up to 4" wg inlet air pressure.

4. Factory-mounted.
5. Removable.

E. Depth of units: 20" maximum.

F. Moving parts designed for minimum of 300000 cycles.

G. Heating Coils:

1. Electric, labeled as a complete assembly with the terminal unit per UL 1995-2015 or ETL listed to comply with the requirements of UL 1995-2015, complete with unit-mounted terminal box with hinged cover, and intermediate coil supports.
2. Heating elements, exposed element type:

    a. Nickel chrome (80% nickel, 20% chrome) coiled wire, with minimum 1 wire diameter open space between adjacent coils.
    b. Maximum wire density: 37 W/in².
    c. Maximum wire surface temperature: 1400°F.

3. Coils rated more than 48 A shall have heating elements subdivided. Each subdivided load shall not exceed 48 A and shall be fuse protected.
4. Provide a wiring diagram showing terminal designations of power and control circuits, mounted inside the terminal box.
5. Integral terminal boxes shall include:

    a. Terminal blocks for line feeder and control connections.
    b. Incoming line fuses for ungrounded conductors.
    c. Control circuit transformer with fused primary 24 V secondary.
    d. Automatically reset thermal cutouts for primary over-temperature protection.
    e. Manually reset thermal cutouts, load carrying type, for secondary over-temperature protection.
    f. Contactors and PE switches. Controlling and back-up contactors shall be magnetic. Back-up contactors shall break ungrounded conductors.

6. Controls:

    a. Coil shall be interlocked with fan by pressure differential air flow switch.
    b. Steps of heat shall be operated with contactors.

H. Variable Volume Units:

1. Complete with:

    a. Air valve assembly.
    b. Variable air volume from maximum of 100% to minimum of approximately 0%.
    c. Units shall be factory-wired for a single electrical connection point, including input fuses, single disconnect switch for heating coil, and transformers.

I. Manufacturer: Carnes, Carrier, Enviro-Tec, Johnson Controls YVS, Krueger, Metal*Aire, Nailor, Price, Titus ESV, TQS or TQP, or Trane, or Tuttle & Bailey.

2.4 AIR HANDLING UNITS

A. General, except as otherwise specified herein:

1. Complete with fan, motor, drive, coils, access sections, discharge plenum, and filters housed in a finished solid double-wall casing with thermal insulation and drain pan. Functional components shall be accessible for inspection and maintenance through hinged, solid double-wall access doors in each section. Piping connections shall extend through the casing. Unit performance for standard and modular units shall be certified in accordance with AHRI 430-2014 Addendum 1.
2. Fans:

    a. Tested in accordance with ASHRAE 51/AMCA 210-2016.
    b. Statically and dynamically balanced. Fans with variable frequency drives shall be dynamically balanced throughout the complete speed range.
    c. Bearings: pillow block or flange type with L_{10} life of 40000 hours at the peak operating condition. Extend grease leads to allow lubrication during inspection on the access side.
    d. For housed centrifugal fans in draw-through units, fan wheel rotation shall be in the same direction as flow in elbows installed within 3 duct diameters of the fan discharge, where discharge from the elbow is perpendicular to the fan shaft.

3. Cooling coils: chilled water type, as specified in Paragraph 2.01, Coils.
4. Heating coils: electric type, as specified in Paragraph ____, Electric Heating Coils.
5. Filters: pleated and cartridge type, as specified in Section 237000, Air Distribution.
6. Internal vibration isolation: at Contractor's option, internal vibration isolators may be provided in lieu of external isolators. Fan and motor shall be mounted on a common steel vibration base. Fans shall have a flexible connection to the casing. Internal vibration isolators shall be as specified in Section 230010, HVAC General, and as indicated on the Drawings.
7. Drives: V-belt type, as specified in Section 237000, Air Distribution.
8. Motors: as specified in Section 230010, HVAC General.
9. Variable frequency drives: as specified in Section 230010, HVAC General.
10. Control dampers: as specified in Section 238000, Automatic Temperature Controls.
11. Drain pans: double-wall galvanized steel construction with insulation sandwiched between inner and outer pans. Corners shall be welded. Pans shall be pitched toward drain outlet. Units with stacked coils shall include a secondary drain pan under each coil with drain piping to main pan.
12. Double-wall casing insulation: 2" thick spray injected foam with a maximum K-value of 0.167 Btu·in/(h·ft²·ºF) at 75° F. Insulation shall have a composite flame spread rating of not more than 25 and a smoke developed rating of not more than 50 in accordance with NFPA 90A-2018.

B. Blow-Through Type Units:

1. Multizone, cabinet type complete with individual zone dampers, resistance plates and diffuser section.
2. Zone dampers: minimum 16 gauge galvanized steel. Hot and cold deck blades shall be oriented at right angles to each other on common steel pivot rods. Blades shall have interlocking or overlaying edges, and compressible neoprene or extruded vinyl blade seals

and compressible metal side seals. Seals shall be designed for temperatures of -40°F to 180°F.

3. Resistance plates: in hot deck to equalize hot and cold deck air resistance.
4. Provide diffuser plates to equalize air flow over the coils.
5. Manufacturer: Trane MCC.

C. Heating and Ventilating Type Units:

1. Manufacturer: Trane.

2.5 PRECISION AIR CONDITIONING UNITS

A. Ceiling-Mounted Type Units:

1. Air-cooled type, factory-assembled, UL listed, ceiling-mounted type.
2. Cabinets: cabinets and chassis shall be constructed of heavy gauge galvanized steel and designed for installation and service access from the room side only. Ceiling-mounted units shall be designed for installation in a 24" x 48" ceiling grid and shall have integral supply and return grilles.
3. Fans: direct-drive fan assembly equipped with double-inlet blower, self-aligning sleeve bearings, and lifetime lubrication. Fan motor shall be permanent-split capacitor, 2-speed type.
4. Filters: pleated type, as specified in Section 237000, Air Distribution. Filters shall be removable without shutting down the system.
5. Humidifier: steam generator type, factory-piped, mounted and wired to the integral control system. Steam generator shall provide dry steam to the bypass air around the evaporator coil. Controls for the humidification system shall include humidity setpoint, automatic water feed, and drain valves.
6. Reheat: low watt density, finned-tubular electric type, with UL classified safety switches, capable of maintaining room dry bulb conditions when the system is calling for dehumidification.
7. Controls: microprocessor-based, in a wall-mounted control enclosure containing an LCD custom display providing a continuous display of operating status and alarm conditions. An 8 key membrane keypad for setpoint/program control, unit on-off switch, and fan speed control shall be located below the display.

    a. Controls shall have 2 temperature control setpoints for cooling and heating functions with a minimum 2°F differential between them. Controls shall automatically switch from cooling to heating modes based on return air conditions. The temperature control setpoint range shall be 40°F to 85°F.
    b. Controls shall have 2 humidity control setpoints for humidification and dehumidification functions with a minimum 4% RH differential between them. Controls shall automatically switch from humidifying to dehumidifying based on return air conditions. The humidity control setpoint range shall be 20% RH to 80% RH. Dehumidification shall utilize the low fan speed.
    c. Controls shall be programmable on a daily basis or on a 5 day/2 day program schedule, and shall be capable of accepting 2 programs per day.
    d. Controls shall include the capabilities to calibrate the temperature and humidity sensors and adjust the sensor response delay time from 10 s to 90 s.
    e. Controls shall be capable of displaying temperature values in Fahrenheit or Centigrade.

f. The LCD display shall provide indication of on-off, fan speed, operating mode (cooling, heating, humidifying, dehumidifying), and current day, time, temperature and humidity.

g. Controls shall monitor unit operation and activate an audible and visual alarm for the following field adjustable conditions:

1) High temperature: maximum 90°F.
2) Low temperature: minimum 35°F.
3) High humidity: maximum 85% RH.
4) Low humidity: minimum 15% RH.

h. Controls shall be capable of disabling any alarm if required.

8. Cooling coils: copper tubes and aluminum fins, as specified in Paragraph 2.01, Coils. Drain pan shall be stainless steel.
9. Refrigeration system: hermetic compressor, pressure safety switches, externally equalized expansion valve, and a refrigerant sight glass and moisture indicator.
10. Condensers: self-contained, air-cooled type, with coil and a direct-drive centrifugal fan. Fan shall be sized to provide full rated cooling capacity at 95°F entering air from plenum space. The system shall be provided with a fan speed control to permit operation at -20°F ambient temperature.
11. Coils shall have normally closed, 2-way modulating control valves capable of full closure against a 25 100 psig head.
12. Condensate pumps: complete with pump, motor, integral float switch, reservoir, and secondary float switch to shutdown the unit upon a high water level condition.
13. Manufacturer: Liebert.

2.6 DUCTLESS SPLIT SYSTEMS

A. Systems shall be commercial grade equipment, complete with an outdoor condensing unit, indoor fan-coil unit, refrigerant piping, and controls. Units shall be rated in accordance with AHRI 210/240-2008 Addendum 1 and 2. Units shall be factory-charged with refrigerant R-410A. Systems shall operate as cooling only systems as indicated on the Drawings.

B. Outdoor condensing units: factory-assembled, complete with compressors, condenser fans, condenser coils, motors, controls, electronic expansion valves, solenoid valves, distribution headers, capillaries, filters, shut off valves, oil separators, service ports, refrigerant regulators, and controls.

1. Compressors shall be variable speed scroll type. Compressor speed shall be varied between 5% to 100% speed in response to load variation. Compressors shall be equipped with crankcase heaters, high pressure safety switches, and internal thermal overload protection.
2. Condenser fans shall be propeller type with variable speed digitally commutating motors.
3. Condenser coils shall have copper tubes, and aluminum fins.
4. Controls: microprocessor-based.
5. Electric connections: single point 208 V, 3-phase.

C. Indoor Fan-Coil Units:

1. Ductless wall-mounted type, factory-assembled complete with cabinet, fan, coil, air filter, condensate pan, and controls. Units shall be provided with supply and return grilles and shall be designed for installation on wall in a conditioned space.
2. Filters: throw away type, as specified in Section 237000, Air Distribution.
3. Controls: microprocessor-based.
4. Electric connections: each fan-coil unit shall be single point connection.

D. Refrigerant Piping:

1. As specified in Section 231000, Piping, Valves and Accessories.
2. Piping joints and headers shall be provided by the system manufacturer in order to provide balanced refrigerant flow, and to provide specified capacity and performance.

E. Wall-mounted space temperature sensors: provide for all indoor fan-coil units with the following features:

1. Thermistor type temperature sensor.
2. Setpoint adjustment buttons.
3. Backlit LCD display in English.
4. Display of sensed room and set point temperatures.
5. Cooling set point range limits.
6. Unoccupied mode with independent cooling setup set points.
7. Buttons shall be capable of being disabled by maintenance personnel.

F. Manufacturer: Carrier, Daikin, Friedrich, JCI/York, LG, Mitsubishi, or Panasonic.

2.7 ELECTRIC HORIZONTAL UNIT HEATERS

A. Fans: propeller type with aluminum blades dynamically balanced with single-speed motor and an inlet guard.

B. Motors with contactors shall be wired within the unit to the heating coil power supply. Provide 24 V or 120 V control circuit transformer fused on primary side and grounded.

C. UL listed, with high limit thermal control switch, automatic reset, and integral unit disconnect switch. Elements shall be sheathed type with nickel chrome coiled wire imbedded in magnesium oxide refractory material, enclosed in sheath with spirally wound fins.

D. Enclosures: steel, welded, with baked enamel finish, and adjustable horizontal louvers.

E. Manufacturer: American Stabilis, Berko HUHAA, Brasch BTU or BTUH, Erincraft, INDEECO, Markel 5100, Q-Mark MUH, Raywall, or Trane.

2.8 ELECTRIC CEILING HEATERS

A. UL listed, wall type. Heating elements shall be the tubular finned metal sheath type with helical coiled fins. Heaters shall have automatically reset thermal overheat protection, power disconnect device or positive off switch, and shall be factory wired for a single point connection including power disconnect.

B. Complete with: direct-drive propeller fan and permanently lubricated motor. Motor shall be permanent split capacitor type with built-in automatically reset motor overload protection.

C. Enclosures: recessed, flush with ceiling, 20 gauge steel, with horizontal inlet and discharge grilles, baked enamel finish, color selected by the Architect.

D. Controls: self-contained internally wired thermostat with remote bulb in return air.

E. Manufacturer: Berko NFR, Brasch SR, INDEECO, Markel 3420, Q-Mark A, or Raywall.

2.9 ELECTRIC FINNED TUBE RADIATION:

A. General:

1. Factory-assembled, wired and tested, UL listed.
2. Designed to eliminate 60 Hz sound.
3. High limit thermal cutout, automatic reset, linear full length type sensing bulb along entire length of heater. Self-contained thermostat for elements in each room.
4. Disconnect switch.
5. 2-stage control for 500 W/ft density and greater.
6. Heating Elements:

    a. Nickel chrome (80% nickel, 20% chrome) coiled wire imbedded in magnesium-oxide refractory material and enclosed in sheath. Spirally wound steel fins furnace brazed to steel sheath, or aluminum fins mechanically bonded to aluminum or steel sheath.
    b. Heat-resistant nonoxidizing finish on sheath and fins. Copper-plated, high temperature aluminum finish, or ceramic coating for corrosion protection.
    c. Maximum 6 fins per in.
    d. Support anchor with cushioned space for expansion.
    e. Maximum surface temperature: 350°F.

B. Commercial Draft Barriers:

1. Enclosures: 16 gauge steel.
2. Grilles: louvered 16 gauge stamped steel or 14 gauge extruded aluminum.
3. Finish: baked enamel, color as selected by the Architect.

C. Architectural Draft Barriers:

1. Enclosures: minimum 16 gauge extruded aluminum.
2. Grilles: minimum 16 gauge extruded aluminum.
3. Finish: baked enamel, color as selected by the Architect.
4. Provide pedestal mounts where indicated on the Drawings.

D. Manufacturer: Berko, Brasch, Electromode, Erincraft, INDEECO, Markel, Q-Mark, or Raywall.

2.10 ELECTRIC HEATING COILS:

A. UL listed, complete with terminal box with removable cover on the end of the coil, intermediate coil supports, automatically reset thermal cutouts for primary over-temperature protection, heat limiters or manually reset thermal cutouts for secondary over-temperature protection, and pressure differential airflow switch. Arrange circuiting to prevent stratification of hot and cold air.

B. Heating elements: either sheathed or exposed element type.

1. Sheathed Element Type:

a. Nickel chrome (80% nickel, 20% chrome) coiled wire imbedded in magnesium-oxide refractory material and enclosed in sheath. Spirally wound steel fins furnace brazed to steel sheath, or aluminum fins mechanically bonded to aluminum or steel sheath.
b. Heat-resistant nonoxidizing finish on sheath and fins. Copper-plated, high temperature aluminum finish, or ceramic coating.
c. Maximum 6 fins per in.

2. Exposed Element Type:

a. Nickel chrome (80% nickel, 20% chrome) coiled wire, with minimum one wire diameter open space between adjacent coils.
b. Maximum wire density: 37 W/in².
c. Maximum wire surface temperature: 1400°F.

C. Coil dimensions shall be the same as the duct in which installed or opening to which attached.

D. Coils rated more than 48 A shall have heating elements subdivided. Each subdivided load shall not exceed 48 A and each nongrounded conductor shall be fuse protected.

E. Integral control boxes shall contain a terminal block and terminals sized for single incoming power feeder; control circuit transformer with fused primary and fused 120 V secondary; 100000 cycle service, 3-pole line break contactor for each circuit and fuses, housed in a NEMA 1 enclosure.

F. Remote control cabinets shall contain a control circuit transformer with fused primary and 120 V secondary; 100000 cycle service, 3-pole line break contactor for each circuit; fuses for each circuit and separate terminal blocks and terminals for a single incoming power feeder and control circuits, housed in a NEMA 1 cabinet. Main busses and main lugs shall be sized for main feeder.

G. Energize contactors through pilot duty devices, PE switches and multistep thermostats up to 3 steps, step controllers for more than 3 steps. Step controllers shall recycle on power interruption.

H. Pipe pneumatic devices to bulkhead fittings on the side of the control box or cabinet.

I. Provide a wiring diagram showing terminal designations of power and control circuits, mounted inside the control box or cabinet.

J. Manufacturer: Brasch, INDEECO, Markel HF, or Nailor.

2.11 GAS-FIRED INFRARED HEATERS

A. Vacuum assisted or natural-draft, AGA certified, low intensity type complete with cast iron burners, direct spark electronic igniter with 100% gas shutoff safety controls, and steel tube and aluminum or stainless steel reflector with end caps. Provide prewired controls, transformer, gas vent, wall thimble, and mounting hardware.

B. Provide low voltage black bulb environmental warmth thermostats designed to sense radiant temperature of surroundings, air temperature, and air velocity.

C. Vacuum assisted type heaters shall be furnished with enclosed combustion chamber, fan, motor with thermal overload protection, safety vacuum switch interlocked with the operation of the burners and the vacuum pump, and accessories.

D. Units shall be provided with manufacturer’s supplemental draft inducer. Vent piping shall be manifolded together as indicated on the Drawings.

E. Natural-draft type shall be furnished with atmospheric burner, draft hood, and accessories.

F. Manufacturer: Space-Ray.

PART 3 - EXECUTION

3.1 CHILLERS

A. Assembly shall be erected by trained mechanics in the employ of the manufacturer or under the supervision of an employee of the manufacturer in accordance with manufacturer's instructions.

B. Piping connections and control sequence shall conform to the manufacturer's specific requirements.

C. Start-up service and commissioning shall be performed by mechanics retained by the manufacturer. Perform chiller commissioning and provide assistance and support during controls system commissioning. Submit a statement that the chillers are installed in accordance with the manufacturer's recommendations, and that safeties and controls are operating properly.

3.2 TERMINAL UNITS

A. Install terminal units with manufacturer's recommended upstream duct conditions for operation of velocity sensors and volume controls, and required clearances for control panels, coils, return air openings, and other components.

B. Install throw away filters while building is under construction. Upon completion of construction and final clean-up, remove these filters.

3.3 AIR HANDLING UNITS

A. For air handling units with coil sections that are near the floor, coordinate the unit mounting height with the condensate drain trap detail. If the bottom of the insulated drain trap conflicts with the floor slab, provide height adjustment supports between the air handling unit and housekeeping pad. Locate supports at manufacturer recommended load points.

3.4 PRECISION AIR CONDITIONING UNITS

A. Install a complete gasket between each floor-mounted unit and the raised floor.

B. Install ceiling-mounted precision air conditioning units in accordance with manufacturer's instructions. Install units plumb and level, firmly anchored, and maintain manufacturer's recommended clearances.

C. Ceiling-mounted units shall be aligned with the ceiling grid.

D. Install filters to be used while the building is under construction. Replace during construction as filters become loaded. Prior to final inspection, remove these filters and replace with new filters.

E. Install and connect accessories and electrical devices furnished by the manufacturer.

3.5 GAS-FIRED INFRARED HEATERS

A. Maintain minimum clearances to combustibles as recommended by the manufacturer.

END OF SECTION 236000

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SECTION 237000 - AIR DISTRIBUTION

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other HVAC systems are specified in other Sections of Division 23.

B. This Section covers air distribution systems and equipment.

C. Motorized dampers not furnished with equipment shall be provided under Section 238000, Automatic Temperature Controls.

D. Testing, adjusting and balancing is specified in Section 230095, Testing, Adjusting and Balancing.

E. This Section includes responsibilities and obligations in support of the performance verification specified in Section 230090, HVAC Performance Verification.

1.2 QUALITY ASSURANCE

A. Vent systems for gas-fired equipment shall conform to the following:

1. International Fuel Gas Code-2015 with South Carolina Modifications-2016.
2. NFPA 211-2016.

B. Air conditioning systems shall conform to the following:

1. International Energy Conservation Code-2009.
2. International Mechanical Code-2015 with South Carolina Amendments.
3. NFPA 90A-2018.

1.3 DEFINITIONS

A. Sizes for lined ductwork indicated on the Drawings are sheet metal sizes.

B. Ductwork shall have the following static pressure classifications, unless otherwise specified herein:

1. From variable volume air handling units to terminal units: 3" wg.
2. From terminal units to grilles, registers and diffusers: 2" wg.
3. On the inlet of return air and toilet exhaust fans: -1" wg.
4. On the discharge of return air and toilet exhaust fans: 1" wg.
5. Fueling station ventilation exhaust: -2 " wg.
6. Field-fabricated plenums and casings on the suction side of air handling units and fans: -4" wg.
7. Field-fabricated plenums and casings on the discharge side of fans: 6" wg.

C. The first 20' of rectangular supply and return ductwork outside the HVAC room shall be constructed of 16 gauge sheet metal with a 6" wg static pressure classification for ductwork and transverse joints. The test pressure for duct leakage testing specified in 230095, Testing, Adjusting and Balancing may be equal to that used for downstream ductwork.

PART 2 - PRODUCTS

2.1 SHEET METAL WORK - GENERAL

A. Ductwork, except where otherwise specified herein, including factory-fabricated round and flat oval, and apparatus casings shall be constructed of galvanized steel in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, 2005.

2.2 SHEET METAL WORK - ACCESSORIES

A. Zinc-rich paint: Sherwin-Williams Zinc-Clad Primer, or ZRC Worldwide Galvilite.

B. Weld or mechanical grip pins: AGM, Duro-Dyne, or Erico.

C. Duct sealants: liquid, mastic, gasket, or tape and activator type, asbestos-free, complying with NFPA 90A-2018 and UL 181-2013.

D. Draw bands: nylon type, complying with UL 181-2013, Class 1, and NFPA 90A-2018.

E. Lining adhesive: ASTM C916-2014.

F. Instrument test ports: flanged base with screw cap and gasket, and flat mounting gasket for flat or round duct. Height shall accommodate duct insulation thickness.

1. Manufacturer: Ventlok 699 series.

2.3 PLENUM LINING

A. Fibrous:

1. Plenum lining shall be 2" thick, 3 pcf density, rigid, coated fiberglass board meeting ASTM C1071-2016, Type II. Coating shall not support the growth of fungus or bacteria when tested in accordance with ASTM G21-2015.
2. Lining and accessories shall have a composite flame spread rating of not more than 25 and a smoke developed rating of not more than 50.
3. Manufacturer: CertainTeed ToughGard Rigid Liner Board, Johns Manville Linacoustic R-300, or Owens Corning QuietR Duct Liner Board.

2.4 FLEXIBLE CONNECTIONS

A. Coated glass fabric not less than 3" active length.

B. Connections shall comply with NFPA 90A-2018, NFPA 701-2015, and shall be asbestos-free and designed for continuous use at 275°F.

C. Manufacturer: Duro-Dyne, or Ventfabrics.

2.5 ACCESS PANELS

A. Tight fitting, hinged, except removable where necessitated by space conditions, double-wall insulated type, manufactured in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, 2005.

B. Manufacturer: Air Balance, Krueger, Louvers & Dampers, Nailor, National Controlled Air, Phillips-Aire, Ruskin, or Ventlok.

2.6 ACCESS DOORS

A. Tight fitting, hinged, double-wall insulated type, 24" x 60" clear inside opening.

1. Manufacturer: Air Balance, Louvers & Dampers, National Controlled Air, or Ruskin.

B. Handles, latches and hinges: cadmium-plated steel.

1. Manufacturer: Duro-Dyne, Ventlok, or Young Regulator.

2.7 PRESSURE RELIEF DOORS

A. Galvanized steel, 18" x 18", 12 gauge construction, insulated type with positive latch mechanism, perimeter door gasket, and automatic reset.

B. Doors shall have pressure relief settings equal to 0.5" wg less than the static pressure rating of the duct.

C. Manufacturer: Ruskin PRD18.

2.8 FLEXIBLE DUCTWORK

A. Chlorinated polyethylene; aluminum foil, fiberglass, and aluminized polyester trilaminate; or coated woven fiberglass cloth, mechanically locked or permanently bonded to a noncorrosive metal helix. Factory-insulated with fiberglass with a protective vapor barrier jacket to achieve an ADC certified minimum R-value of 6.0°F·ft²·h/Btu at 75°F.

B. Listed under UL 181-2013 as a Class 1 air duct, in compliance with NFPA 90A-2018, and rated for minimum 6" wg positive pressure and 0.75" wg negative pressure.

C. Manufacturer: Flexmaster, or Thermaflex.

2.9 PRESS-ON COLLAR FITTINGS

A. Minimum 26 gauge galvanized steel, with a 1" wide mounting flange, pre-punched mounting holes, an adhesive-coated flange gasket, and a manual damper with locking device, for round diffuser runout duct connections to supply duct. The outlet collar shall be crimped and incorporate a bead.

2.10 GAS VENTS

A. Prefabricated, multiwall, UL listed, Type B type constructed in accordance with the requirements of NFPA 211-2016.

B. Provide storm collars, vent flashing, elbows, tees, tee caps, support plates, and supports and guys as recommended by the manufacturer.

C. Provide draft hood connectors and barometric dampers as recommended by the manufacturer of the connected gas appliances.

D. Manufacturer: Ampco R, Metal-Fab M, or Selkirk Metalbestos RV or QC.

2.11 HANGERS AND SUPPORTS

A. Duct hangers and supports shall be in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, 2005.

2.12 FIRE DAMPERS

A. Factory-built curtain type, except where multiblade type is specified herein. Dampers shall be spring-operated with stainless steel constant tension springs, conforming to requirements of UL 555-2006 for dynamic operation, NFPA 90A-2018, and UL listed.

B. Rating: 1.5 hours.

C. Provide factory-built sleeves of design and length to permit mounting within the opening.

D. Dampers in round ductwork shall be Type C.

E. Dampers in rectangular ductwork with minimum dimension 30" and larger shall be the multiblade type with airfoil shaped blades.

F. Dampers in rectangular ductwork with minimum dimension less than 30" shall be as follows:

1. Dampers in return air openings, or behind grilles or registers shall be Type A.
2. For ductwork with a static pressure rating of 2" wg or less, dampers with a minimum dimension of 18" or smaller shall be Type B, and those with a minimum dimension of 19" and larger shall be Type A.
3. For ductwork with a static pressure rating greater than 2" wg, dampers shall be Type C.

G. Fusible links shall have a temperature rating approximately 50°F above the maximum temperature that would normally be encountered with the system in operation or shutdown, but not less than 165°F.

H. Manufacturer: Greenheck, Leader, Nailor, National Controlled Air, Prefco, Ruskin, or Safe-Air.

2.13 SMOKE DAMPERS

A. Factory-fabricated type, complying with UL 555S-2014 at 250°F and a minimum test pressure differential of 4" wg.

1. Dampers in ductwork with a 2" wg and greater static pressure classification: airfoil blade design, Leakage Classification II, maximum rated airflow rate of at least 3000 fpm.
2. Dampers in ductwork with a 1" wg and less static pressure classification, and in openings: Leakage Classification II, maximum rated airflow rate of at least 2000 fpm.

B. Damper operators shall be factory-installed, power open, spring closed, 24 V AC, and shall be rated for a minimum of 250°F. Damper closure rate shall be 15 seconds minimum and 30 seconds maximum.

C. Dampers in round ductwork up to 18" in diameter shall be the single-blade type. Dampers in round ductwork larger than 18" diameter shall be the multiblade type with connector sleeves. Minimum connector sleeve size shall be 2" larger in each dimension than the duct connection.

D. Dampers in rectangular ductwork and in openings shall be multiblade type. Provide connector sleeves.

E. Manufacturer: Air Balance, Greenheck, Leader, Nailor, National Controlled Air , Ruskin, or Safe-Air.

2.14 COMBINATION FIRE/SMOKE DAMPERS

A. Factory-fabricated type, complying with UL 555-2006 and UL 555S-2014 at 250°F and a minimum test pressure differential of 4" wg.

1. 1.5 hour rating, with UL fire and leakage classification markings.
2. Dampers in ductwork with a 2" wg and greater static pressure classification: airfoil blade design, Leakage Classification II, maximum rated airflow rate of at least 3000 fpm.
3. Dampers in ductwork with a 1" wg and less static pressure classification, and in openings: Leakage Classification II, maximum rated airflow rate of at least 2000 fpm.

B. Dampers shall have a 212°F thermal device which will close and lock the damper in the closed position. Damper operators shall be factory installed, power open, spring closed, 24 V AC, and shall be rated for 250°F. Damper closure rate, on smoke mode, shall be 15 seconds minimum and 30 seconds maximum.

C. Dampers in round ductwork up to 18" in diameter shall be the single-blade type. Dampers in round ductwork larger than 18" diameter shall be the multiblade type with connector sleeves. Minimum connector sleeve size shall be 2" larger in each dimension than the duct connection.

D. Dampers in rectangular ductwork and in openings shall be multiblade type. Provide connector sleeves.

E. Manufacturer: Air Balance, Greenheck, Leader, Nailor, National Controlled Air, or Ruskin.

2.15 MANUAL DAMPERS

A. Single blade up to 8" high, opposed multiblade over 8" high; minimum 80% free area based on damper frame outside dimensions.

B. Blades: minimum 16 gauge galvanized steel, or airfoil shape extruded aluminum.

1. Pivot rods: steel, minimum 0.5" diameter or hex, with one rod extended 6" to permit operation of damper from outside the duct.
2. Maximum length 42"; maximum width 8".
3. For low leakage applications: at points of contact provide interlocking or overlapping edges, compressible neoprene or extruded vinyl blade seals, and compressible metal side seals, designed for temperature of -40°F to 180°F at leakage rate specified herein.

C. Frames: galvanized steel bar minimum 2" wide x 12 gauge for dampers 10" high or less, and 3.5" x 0.875", 16 gauge galvanized roll-formed channel with double-thickness edges or 5" x 1" x 0.125" extruded aluminum channel for 11" high and larger.

1. Corner bracing.
2. Full size of duct or opening in which installed.

D. Bearings: bronze sleeve, steel ball type, or Cycoloy 800.

1. Vertically-mounted: thrust bearings.
2. Maximum spacing: 42".

E. Quadrants: cadmium-plated steel, with damper locking device, and damper position indicator.

1. Manufacturer: Arrow Q-38, Duro-Dyne KL-7R, or Ventlok 560.

F. Finish on steel parts: galvanized.

G. Operating linkage: factory-assembled, concealed in frame out of airstream, steel construction.

H. For low leakage applications: leakage when closed shall be less than 4 cfm/ft² at 1" wg differential static pressure based on a 48" damper width.

2.16 CONTROL DAMPERS

A. As specified in Section 238000, Automatic Temperature Controls.

2.17 GRILLES, REGISTERS AND DIFFUSERS

A. General:

1. Selection of grilles, registers and diffusers shall be based on air introduced at a 20°F temperature differential.
2. Grilles and registers with borders shall have felt or rubber gaskets cemented to the back face and holding screws not over 18" on center around the perimeter.
3. Wall-mounted grilles and registers located less than 7' above finished floor shall be heavy duty, impact-resistant type.
4. Diffusers in lay-in ceilings shall lay in a nominal 24" x 24" grid opening and shall be furnished without exposed flanges.
5. Register dampers: gang-operated, opposed-blade type, operated through the face of the register. Operating mechanism shall not project through the register face.
6. Extractors: adjustable through the face of the grille or register.

7. Diffusers shall be complete with straightening vanes, and opposed or rotating blade volume control dampers. Straightening vanes are not required where diffusers are attached to round flexible ductwork. Volume control dampers are not required where single diffusers are served by branch ducts with dampers at take-offs.
8. Internal parts of diffusers shall be designed so they can be adjusted, removed, and assembled without special tools.
9. Diffusers shall have round necks or shall be provided with square-to-round collars where connected to round or flexible duct.
10. Finishes, unless otherwise specified herein:

    a. Steel grilles and registers: white baked enamel.
    b. Diffuser faces and frames: baked enamel, color selected by Architect.
    c. Diffusers interior: flat black.

11. Grilles, registers and diffusers shall be provided with frames, borders, and mounting attachments for installation in the actual wall, soffit, and ceiling construction in which installed.

B. Supply Devices:

1. Type S-CF - Square cone face diffuser type, 24" x 24" face, minimum of 3 stamped cones, horizontal/vertical pattern adjustment device, 1-piece construction.
2. Type S-SR - Sidewall supply register, double-deflection type with vertical front blades, horizontal rear blades, and opposed-blade volume damper.
3. Type S-SG - Sidewall supply grille, double-deflection type with vertical front blades and horizontal rear blades.
4. Type S-LB - Linear bar diffuser, extruded aluminum, continuous multiple-bar type, heavy duty type for floor installation. Bars shall be 0.125" thick, 0^{o} deflection, 0.25" support members shall not exceed 18" on center; and width shall be 6". Diffusers shall be continuous where indicated on the Drawings. Provide blank-off sections, mitered corners, and vertical pattern control dampers. Ceiling application: provide extruded aluminum snap-in mounting frame. Sections shall be butted without breaks or flanges at joints. Finish as directed by Architect.

    a. Diffusers shall have opposed-blade volume control dampers and vertical pattern control dampers.
    b. Floor diffusers shall have permanent finish designed for heavy duty traffic. Provide heavy duty frame for flush floor mounting with vertical edge to abut carpet.

5. Type S-LD - Linear diffuser, extruded aluminum type, with integral volume control and pattern adjustment and concealed mounting frame. Finish in baked enamel with white face, and interior components visible after installation finished flat black.

Type	Length	Number of Slots	Slot Width
S-LD1	4'	2	1"
S-LD2	6'	2	1"
S-LD3	4’	4	1”

6. Type S-PN - Round surface mount punkah nozzle type, constructed of heavy gauge aluminum, with round gasketed outer frame. A felt seal shall separate nozzle from frame.

Nozzle shall be 70° adjustable in all directions, and shall be provided with an integral volume control damper and adjustable knob. Finish shall be selected by the Architect.

a. Manufacturer: Anemostat SPT, Krueger RPN, Metal*Aire MPK, E.H. Price JN, or Tuttle & Bailey DJ.

C. Return and Exhaust Devices:

1. Type R-SG - Sidewall grille, single-deflection, 35° fixed position, 0.5" on center, horizontal blades.
2. Type R-EG - Eggcrate grille, 0.5" x 0.5" x 0.5" fabricated aluminum eggcrate.
3. Type R-SR - Sidewall register, single-deflection, 35° fixed position, 0.5" on center, horizontal blades with opposed-blade volume damper.
4. Type R-ER - Eggcrate register, 0.5" x 0.5" x 0.5" fabricated aluminum eggcrate with opposed-blade volume damper.
5. Type R-LB - Linear bar return grille, continuous multiple-bar type, heavy duty floor type. Extruded aluminum. Bars 0.25" on center; support members not to exceed 18" on center. Width shall be 6". Grilles shall be continuous where indicated on the Drawings. Provide blank-off sections and mitered corners. Ceiling application: provide extruded aluminum snap-in mounting frame. Sections shall be butted without breaks or flanges at joints. Finish as directed by Architect. Floor grilles shall have permanent finish designed for heavy foot traffic. Provide heavy duty frame for flush floor mounting with vertical edge to abut carpet.
6. Type R-LD - Linear return grille, extruded aluminum 1" slot type with concealed mounting frame. Finish in baked enamel with white face and interior components visible after installation, finished flat black. Appearance shall match Type S-LD linear diffusers, including balancing and directional devices.

D. Manufacturer, unless otherwise noted: Anemostat, Carnes, Krueger, Metal*Aire, Nailor, E.H. Price, Titus, or Tuttle & Bailey.

2.18 FANS - GENERAL

A. Rated in accordance with AMCA 211-2013 (R2017), AMCA 300-2014, and ASHRAE 51/AMCA 210-2016.

B. Fans used in smoke control systems shall be UL listed as power ventilators for smoke control systems.

C. Drives:

1. V-belt type, sized for 140% of motor size. Belt drive fans used in smoke control systems shall have 1.5 times the number of belts required for the design duty, minimum 2 belts.
2. Construction: cast iron. Sheaves for drives 5 hp and larger shall have bushed bores.
3. Motor sheaves: fixed pitch once final balancing and commissioning is completed.
4. Companion sheaves: to maintain belts parallel.
5. Temporary motor sheaves for final balancing and commissioning: variable pitch for motors through 25 hp or fan speeds less than 1000 rpm; fixed pitch for motors over 25 hp or fan speeds over 1000 rpm, and for variable frequency drives.

D. Motors and variable frequency drives: as specified in Section 230010, HVAC General, unless otherwise specified herein.

E. Control circuit transformers: for actuators on fans with 3-phase motors.

F. Wheels and shafts: factory-balanced, both statically and dynamically as an assembly. Fans with variable frequency drives shall be dynamically balanced throughout the complete speed range. Fan wheel rotation for utility sets, and centrifugal fans shall be in same direction as flow in elbows installed within 3 duct diameters of the fan discharge, where discharge from the elbow is perpendicular to the fan shaft.

G. Bearings: ball, roller, or taper roller type. Bearings for cabinet fans, centrifugal inline duct fans, propeller fans, and power roof ventilators shall have an L_{10} life of 50000 hours. Other bearings shall have an L_{10} life of 100000 hours. Bearing life shall be calculated based on the peak operating condition indicated on the Drawings.

1. Fans 27" and larger shall be provided with horizontally split type bearing housings, and pressure type lubricating fittings extended to accessible locations.

H. Fans for variable volume duty shall be capable of operating at 25% of design capacity without surge or pulsation.

I. Fan guards: shall shield the perimeter and face of belt drives, with openings opposite driver and driven shafts to permit use of tachometer. Guards for double-inlet fans shall have face of expanded metal.

2.19 PROPELLER FANS

A. Wall type, steel construction with inlet and outlet guards, square mounting plate stiffened by turned up edges or fitted with steel angles, streamline inlet ring, motor, and drive.

B. Fans shall be equipped with motorized discharge dampers. Dampers shall be heavy duty type with steel damper linkage, motor, and heavy gauge blades. Dampers shall be interlocked to open when the fan is on and to close when the fan is off. A mechanical limit switch shall prove damper open position before starting fan.

C. Manufacturer: Acme, American Coolair, Breidert, Buffalo, Carnes, Cook, Greenheck, JencoFan, or PennBarry.

2.20 PROPELLER FANS, AIRFOIL BLADES

A. Wall, airfoil blade type, steel construction with inlet and outlet guards square mounting plate stiffened by turned up edges or fitted with steel angles, streamline inlet ring, direct-drive motor, and adjustable pitch high strength resin or cast aluminum airfoil blades.

B. Fans shall be equipped with motorized discharge dampers. Dampers shall be heavy duty type with steel damper linkage, motor, and heavy gauge blades. Dampers shall be interlocked to open when the fan is on and to close when the fan is off. A mechanical limit switch shall prove damper open position before starting fan.

C. Manufacturer: American Coolair CDC, or Chicago PowerMate.

2.21 CENTRIFUGAL INLINE FANS

A. Tubular type, steel construction, with inlet and outlet flanges, quick opening access door, streamline inlet and outlet, airfoil type nonoverloading wheel, inlet and outlet screens, and V-belt drive with motor mounted on adjustable base.

B. Manufacturer: Acme, Chicago, Cook, Greenheck, NY Blower, PennBarry, or Twin City.

2.22 CENTRIFUGAL INLINE DUCT FANS

A. Tubular or square inline duct type, steel or aluminum construction, with inlet and outlet flanges, inlet cone, access door, nonoverloading wheel, and mounting brackets.

B. Manufacturer: Acme, American Coolair, Breidert, Carnes, Cook, Greenheck, JencoFan, or PennBarry.

2.23 CABINET FANS

A. Horizontal, suspended, complete with forward-curved fan, motor, V-belt drive, and drive guard and 1" thick throw away filters, housed in a finished 20 gauge steel casing with thermal insulation and removable panel for access.

B. Motor base shall be adjustable for tightening belt tension. Moving parts shall be mounted on a steel frame isolated from the cabinet by neoprene mounts.

C. Manufacturer: Acme, Airmaster, Breidert, Brod & McClung, Carnes, Carrier, Cook, PennBarry, Trane, or York.

2.24 HIGH VOLUME LOW SPEED FANS

A. Basis of Design (Specified Manufacturer): To establish a standard of quality, design and function desired, Drawings and specifications have been on Big Ass Fans Inc., Lexington, KY, "Essence 144-inch diameter fan in special order custom finish".

1. The identified Basis-of-Design is a specialty product/system with unique characteristics, features, and/or operation. The Contractor shall provide the products of the named manufacturer(s) without substitution unless a "Pre-Bid Request for Prior Approval" for an alternate product/system is submitted and approved 10 days in advance of the Bid Date as described in Divisions 00 and 01.

B. Fan components:

1. Airfoil material: Extruded anodized aluminum. Color selected by Architect.
2. Number of fans speeds: Infinite.
3. Winglets, lower motor, upper motor, RF cover and tube. Color selected by Architect.
4. Heat sink. Color selected by Architect.
5. Provide all components for a complete installation including fan unit and blades, mounting system, hub, safety cable, wall controls and guy wires.

C. Provide wall mounted controllers for group control of multiple fans.

D. Factory finishing:

1. All components: Shop prefinished.
2. Metal: Degrease and phosphate etch, prime and apply minimum two coats factory baked epoxy enamel.

2.25 FILTERS

A. General:

1. MERV, efficiency, and arrestance ratings shall be based on ASHRAE 52.2-2017.
2. Filters shall be UL 900-2015 Class 2.

B. Temporary Filter Media:

1. 1" thick, dual-density, depth-loading polyester media with a minimum MERV rating of 8.
2. Manufacturer: Fiberbond Dual-Ply Dustlok.

C. Throw Away Filters:

1. 1" thick throw away type with factory-fabricated frames and a MERV rating of 6. Capacity shall be based on 300 fpm face velocity. Initial resistance shall not exceed 0.08" wg.
2. Manufacturer: Airguard F312, American Air Filter 5700, or Farr 20-20.

D. Pleated Filters:

1. 2" thick pleated, disposable type. Each filter shall consist of media and enclosing frame. Media shall be self-supported or shall contain a support grid. Initial resistance shall not exceed 0.30" wg based on 500 fpm face velocity.
2. Filter media shall be reinforced nonwoven cotton fabric type with a minimum MERV rating of 6.
3. The effective filter media shall be not less than 4.6 ft² of media per ft² of filter face area.
4. Self-supported media shall be capable of maintaining its shape and pleat spacing during normal use. Filters with self-supported media shall maintain functionality if filter frame is damaged.
5. The media support shall be a welded grid with an effective open area of not less than 96%. The welded wire grid shall be bonded to the filter media to eliminate the possibility of media oscillation and media pullaway. The media support grid shall be formed in such a manner that pleats are rounded, allowing total use of filter media.
6. The enclosing frame shall be constructed of rigid, heavy duty, chipboard with diagonal or longitudinal support members bonded to the air entering and air exit side of each pleat to ensure pleat stability. The inside periphery of the enclosing frame shall be bonded to the filter pack.
7. Housings: factory-fabricated of galvanized steel, double-wall insulated type, with tracks for filters, and side access door with seal. Filter enclosing frames and housing shall form an airtight seal.
8. Manufacturer: Airguard DP, American Air Filter Am-Air 300X PerfectPleat, or Farr 30-30.

E. Cartridge Filters:

1. 12" deep with synthetic glass fiber media with a minimum MERV rating of 14. Dimensions shall be based on capacities as indicated on the Drawings and a 500 fpm face velocity. Initial pressure drop, including prefilters, shall not exceed 0.95" wg. Provide 2" thick pleated prefilters with a minimum MERV rating of 6.
2. Enclosing frame shall be galvanized steel assembled in a rigid manner. Overall frame dimensions shall be correct to 0.063", and squareness shall be maintained to within 0.125".
3. Housings: factory-fabricated of galvanized steel, double-wall insulated type, with tracks for filters and prefilters, complete with seals and high pressure double-wall access doors, designed and leak tested by the manufacturer to operate at 5" wg positive internal pressure. Access door or panels shall be provided for both sides of filter housings for side removal and access.
4. For filters installed on the discharge of air handling units, provide a diffuser section to equalize filter face velocity. Maximum static pressure drop of diffuser section shall not exceed 0.2" wg.
5. Filter and housing assemblies shall be guaranteed by the manufacturer to be 90% efficient.
6. Manufacturer: Airguard Variflow, American Air Filter Varicel, or Farr Riga-Flo.

2.26 FILTER PRESSURE GAUGES

A. Differential pressure gauges shall have a range 0" wg to 1" wg. Gauges shall have 4" dial face, pointer zero adjustment, transmitter with two wire 4-20 mA output and zero and span adjustments for remote monitoring, 1/8 female NPT connections, and mounting accessories.

1. Manufacturer: Dwyer Magnehelic 605.

2.27 ROOF CURBS AND EQUIPMENT SUPPORT RAILS

A. Prefabricated type, 18 gauge galvanized steel with welded joints, raised cant to match roof deck insulation, and 1.5", 3 pcf fiberglass insulation. Top surfaces shall be level, with construction to fit roof pitch. Minimum height, at the lowest point, shall be 8".

B. Manufacturer: AES Industries, Pate, Penn, Roof Curb Products, Roof Products & Systems, or Thy Curb.

2.28 SIDE TAKEOFF FITTINGS

A. Minimum 26 gauge galvanized steel, designed for minimum pressure drop by an expansion from a rectangular connection to a round duct. The fitting shall include a 1" wide mounting flange with die formed corner clips, prepunched mounting holes, and an adhesive-coated flange gasket. The outlet collar shall be crimped and incorporate a bead.

B. Manufacturer: Crown, or Flexmaster.

2.29 SMOKE DETECTORS

A. As specified in Section 238000, Automatic Temperature Controls.

PART 3 - EXECUTION

3.1 SHEET METAL WORK - GENERAL

A. Unless otherwise specified herein or indicated on the Drawings, construct and install sheet metal work in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, 2005.

B. Workmanship, methods of assembly, joint and seam construction, and sealants for sheet metal work shall be designed for the duct leakage classifications specified in Section 230095, Testing, Adjusting and Balancing.

C. Changes in shape, dimension, or direction shall be made with a maximum transition, offset, or combination thereof of 1 to 5.

D. Openings in plenum casings for access doors shall be 9" above the floor. Hinge doors to close with plenum pressure.

E. Separate galvanized sheet metal from aluminum or copper with lead or felt gaskets.

F. Provide supplemental stiffening and supports to ducts and apparatus casings to prevent drumming, sagging and to provide a structurally sound assembly.

G. Ductwork and sheet metal seams, joints, penetrations, connections and attachments shall be sealed.

1. Sealants shall be applied in accordance with the manufacturer's recommendations for each specific application.
2. Ductwork failing the leakage tests specified in Section 230095, Testing, Adjusting and Balancing shall be repaired, reworked or rebuilt until satisfactory, before additional ductwork is installed and before ductwork is concealed.

H. Entire air system installation shall be rigid, and free from rattles and air noises. Interior of ducts shall be smooth.

I. On multizone air handling units, match size and arrangement of zone ducts to zone damper sections to achieve uniform outlet velocity for each zone.

J. Provide transitions between different size sections of air handling units.

K. Install uninsulated ductwork exposed in finished areas against the ceiling.

L. Provide offsets, elbows, and transitions to coordinate with other work.

M. Provide transitions to connect ductwork to equipment and coils.

N. Elbows:

1. Elbows in round and flat oval ductwork are specified hereinbefore.
2. Radius elbows in rectangular and square ductwork shall have an inside radius equal to the width of the duct, except where space conditions prohibit, in which case a reduced inside radius with full heel radius is permitted. Where the space conditions require the inside

radius to be less than 75% of the duct width, provide multiple splitter vanes inside the elbow.

3. Square (mitered) elbows in rectangular and square ductwork shall contain single-thickness turning vanes and shall be limited to 90° turn applications.

    a. Vanes shall be parallel to airflow.
    b. Vanes exceeding the maximum unsupported length defined by SMACNA shall be divided into multiple sections with intermediate vane rails or shall be braced with tie rods spanning perpendicularly across the leading edges of the vanes. The tie rods shall be welded to the leading edge of each vane.

4. Turns less than 90° in rectangular and square ductwork shall be made with radius type elbows. Mitered elbows are not permitted.

O. Seal wall and floor penetrations as specified in Section 23 00 10, HVAC General.

P. Instrument test ports: provide where required for measurements.

3.2 ROUND DUCTWORK

A. Exposed ductwork shall be parallel to building surfaces and structural members, and shall have seams aligned at joints.

B. Construct a mock-up of exposed ductwork showing typical joints, methods of support, linear diffusers, and fittings for approval by the Architect before fabrication of exposed ductwork.

C. Joints shall be sealed with duct sealer. Duct sealer shall not be visible on the exterior of the ductwork.

3.3 FLEXIBLE CONNECTIONS

A. Joints and seams shall be sealed airtight.

B. Provide at:

1. Inlet and outlet of fans.
2. Duct connections to air handling units, or on inlet and outlet of fan section only if fan section is separate.

C. Not required at:
1. Air handling units with internally isolated fan, motor and drive.

3.4 ACCESS PANELS AND ACCESS DOORS

A. Provide access panels of sufficient size and quantity for access to fire dampers, smoke dampers, controls, coils, duct smoke detectors, and where ductwork covers electrical boxes. Install in appropriate locations to allow cleaning, oiling, inspection, repair and maintenance.

B. Open each to verify that swing space is clear and access into duct or plenum is unobstructed.

3.5 PRESSURE RELIEF DOORS

A. Install vertically with the latch mechanism at the top.

3.6 FLEXIBLE DUCTWORK

A. Install flexible ductwork in a fully extended condition, free of sags and kinks, using the minimum length to make connection. Seal joints as recommended by manufacturer. Maximum length of flexible ducts to diffusers shall be 7'. Maximum length of flexible ducts to terminal units shall be 3'. Use round galvanized duct, same size as flexible duct, for longer runouts.

B. Flexible ductwork shall be fastened to spin-in fittings, collars and transitions by draw bands and duct tape.

C. For diffusers, size same diameter as diffuser neck to which it connects.

D. For terminal units, size as indicated on the terminal unit detail.

E. Where size of flexible duct is different than size of collar, make connection with a sheet metal transition.

3.7 PRESS-ON COLLAR FITTINGS

A. Provide for each flexible duct takeoff and for each round sheet metal duct runout to flexible ducts serving diffusers.

B. Fasten with sheet metal screws at pre-punched mounting holes.

3.8 GAS VENTS

A. Install in accordance with the listing requirements and the manufacturer's instructions.

3.9 HANGERS AND SUPPORTS

A. Adjust hangers and supports so that loading is uniform.

B. Unless otherwise specified herein or indicated on the Drawings, duct hangers and supports shall be in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, 2005.

C. Support horizontal ductwork not more than 8' on center. Ductwork shall be directly suspended from or supported by the building structure.

D. Support round ductwork with straps and hangers as recommended by the manufacturer and SMACNA.

E. Where ducts are suspended below ceilings, extend hangers through the ceiling and secure to the structure as specified herein.

F. Support vertical ducts at each floor with a minimum of 2 supports attached to the duct and fastened to the floor or structure.

3.10 FIRE DAMPERS

A. Install within the thickness of the rated construction.

B. Verify accessibility of each fire damper through duct and building access panels, and operation of each fire damper by removing link and operating damper.

3.11 SMOKE DAMPERS

A. Install in accordance with conditions of UL listing.

B. Locate within 24" of the smoke barrier.

C. Install so that blades, when open, are no more than 5° off-axis with airflow.

D. Verify accessibility of each smoke damper through duct and building access panels, and operation of each smoke damper by removing operator and operating damper.

3.12 COMBINATION FIRE/SMOKE DAMPERS

A. Install within the thickness of the rated construction.

B. Install so that blades, when open, are no more than 5° off-axis with airflow.

C. Verify accessibility of each combination fire/smoke damper through duct and building access panels, and operation of each combination fire/smoke damper by removing link and operator and operating damper.

3.13 MANUAL DAMPERS

A. Install dampers in accordance with manufacturer's instructions to operate freely.

B. Provide standoff brackets, sized to clear the insulation thickness, for quadrants installed on insulated ductwork.

3.14 CONTROL DAMPERS

A. Install dampers in accordance with manufacturer's instructions to operate and to obtain leakage rates specified herein. Adjust the damper linkage such that the damper closes before the actuator is fully closed to assure tight closure of the damper.

B. Blank-off and seal around dampers and between dampers and sleeves or frames to eliminate air bypass.

3.15 GRILLES, REGISTERS AND DIFFUSERS

A. Wall return and relief grilles installed above eye level shall be installed with blades angled so the inside of the duct or the adjacent space will not be visible through the grilles.

B. Lengths of linear diffusers indicated on the Drawings are nominal. Coordinate actual lengths required with field conditions and/or the Architectural Drawings.

3.16 FANS - GENERAL

A. Install centrifugal fans with a minimum of 2.5 duct diameters of straight duct at the inlet.

3.17 FILTERS

A. Install filters to be used while the building is under construction. Replace during construction as filters become loaded. Prior to final inspection, remove these filters and replace with new filters.

B. Install temporary filter media to protect return air grilles, registers and openings of permanent air handling systems operated while the building is under construction. Media shall be installed to prevent leakage around and bypass of filters.

C. Do not install cartridge filters until the building is substantially complete and free of construction debris, and associated duct systems have been cleaned.

3.18 FILTER PRESSURE GAUGES

A. Provide a differential pressure gauge, unless otherwise specified herein, across each bank of filters and/or filter housing.

B. Gauges shall be located so as to be visible.

3.19 SIDE TAKEOFF FITTINGS

A. Provide for takeoffs from rectangular ductwork to terminal units.

B. Install 45° takeoff fittings to correspond with direction of airflow.

C. Install concentric takeoff fittings where terminal units are connected to the supply duct loop.

3.20 SMOKE DETECTORS

A. Duct-mounted smoke detectors shall be located as follows:

1. Within 60" of its respective smoke damper with no outlets or inlets between the detectors and damper.
2. Between the smoke damper and any duct opening or connection.
3. In a straight section of duct.
4. To be accessible.

END OF SECTION 237000

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SECTION 238000 - AUTOMATIC TEMPERATURE CONTROLS

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and HVAC systems are specified in other Sections of Division 23.

B. This Section covers automatic temperature control systems and equipment. Automatic temperature control systems include the building control system (BCS), facility management control system (FMCS) and other ancillary systems specified herein.

C. This Section includes responsibilities and obligations in support of the performance verification specified in Section 230090, HVAC Performance Verification.

D. The BCS includes the network of interoperable, stand-alone digital controllers communicating via network devices. The FMCS includes the network of BCSs, a central server, graphical user interface software, printers, and network devices.

1.2 RELATED WORK

A. The installation of motor starters that are not factory-installed, thermal overload switches, and power wiring to motors, starters, thermal overload switches, electric heating coils, and contactors, is specified in another Division. This Section includes the furnishing and installation of controls and wiring for automatic controls, electric damper and valve actuators and motors, terminal unit controllers, interlocks, starting circuits, and 120 V and low voltage power wiring to power consuming control devices.

B. Area smoke detectors are provided, installed and wired under Division 28. Duct smoke detectors shall be installed under Division 23, but furnished and wired into the fire alarm system under Division 28. This Section includes wiring fire alarm signal relays, provided and installed under another Division, to the automatic temperature control systems.

C. Flow measuring systems, except flow meters for system control, are specified in Section 231000, Piping, Valves and Accessories.

D. The monitoring and data logging capabilities of the BCS shall be available for use in the commissioning process.

1.3 QUALITY ASSURANCE

A. Within 30 days after notice to proceed, submit resumes for the project manager, application engineer and field supervisor assigned to the Project. The Owner and Engineer reserve the right to exclude proposed staff not having the experience deemed sufficient for the Project. The proposed staff shall have the following minimum experience levels:

1. Project manager: 5 years experience, and two projects of similar size and type.
2. Application engineer: 7 years experience, and be manufacturer-certified for the system being provided.

3. Field supervisor: 5 years experience, and be manufacturer-certified for the system being provided.

B. Conform to the following:

1. NFPA 70-2017.
2. National Electrical Code-2014 with South Carolina Modifications-2016.

C. Installation shall be by technicians trained by the control manufacturer.

D. Controllers and software shall have a current BTL listing.

1.4 SUBMITTALS

A. Submit a single comprehensive submittal package including the following items. At the Contractor's option, control valves and control dampers may be submitted in a separate submittal in advance of the other items to maintain project schedule.

1. Control valve data: including manufacturer's product data and schedule indicating body type, size, flow rate, pressure drop, actuators and motors, end switches, normal (failure) position, and maximum differential pressure at which valve is capable of full closure for each valve.
2. Control damper data: including manufacturer's product data and schedule indicating damper type, size, flow rate, pressure drop, leakage rate, actuators and motors, actuator torque, end switches and normal (failure) position for each damper.
3. Pressure sensor data: including manufacturer's product data and schedule indicating the sensor type, range, and accuracy, and denoted with a discrete tag for each sensor and a description of the associated system and mounting location.
4. BCS and FMCS data: including control manufacturer's data sheets on BCS controllers, NACs, workstations, sensors, meters, relays, actuators, motors, terminal unit controllers, protection devices, and other devices specified herein. Include data on software.
5. Network data: including switches, converters, routers, broadcast management devices and cabling, as necessary.
6. Graphics: include illustrations of proposed graphics displays, including a flowchart or site map indicating system navigation links.
7. Diagrams: separate field wiring diagrams for each system, including motor starting and interlock wiring, ladder diagrams, control wiring, interior electrical circuits of control instruments with terminal and control device designations, actuators and motors, colors of wires, locations of instruments and remote elements, interfaces with communications equipment provided with equipment specified in other Sections, and normal position of relays. Each diagram shall have terminals labeled as they will be marked on the installed equipment.
8. System architecture: provide a drawing of the proposed system architecture showing configuration and locations for BCS controllers, terminal unit controllers, system servers, control wiring for each device, and hardware and wiring for connections. Indicate the spare capacity and BACnet instance number or network address for each device. Include networking hardware such as switches, converters, routers, and broadcast management devices, and indicate IP addresses. Provide diagrams of the proposed control power infrastructure, including the designation of the electrical panelboards that will be utilized to provide control power, the quantity, configuration, size, and location of controls system

transformers, and the distribution wiring to power consuming control devices. Provide floor plans locating equipment coordinated with the work of other trades.

9. Uninterruptible power supplies: provide wiring diagrams and sizing calculations for uninterruptible power supplies.
10. Sequences of operation: complete detailed sequences of operation, including a narrative of the system operation and interactions and interlocks with other systems, notations indicating whether interlock or interaction is accomplished through software or hard wired connections, detailed delineation of control between packaged controls and the BCS, and sequences of operation for packaged controlled equipment that interfaces with the BCS.
11. System implementation requirements: network, workstation, and Web browser requirements for BCS functionality on the Owner's systems. Indicate operating system and java requirements for compatibility.
12. Existing FMCS system expansion data: proposed system modifications if any are required to support this addition; complete field wiring diagrams showing interconnection with existing controllers, devices, and server equipment; illustrations of proposed graphics displays if specified herein; and proposed database and software additions or modifications, if required.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Automated Logic installed by Harris Controls.

B. The manufacturers' product lines specified above shall be a complete system of NACs, BCS controllers, and terminal unit controllers used consistently throughout the Project. BCS and terminal unit controllers shall be programmable from the NACs.

2.2 SYSTEM ARCHITECTURE

A. Provide a complete peer-to-peer networked, stand-alone, distributed BCS and FMCS to perform the controls functions and monitor the points specified herein and on the Drawings. The BCS and FMCS shall be engineered and equipment selected by the manufacturer as required to meet the performance specified herein. The BCS shall be comprised of a network of interoperable, stand-alone digital controllers communicating via the BACnet communication protocols with one or multiple NACs. Lower level networks utilizing BACnet over MS/TP shall only serve terminal units. The FMCS shall interface with the electric and electronic systems to provide control outputs and monitoring inputs to the FMCS as specified herein and as indicated on the Drawings. Complete electric control systems shall be provided to perform sequences not indicated to be performed by the FMCS. The BCSs shall interface with the electric, and electronic systems to provide control outputs and monitoring inputs to the BCSs as specified herein and as indicated on the Drawings. Provide communications media, connectors, repeaters, bridges, switches, and routers necessary to provide a fully functional BCS network. Complete electric control systems shall be provided to perform sequences not indicated to be performed by the BCSs. The location and quantity of BCS controllers shall be as determined by the BCS manufacturer except that, as a minimum, a separate stand-alone controller shall be provided for each refrigeration plant, heating plant, air handling unit over 3 hp, and as indicated on the Drawings. Sensors and control points for each system shall be connected to its associated stand-alone controller. Each BCS controller shall be designed to allow for the future addition of at least 20% of the number of connected input/output points; it is acceptable to achieve the 20% spare capacity with 10% spare

on the BCS controller with capability of adding input/output expansion modules with an additional 10%. BCS controller spare capacity shall apply to both analog and digital control points. The BCS and FMCS, including the system servers, the network components, and network area controllers (NACs), shall be designed to allow for the future addition of at least 100% of the number of control objects connected to the components or systems. An alarm condition shall be reported to the appropriate operator device no more than 10 seconds following the occurrence of that condition. Sensor and control values displayed to the operator in graphics displays shall be dynamically updated within 10 seconds of significant change of value, with a typical response time of 1 second or less.

B. This Project involves expansion of an existing FMCS including new BCS equipment, software, programming and controls. The new BCS controllers shall be connected to the existing FMCS. Updates to the existing FMCS, including programming and graphics, as required to perform the work specified herein shall be included. This work shall include updates to campus mapsand associated links, lists or associated data trees. New system components shall be 100% hardware and software compatible with the existing system and shall be by an approved manufacturer. Programming logic, database definition, and point identifiers shall conform to, and be a logical extension of, the existing systems.

C. Lower level networks serving terminal units, such as BACnet over MS/TP, shall be connected to the associated air handling unit controller. When multiple lower level networks are required for a single air handling unit, those networks shall be divided in an orderly method, such as by floor or wing. Remote sensors shall be wired to the controller associated with that sensor, unless specified otherwise.

D. The following functions shall be performed at the server or NAC:

1. Calendar functions.
2. Scheduling.
3. Trending.
4. Alarm monitoring and routing.

    a. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including, but not limited to:

        1) In alarm.
        2) Return to normal.
        3) Fault condition.

    b. Provide for the creation of a minimum of 8 alarm classes.
    c. Provide time scheduled routing of alarms by class, object, group, or node.
    d. Provide alarm generation for equipment runtimes and other event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.
    e. Controller and network failures shall be treated as alarms and annunciated.
    f. Alarms shall be annunciated in any of the following manners as defined by the user:

        1) Screen message text.
        2) E-mail of the complete alarm message to multiple recipients via the Owner's e-mail service. Provide the ability to route and e-mail alarms based on:

            a) Day of week.

b) Time of day.
c) Recipient.
d) Pagers.
e) Graphics showing flashing items in alarm.
f) Printed message routed directly to a dedicated alarm printer.

g. The following, at a minimum, shall be recorded:

1) Time and date.
2) Location (building, floor, zone, office number, etc.).
3) Equipment (air handling unit number, access way, etc.).
4) Acknowledge time, date, and user who issued acknowledgement.
5) Number of occurrences since last acknowledgement.

h. Alarm actions may be initiated by user-defined programmable objects created for that purpose.
i. Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms.
j. A log of all alarms shall be maintained by the NAC and/or a server (if configured in the system) and shall be available for review by the user.
k. Provide a "query" feature to allow review of specific alarms by user defined parameters.

5. Time synchronization.
6. Web browser access via an intranet and the internet, supporting a minimum of 32 simultaneous users.
7. The following additional logs shall be included and made available to the user:

a. System alerts, such as controller and network failures.
b. Errors, such as invalid property changes or commands.

2.3 CONTROLLERS

A. Network Area Controllers (NACs):

1. The Contractor shall supply one or more NACs. The quantity and location of NACs is dependent on the type and quantity of control points and devices, and the functionality specified herein, and shall be determined by the Contractor.
2. NACs shall provide the interface between the building's communications system and the BCS control devices, and provide global supervisory control functions over the control devices connected to each NAC. It shall be capable of executing application control programs. It shall perform the following functions:

a. Integration of BACnet controller data.
b. Network management functions for control devices.

3. NACs shall have the following hardware features as a minimum:

a. One ethernet port – 10/100 Mbps.
b. One RS-485 port.

c. Battery back-up and flash memory for long term data backup, with minimum 1 gigabyte storage capacity.

4. NACs shall be capable of operating under a temperature range between 32°F to 122°F and a humidity range between 5% to 95% RH, non-condensing, and of being stored under a temperature range between 0°F and 158°F.
5. NACs shall provide multiple user access to the system and support for ODBC or SQL. A database resident on the NACs shall be an ODBC-compliant database or shall provide an ODBC data access mechanism to read and write data stored within it.
6. Alarm Notifications and Actions:

   a. NACs shall provide alarm recognition, storage, routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.
   b. NACs shall be able to route any alarm condition to any defined user location whether connected to a local network, or remote via dial-up telephone connection or wide-area network.

B. BCS controllers: field programmable, microprocessor-based type incorporating direct digital control and energy management functions. Each BCS controller shall perform its assigned control and energy management functions as a stand-alone unit and shall comply with FCC Part 15, Subpart B 2013. Provide a communication interface for communication with the BCS. Controls shall be performed in a digital manner using the digital signal from the microprocessor based controller, converted through electronic circuitry for modulation of actuators. Each BCS controller shall be expandable by adding additional input/output modules that operate through the processor of the BCS controller. The master processor in the BCS controller shall be able to manage remote field interface units thereby expanding its control loop and energy management point capacity. Each BCS controller including associated input/output modules shall have a minimum of 10% spare input and output points of each type installed. The BCS controller shall be supplied with a minimum of 8 hours of battery back-up for the clock operation and memory retention with an automatic battery charger. Provide interface for valve and damper actuators. BCS controller hardware shall provide relay or solid state isolation on each contact input circuit and each output circuit to prevent high voltage surges from entering the logic circuits.

1. Provide a digital display unit, programmed to display analog variables, binary conditions, off-normal conditions and other analog or binary information for analysis and adjustment of the system being controlled. The display unit shall provide visible indication of automatic operation, manual or override operation, a test and associated trouble indication, and alarm indication. The display unit shall include a keyboard containing keys to call-up the described point and type of value to be displayed and several special dedicated keys for such functions as manual-automatic, test and function and value enter, as an aid to the operator. This display unit may be furnished either as an integral component of the BCS controller or as a separate portable unit providing equivalent functions.
2. BCS controllers shall be arranged and installed to allow controllers to share global data. This global data shall include, but not be limited to: time-of-day, outside air temperature and humidity, and electrical meter and demand information. If BCS controllers are not configured in a communication network to share this data, then each BCS controller shall be provided with sensor inputs to implement sequences indicated on the Drawings when operating in a stand-alone mode.

C. Terminal Unit Controllers:

1. Control of terminal units shall be accomplished by microprocessor-based stand-alone terminal unit controllers utilizing direct digital control. An individual terminal unit controller shall be provided for each terminal unit and shall interface to the BCS. Terminal unit controllers shall not be the wireless communications type utilizing ZigBee technology. Terminal unit controller components shall be furnished to the terminal unit manufacturer for factory mounting and calibration. Terminal unit controller power shall be 24 V AC. Each terminal unit controller shall contain resident programs which are field-selectable for a specific application. Resident programs shall be contained in nonvolatile memory using EEPROM, EPROM, or RAM. Systems that employ volatile (RAM) memory shall provide 72 hour battery back-up for each terminal unit controller. Temperature setpoints for heating and cooling and night setback shall be independent of each other and shall provide a zero energy band between heating and cooling modes.
2. Each terminal unit controller shall be accessible for purposes of control parameter and setpoint adjustment and monitoring from the BCS. An operator's terminal connected to any BCS controller on the network shall have access to all terminal unit controllers.

2.4 COMMUNICATIONS

A. The BCS communications shall comprise control products, communication media, connectors, repeaters, hubs, and routers. Controller and operator interface communication shall conform to ASHRAE 135-2016. Install new wiring and network devices as required to provide a complete and workable control network. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring.

B. Each NAC and BCS controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.

C. System shall support Web services data exchange with any other system that complies with XML (extensible markup language) and SOAP (simple object access protocol) standards specified by the Web Services Interoperability Organization (WS-I) Basic Profile 1.0 or higher. Web services support shall as a minimum be provided at the workstation or web server level and shall enable data to be read from or written to the system.

1. System shall support Web services read data requests by retrieving requested trend data or point values (I/O hardware points, analog value software points, or binary value software points) from any system controller or from the trend history database.
2. System shall support Web services write data request to each analog and binary object that can be edited through the system operator interface by downloading a numeric value to the specified object.
3. For read or write requests, the system shall require username and password authentication and shall support SSL (Secure Socket Layer) or equivalent data encryption.
4. System shall support discovery through a Web services connection or shall provide a tool available through the operator interface that will reveal the path/identifier needed to allow a third party Web services device to read data from or write data to any object in the system which supports this service.

2.5 SOFTWARE

A. Web-Based Graphical User Interface (GUI):

1. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer, Google Chrome, Mozilla Firefox, or Safari. Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacture-specific browsers are not acceptable.
2. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the FMCS, are not acceptable.
3. The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the GUI (if used). Systems that require different graphic views, different means of graphic generation, or that require different means of interacting with objects such as schedules, or logs, are not permitted.
4. Real-time displays: GUIs shall, at a minimum, support the following graphical features and functions:

    a. Graphic screens shall be capable of being developed using any drawing package capable of generating a GIF, BMP, or JPG file format. Use of proprietary graphic file formats shall not be required. In addition to, or in lieu of, a graphic background the GUI shall support the use of scanned pictures.
    b. Graphic screens shall have the capability to contain objects for text, real-time values, animation, color spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URLs, and links to other graphic screens.
    c. Graphics shall support layering and each graphic object shall be configurable for assignment to a layer. A minimum of 6 layers shall be supported.
    d. Modifying common application objects, such as schedules, calendars, and setpoints shall be accomplished in a graphical manner.

        1) Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
        2) Holidays shall be set by using a graphical calendar without requiring any keyboard entry from the operator.

    e. Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No text entry shall be required.
    f. Adjustments to analog objects, such as setpoints, shall be done by right-clicking the selected object and using a graphical slider to adjust the value. No text entry shall be required.

5. System configuration: at a minimum, the GUI shall permit the operator to perform the following tasks, with proper password access:

    a. Create, delete, or modify control strategies.
    b. Add or delete objects to the system.
    c. Tune control loops through the adjustment of control loop parameters.
    d. Enable or disable control strategies.

e. Generate hard copy records or control strategies on a printer.
f. Select points to be alarmable and define the alarm state.
g. Select points to be trended over a period of time and initiate the recording of values automatically.

6. On-line help: provide a context sensitive on-line help system to assist the operator in operation and editing of the system. On-line help shall be available for all applications and shall provide the relevant data for the currently displayed screen. Additional help information shall be available through the use of hypertext. System documentation and help files shall be in HTML format.
7. Security: each operator shall be required to log on to the system with a username and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system administrator shall have the ability to set passwords and security levels for other operators. Each operator password shall be able to restrict the operators' access for viewing and/or changing each system application, full screen editor, and object. Each operator shall automatically be logged off the system if no keyboard or mouse activity is detected for a specified time. This auto log-off time shall be set per operator password. System security data shall be stored in an encrypted format.
8. System diagnostics: the system shall automatically monitor the operation of workstations, printers, modems, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.
9. Alarm Console:

    a. The system shall be provided with a dedicated alarm window or console. This window shall notify the operator of an alarm condition and allow the operator to view details of the alarm and acknowledge the alarm. The use of the alarm console may be enabled or disabled by the system administrator.
    b. When the alarm console is enabled, a separate alarm notification window will supersede other windows on the desktop and shall not be capable of being minimized or closed by the operator. This window will notify the operator of new alarms and unacknowledged alarms. Alarm notification windows or banners that can be minimized or closed by the operator are not acceptable.

10. The system shall provide the capability to specify a user's (as determined by the log-on user identification) home page. Provide the ability to set a specific home page for each user. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.
11. Graphic screens on the Web browser client shall support hypertext links to other locations on the internet or on intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.
12. Graphics: the monitor display format shall be organized to permit the output of displays, and/or summaries specified herein, while concurrently displaying the most recent change-of-state occurrence.

    a. The format shall also include in a dedicated and protected area of the viewing screen, the current user of the monitor, date, time, and program day. The monitor shall output advisories in a dedicated and protected area of the viewing screen and an appropriate display in the event of control system hardware malfunction or restoration.
    b. Graphic displays for systems and system components shall be provided as indicated in the I/O summaries.

1) The operator shall be capable, upon command entry, of calling for graphic displays of systems or zones.
2) Displays shall contain flow schematics, and schematics of mechanical duct and piping systems, electrical switchgear, electrical distribution systems, pumps, fans, valves, dampers, chiller, coils, pull stations, smoke detectors, heat detectors, circuit breakers, and engine-generator sets, for systems indicated in the I/O summaries to have graphic display.
3) Displays shall include scaled building floor plans with air handling unit and terminal unit temperature control zones identified and space sensors indicated.
4) Displays shall indicate values or status of I/O points associated with that system and those shall be dynamically updated at least once every 10 seconds. Software shall be provided to allow operator modification of graphic displays provided with the system and to allow operator creation and storage of new graphic displays.
5) For each air handling unit provide a tabular graphic summary of that unit and its associated air distribution system. Graphics shall contain, at a minimum, the following information:

    a) Supply fan's current operating speed and setpoint.
    b) Manual adjustment of supply fan speed.
    c) Supply air static pressure and temperature.
    d) For each associated terminal unit, as appropriate:

        (1) Minimum, maximum, and current airflow.
        (2) Current damper position or command.
        (3) Current associated space temperature.
        (4) Current reheat command.

    e) A commandable override point to place associated terminal units at maximum airflow.
    f) A commandable override point to place associated terminal units at minimum airflow.

6) For each hydronic system, provide a tabular graphic summary of the primary equipment for that system and its associated air distribution system. Graphics shall contain, at a minimum, the following information, as required by the system's I/O summary.

    a) Supply and return water temperatures and flows.
    b) Distribution pump's current operating speed and setpoint.
    c) Distribution system controlling differential pressure.
    d) Manual adjustment of distribution pump's speed.
    e) For each associated air handling unit or consuming equipment, as appropriate:

        (1) Current valve position or command.
        (2) Current associated discharge air temperature.
        (3) A commandable override point to place associated terminal units at maximum reheat flow.

f) A commandable override point to place associated consuming equipment at full flow.
g) A commandable override point to place associated consuming equipment at no flow.

B. BCS and FMCS Software:

1. General: provide global synchronization of BCS controller clocks and global coordination of BCS controller activity. Standard utility software packages shall be contained in memory including self-test diagnostics and on-line memory diagnostics. System displays (hard and soft copy) shall be in plain English. Field selected control and monitoring points shall be capable of being described using operator selected menu penetration techniques. Values shall be described in appropriate units. The system shall have at least 3 user access levels. Menus and screens shall be organized to present orderly information. The system shall perform the following functions:

a. Operator communication with any BCS and terminal unit controller including programming and data acquisition.
b. Full English operator display, including appropriate engineering units for variable data.
c. Power Failure and Automatic Restart:

1) Power failure recovery: when recovering from a failure of the normal power supply, the system shall automatically:

a) Initialize the time of day within the real-time operating system.
b) Adjust time dependent parameters within the monitoring and control software.
c) Automatically restart and output a message indicating that a power failure occurred with the time and date of occurrence. A system restart shall initialize processors and communications, update time programs, and reset equipment to the appropriate operating status for the correct time.

d. System displays shall be capable of being randomly configured with any point assigned to any system for display/logging, independent of its hardware location.
e. Remote status to allow the operator to display on the monitor any point noting point description and engineering value.
f. System function to allow operator to update time and date.
g. Upload/download to transfer database to/from disk or diskette storage to/from BCS or terminal unit controller.
h. Edit/create database to configure, edit, create or delete database information in whole or in part.
i. Database error checking to provide a method of detecting and annunciating discrepancies that would prevent the system from full normal operation.
j. Whenever a field point status exceeds preset limits, or there are other indications of system exceptions, alarms, error or failures, there shall be at least the following indications:

1) Audible tone: the system shall have an integral audible tone. The audio tone shall be capable of being enabled or disabled on operator command.

2) Display: the alarm point identification shall appear on the monitor and print out along with individual point alarm messages. Upon operator command, alarms resident in the CCU shall be hard copy printed along with individual point alarm messages.
3) Automatic dial out: the system shall automatically initiate calls to up to 4 telephone numbers on a rotating basis. Only those alarms selected by the Owner during BCS training shall initiate automatic dial out features.

2. System programming: controller software and custom programming shall be provided to implement control sequences as indicated on the Drawings. Each BCS controller shall contain mathematic, logic, utility functions and standard energy calculations and control functions in ROM to be available in any combination for field programming the unit. These routines shall include but not be limited to:

a. Math Routines:

1) Basic arithmetic.
2) Binary logic.
3) Relational logic.

b. Utility Routines:

1) Process entry and exit.
2) Variable adjustments and output.
3) Alarm indication.
4) Restart.

c. Control Routines:

1) Signal compensation.
2) Loop control.
3) Energy conservation.
4) Timed programming.

d. Energy Management Routines:

1) Scheduled start-stop and holiday programming.
2) Optimal start-stop.
3) Duty cycling.
4) Day-night setback.

e. Terminal Unit Control:

1) Volume control in response to temperature.
2) Occupied and unoccupied operation with associated temperature.
3) Occupant temperature adjustment.
4) Temperature setpoint override.
5) Occupant override.
6) Global reset of temperature and volume limits.

f. Project tailored programs: the library of routines available in firmware shall be capable of generating additional programs for specific Project requirements. These should include but not be limited to:

1) Chiller efficiency.
2) Supply air temperature control.
3) Variable volume supply fan control.
4) Space temperature control.
5) Fire alarm activated sequences.
6) Totalizing.
7) Event initiated sequences.

3. Each BCS controller shall perform its full control and energy management functions, regardless of the condition of the communications link with other system components. These stand-alone capabilities shall be implemented and shall include, but not be limited to, closed loop control functions (P, PI, PID, incremental, floating) and energy management functions. BCS controllers and terminal unit controllers shall be totally stand-alone and independent of other components of the BCS for control applications specified herein. Failure of other components of the BCS shall in no way inhibit the operation or program execution of BCS controllers and terminal unit controllers.
4. BCS controller control algorithms shall be available and resident in the BCS controller to permit proportional, integral and derivative control modes in any combination to meet the needs of the application. Other control modes, incremental, floating or 2-position, shall be available to adapt to the needs of the Project. Adjustment of control variables shall be available at the BCS controller through the display unit. These adjustments shall include, but not be limited to, proportional gain, integral rate, the velocity and acceleration constants associated with incremental control, and on/off values of 2-position control. Each control loop setpoint and control logic threshold shall be programmed as a variable expressed in the appropriate engineering units and shall be displayable and adjustable through the display unit. Modification of BCS software shall not be required to alter those variables.
5. Software, local variables, and data resident in the BCS controllers shall be resident in nonvolatile memory or shall be down-loadable from the BCS.

C. Energy Management Software:

1. Scheduled start-stop and holiday programs: provide software to start and stop equipment based on the time-of-day for each day-of-week, including holidays. To eliminate power surges and to ensure stable system operation, an operator adjustable time delay shall be provided between consecutive start commands and between consecutive stop commands for electrical loads. Software shall provide for multiple start/stop events scheduled for each output for each day, including holidays.
2. Optimum start-stop program: provide software to start and stop equipment on a sliding schedule based on indoor and outdoor air conditions. The program shall take into account the thermal characteristics of the structure, indoor and outside conditions using prediction software to determine the minimum time of system operation needed to satisfy space environmental requirements at the start of the occupied cycle, and determine the earliest time for stopping equipment at the day's end. The program shall automatically modify the calculation constants based on its past performance.
3. Demand limiting program: provide software to shed electrical loads to prevent exceeding an electrical demand peak value (target). The program shall continuously monitor power demand, and with prediction software, calculate a predicted power demand. When the

predicted power demand exceeds a preset desired target, the program shall turn off or adjust operation of electrical loads on a prescheduled priority basis to reduce the connected load before the actual peak exceeds the target. The demand limiting program shall provide several priority levels of loads. Loads in the lowest priority level shall be shed before loads in the next higher priority level. Loads shed within a priority level shall be rotated automatically, subject to equipment constraints to avoid any one load from always being shed first. Loads shed in the highest priority level shall be restored before loads in lower priority levels. The demand program shall be compatible with time-of-day metering. The program shall permit a minimum of 6 individually resettable time-of-day demand periods in 24 hours. The start and stop time of each time-of-day demand program shall allow different daily schedules for 3 types of days (weekday, weekend, holiday). A time-of-day metering calendar shall be established by the program which shall define daily time-of-day metering schedules.

4. Day-night setback program: provide software to limit the rise or drop of space temperature during unoccupied hours. Whenever the space temperature is above (or below for heating) the operator assigned temperature limit, the system shall be enabled until the temperature is within the assigned temperature limit.
5. Power fail-auto restart: on power failure, the BCS controller shall shutdown without damage to the BCS controller or connected systems, and without loss of programmed information. If power is restored within the time specified herein for battery back-up of BCS controller clock operation, the BCS shall automatically restart, adjust operating parameters according to the proper time of day, and resume full normal operation within no longer than 5 minutes following restoration of power. Each controlled item of equipment 5 hp or greater shall be sequentially restarted or returned to proper operation as appropriate for the time-of-day.
6. Event initiated sequences: based on programmable values of either digital or analog inputs or outputs, the BCS controller shall be able to open or close any output contacts or combination of contact outputs, and adjust any analog output over its normal range.
7. Terminal unit controller software: provide software for the management and control of the BCS terminal unit controllers. Software shall allow for operator definition of terminal unit controllers as functional groups; monitoring, alarming and reporting of terminal unit parameters on an individual or group basis; after hours terminal unit operation monitoring and reporting on an individual or group basis; and remote setpoint adjustment of terminal unit parameters on an individual or group basis in response to operator commands or through software interaction.
8. Chiller demand limit program: provide software to limit maximum available chiller electrical demand. Each adjustable chiller demand control step shall be assigned an equipment priority level in the demand limiting program.

D. Trending and reporting: a utility software data file log package shall be provided that analyzes and formats, into English language, a hard copy printout of hardware and software configurations of the system. This package shall be designed to allow the operator to select individual data file logs specified herein. This software package shall be executable via the BCS to allow site hard copy documentation of current data file caused by system modifications and schedule changes.

1. System configuration log: data file logs shall document basic system parameters, individual channel configuration with listing of type of hardware used with its assigned system address, listing of peripheral device (printer and operator terminals) and address with its associated segregation as to function.
2. Individual point parameter log: this software package shall provide a detailed listing of system points with the following information:

a. Digital points: point address, assigned engineering units, type of point, listing of which programs the point is used in the system.
b. Analog points: point address, engineering units, assigned scale factor, offset, decimal position of value, and a listing of which programs the point is used in the system.

3. System program data file log: provide to document details on individual application programs as listed below:

a. Time program log of programs, or selected programs, listing program number and on and off times assigned for each individual day of the week.
b. A listing of points grouped by initiating devices causing a change in condition. For example, a listing of points scheduled on by a fixed time schedule.
c. Printout listing individual calculation address with its assigned operators and parameters. Also, a listing of other calculation points using its results.

4. Alarm summary: an alarm summary shall be provided which contains the point status of points in the alarm condition.
5. Trend log: a program shall be provided which outputs a log on a time interval basis. This program shall provide the operator with the ability to place a minimum of 16 points on trend logs and the ability to assign the trend interval from 1 second to 99 minutes. Adding, changing, or deleting a trend point, assigning the trend log period, or outputting the trend log shall be performed without any loss of change-of-state reporting on the designated hard copy device. Trend log report information shall be listed in vertical columns. A directory of columnar placement shall appear in the heading of the trend log.
6. Historical data file storage: the system shall provide software to allow operator designation of point values or status to be automatically stored in historical files on the hard disk of the BCS central computer. Software shall allow operator designation of which point data is to be stored, at what frequency it is to be stored, when to start and when to stop storing the data, and shall allow a minimum of 50 points to be assigned to the historical data function at one time.
7. Field generated reports: the system shall have the capability, as installed, to develop custom management report logs. The software shall be capable of displaying, organizing, and editing the historical data files of point data.

2.6 SENSORS

A. BCS Sensors:

1. Provide sensors, controls, instruments, and control interfaces to meet the performance specified herein. Sensors shall be high quality precision electronic type, selected to be compatible with the BCS controllers and appropriate for the service specified herein. Accuracy values specified herein include sensor, wiring, signal conditioning and display accuracies for overall end-to-end performance. Sensors shall be selected to place the expected value in the middle third of the device's range.
2. Temperature sensors: 100 or 1000 ohm platinum resistance temperature device (RTD), Deutsche Industrial Norms (DIN) 43760, with an average percent change in resistance per degree (α) of 0.00385 ± 0.00002 ohms/ohm/ºC, selected for normal range of media sensed with accuracy of ±0.5ºF at 70ºF except chilled water sensors used for Btu calculations or control as indicated on the I/O summaries shall have an accuracy of ±0.25ºF at 32ºF. Sensors used for Btu calculations shall be matched pairs at the calibration point.

Temperature sensor stability errors shall not exceed 0.25ºF cumulative over a 5 year period. Provide thermowells and insertion type sensors for water temperature sensing. Air temperature sensing shall be provided by duct insertion type sensors for supply or return duct temperatures and by extended element averaging type for plenum, and coil entering or leaving temperatures. RTD transmitters shall be a 2-wire, loop-powered device, producing a linear 4-20 mA output corresponding to the temperature span of the connected sensor. The output error shall not exceed 0.1% of calibrated span. Transmitters shall include noninteracting offset and span adjustments and RFI shielding and rejection circuitry to prevent disruption from ambient signals. Transmitter drift shall be less than 0.1ºF per year.

3. Space temperature sensors: space temperature type with setpoint adjustment range of 45ºF to 85ºF. Room space temperature sensors associated with terminal units shall not be the wireless type, utilizing ZigBee technology. The setpoint adjustment shall be locked out, overridden, or limited as to time or temperature in software from a central or remote operator's terminal. Precision thermistors may be used in space temperature sensing applications below 200ºF. Sensor accuracy over the application range shall be minimum 0.5ºF between the range of 32ºF to 150ºF including sensor error and A/D conversion resolution error. Sensor manufacturer shall utilize 100% screening to verify accuracy. Thermistors shall be pre-aged and inherently stable. Stability error of the thermistor over 5 years shall not exceed 0.25ºF cumulative. Sensor element and leads shall be encapsulated. Bead thermistors shall not be used. Space temperature sensors shall include a communications port for local connection of a portable test/terminal device for communications/programming access to the associated BCS controller.

    a. Covers:

        1) Unless otherwise specified herein, space temperature sensors shall have blank cover in public spaces, visible temperature indicator integral to the sensor, occupant override push button integral or adjacent to the sensor assembly, and accessible means of setpoint adjustment in staff spaces.

4. Humidity sensors: bulk polymer type, with self-contained 4-20 mA transmitter and replaceable element. Accuracy shall be ±2% RH in the range of 20% to 90%. The transmitter shall include noninteracting zero and span adjustments with an output error not exceeding 0.1% of calibrated span. Saturation shall not alter calibration. Sensors for space humidity shall have same appearance as space temperature sensors.
5. Pressure sensors: 2-wire strain gauge type, designed for media sensed for static pressure or differential pressure. The span shall be continuously adjustable from 0% to 125% of the expected full pressure or full flow differential pressure. The zero shall be continuously adjustable on outputs. Transmitters shall produce a 4-20 mA signal with an accuracy of ±1.0% of the upper range limit for 6 months from calibration. Instruments shall be capable of withstanding an overrange pressure limit of 300% normal. Pressure sensors measuring water differential pressure at chillers shall be furnished with NEMA 4 cover and digital pressure differential readout.
6. Current sensing relays: current sensing relays shall provide an adjustable setpoint normally open contact rated at a minimum of 50 V peak and 0.5 A or 25 VA, noninductive. There shall be a single opening for passage of current carrying conductors. Relays shall be sized for operation at 50% rated current based on the connected load. Voltage isolation shall be a minimum of 600 V.
7. Filter status: filter status shall be sensed by 4-20 mA input from differential pressure gauges across each filter, as specified in Section 23 70 00, Air Distribution.

8. Water flow meters: turbine, insertion type, with isolation valve and packing gland for removal under full line pressure. Wetted parts shall be corrosion resistant. Range shall be from 3 fps to 30 fps with water as the medium. Accuracy shall be ±3% at any operating point. The flow meter signal conditioner shall output a 4-20 mA signal and shall provide zero and span adjustments. The conditioner enclosure shall be NEMA 4.
9. Building electrical meter: kilowatt-hour pulses shall be obtained from the building electrical meter. Provide current transformers, pulse initiators and equipment for interface of signals to the BCS. Components shall provide a minimum of 5 pulses per minute at 75% design load. System shall have separate input point for each kWH meter.
10. CO sensors: electrochemical or solid state sensing elements, adjustable or selectable sensing range of at least 200 ppm. Sensor elements shall have a minimum operating life of 5 years in normal service, a maximum drift of no more than 0.5% per month, and a response time of no more than 30 seconds to a 90% of full scale change. Sensors and transmitters shall provide a 4-20 mA analog output proportional to sensed gas concentration.

    a. Manufacturer: INTEC Controls, or Mine Safety Appliances.

2.7 MATERIALS

A. Actuators:

1. BCS terminal unit actuators: 24 V nonstall type, providing complete modulating control for the full range of damper movement. Actuators shall be de-energized when the damper has reached the operator or system determined position. Actuators shall be supplied to the terminal unit manufacturer for factory mounting and calibration. Actuators shall be removable for servicing without removing the terminal unit. Actuators shall be provided with transformers for proper operation from the terminal unit controller power source.
2. Other actuators: 24 V electric worm-gear type, sized to provide required starting torque and control the driven apparatus smoothly. Higher voltage actuators are acceptable for specific applications where 24 V actuators are not adequate. Provide adjustable end switches for valve and damper open/closed monitoring where required by the control sequences or as specified herein. For control valves 4" and larger, provide actuators with visual position indicator, self-regulating heater for condensation control, motor thermal protection, and hand-wheel for manual override.

    a. Actuators for outside air, exhaust air, and other openings to the outside shall have spring return.

B. Thermostats: line voltage type and shall have adjustable throttling range with an accuracy of ±1.0ºF. Room type shall have cover with thermometer, and accessible means of adjustment. Remote element type shall have accessible adjustment knob. Provide separable wells for elements in liquids and extended necks for wells in insulated pipe.

1. Low limit safeties: elements shall respond to the lowest temperature to which any 12" segment is exposed; minimum length 8'.
2. Averaging type: for use in coil discharge and mixed air locations.

C. Humidistats: same cover as room thermostats, with an accuracy of ±5%.

D. Manual push buttons: flush-mounted, in NEMA 1 enclosure with pilot light.

E. Control valves: brass-trimmed; 2" and smaller, bronze bodies with screwed connections; over 2", cast iron bodies with flanged connections. Steam valves operating at pressure differentials greater than 25 psig and water valves operating at pressure differentials greater than 40 psig shall have stainless steel trim and replaceable seat ring.

1. Valves shall be capable of full closure against 150% of design pump head, or a 50 psig differential pressure, whichever is greater.
2. Valves for water shall have equal percentage flow characteristics. Modulating control valves shall be sized for a pressure drop of 3 psig to 5 psig, unless indicated otherwise on the Drawings. Two-position valves shall be line size.
3. Ball valves used for modulating service shall have a replaceable flow characterizing disk to provide the required flow characteristics.
4. Pressure/temperature rating: as specified in Section 231000, Piping, Valves and Accessories.
5. At the Contractor's option, control valves may be butterfly type for chilled water service in piping 2" and larger. Modulating butterfly valves shall be sized for full flow pressure drop of 2 psig to 4 psig at 60% open and be limited to this opening. Two-position control valves shall be line size. Valves 8" and larger shall be provided with either worm-gear electric actuators or high pressure pneumatic actuators sized for 150% of the torque required to unseat the valve from the closed position. Valves shall be rated for bubbletight closure at a differential pressure equal to the valve body rating.

F. Control dampers: single-blade up to 8" high, multiblade over 8" high; minimum 80% free area based on damper frame outside dimensions.

1. Blades: minimum 16 gauge galvanized steel, or extruded aluminum. Blades shall be airfoil shape.

    a. Pivot rods: steel, minimum 0.5" diameter or hex, with one rod extended 6" to permit operation of damper from outside the duct.
    b. Maximum length 42"; maximum width 8".
    c. At points of contact: interlocking or overlapping edges, and compressible neoprene or extruded vinyl blade seals, and compressible metal side seals designed for temperature of -40ºF to 180ºF at leakage rate specified herein.
    d. Type:

        1) Opposed blade: for balancing and modulating applications.
        2) Parallel blade: for 2-position, and outside and return air mixing applications. For mixing applications, orient dampers to achieve maximum mixing at throttled conditions.

    e. Maximum damper area per motor: 15 ft².

2. Leakage when closed: less than 4 cfm/ft² at 1" wg differential static pressure based on a 48" damper width.
3. Frames: galvanized steel bar minimum 2" wide x 12 gauge for dampers 10" high or less, and 3.5" x 0.875", 16 gauge galvanized roll-formed channel with double-thickness edges or 5" x 1" x 0.125" extruded aluminum channel for 11" high and larger.

    a. Corner bracing.
    b. Full size of duct or opening in which installed.

4. Bearings: synthetic type.

    a. Thrust bearings: vertically mounted.
    b. Maximum spacing: 42".

5. Finish on steel parts: galvanized.
6. Operating linkage: factory-assembled, concealed in frame out of airstream, steel construction.

G. Panels: surface type cabinet with hinged front panel and cylinder lock. Panels shall utilize one master key.

H. Wiring: low voltage control wiring shall be not less than #18 AWG, 600 V plastic covered, color-coded. Line voltage wiring shall be not smaller than #16 AWG, 600 V. Sensor wiring shall be not less than #20 AWG twisted, shielded.

I. Valve tags: as specified in Section 230010, HVAC General.

J. Labels: as specified in Section 230010, HVAC General.

K. Thermometers:

1. Water: as specified in Section 231000, Piping, Valves and Accessories.
2. Air: 5" diameter, bimetal type.

L. Thermowells: monel, brass, or copper for use in water piping and stainless steel for other applications. Thermowells shall have threaded plug and chain, retaining nut, and lagging neck to clear insulation. Inside diameter of insertion neck shall accommodate the element being installed.

M. Time switches: 7 day electronic programmable microprocessor type, with a temporary override feature for over calling the off position and operating the system without resetting the program, and a 48 hour battery powered carryover for loss of power.

N. Weather shield enclosures: NEMA 3R rated with transparent cover, sized for the device enclosed.

O. Airflow measurement systems: provide complete UL listed assemblies to monitor airflow in ductwork at locations indicated on the Drawings. Each system shall be complete with one or more multipoint measuring probes, airflow sensors and a single microprocessor-based transmitter.

1. Probes: aluminum or stainless steel construction with mounting brackets. Probes shall be supported at both ends.
2. Airflow sensors: designed to operate at velocities of 50 fpm to 5000 fpm, temperatures of -20ºF to 140ºF, and relative humidities of 0% to 99% (noncondensing). Each sensing point shall independently determine the airflow rate which shall be equally weighted and averaged by the transmitter prior to output.
3. The minimum number of sensors for each assembly shall be as follows:

Area, (ft²)	No. of Sensors
1 to 4	4
4 to 8	6
8 to 12	8

12 to 16	12
>16	16

4. Transmitters: designed to operate at temperatures of -20ºF to 120ºF and provided with LCD display, 24 V AC power connection, and analog output signal (0-10 V DC or 4-20 mA) for connection to the BCS.
5. Accuracy: ±2% of reading over the entire operating airflow range.
6. Manufacturer: Ebtron, Fluid Components International, or Tek-Air.

2.8 AUXILIARY EQUIPMENT

A. Transient surge suppressors: suppressors shall be solid state, operate bidirectionally, and have a turn-on and turn-off time of less than one nanosecond, and shall provide the protection specified herein, either as an internal part of the BCS controller or as a separate component. Suppressor manufacturer shall have available certified test data confirming a fail short failure mode.

1. Communication or Signal Conductor Transient Suppressors:

a. Maximum single impulse current conductor-to-conductor or conductor-to-ground: 10000 A, 8 x 20 µs waveform.
b. Pulse life rating: 3000 A, 8 x 20 µs waveform, 2000 occurrences.
c. Maximum clamping voltage at 10000 A, 8 x 20 µs waveform, with the peak current not to exceed the normal applied voltage by 200%.

B. Uninterruptible power supply (UPS): provide a self-contained UPS designed for installation and operation at each BCS controller sized for at least 125% of the peak demand, and to provide a minimum of 15 minutes of full operation of the controller and input/output expansion modules connected to that controller. Equipment connected to the UPS shall not be affected in any manner by a power outage of a duration less than the rated capacity of the UPS. Each UPS shall be wired such that primary power to the controller will be maintained upon failure of the UPS, including either a relay switch upstream of the UPS or two UPSs in parallel. UPS shall be complete with necessary power supplies, transformers, batteries, and accessories and shall include visual indication of normal power operation, UPS operation, abnormal operation and visual and audible indication of low battery power, and shall provide a normally open alarm contact for monitoring by the BCS.

PART 3 - EXECUTION

3.1 GENERAL

A. Where control devices are installed on insulated piping or ductwork, provide standoff brackets or thermowells sized to clear insulation thickness. Provide extended sensing elements, actuator linkages, and other accessories as required.

B. Wiring and tubing shall be identified with the same numbers and symbols as used on the corrected, approved record diagrams.

C. Label control apparatus with nameplates or tags bearing the functional designations shown on approved control diagrams.

D. Where control devices are exposed outside the building, provide weather shield enclosures.

3.2 COMMISSIONING SUPPORT REQUIREMENTS

A. Prepare a written plan indicating in a step-by-step manner the procedures that will be followed to test, check-out, and adjust the control system prior to beginning functional testing. Keep the HVAC Performance Verification Supervisor informed of progress with the Project and of changes to the proposed installation, programming and test plan. At minimum, the plan shall include for each type of equipment controlled by the automatic controls:

1. Step-by-step procedures for testing each type controller after installation, including:

    a. Process of verifying proper hardware and wiring installation.
    b. Process of downloading programs to load controllers and verifying that they are addressed correctly.

2. Process of verifying proper hardware and wiring installation.
3. Process of performing operational checks of each controlled component.
4. Plan and process for calibrating valve and damper actuators and sensors.
5. A description of the expected field adjustments for transmitters, controllers and control actuators should control responses fall outside of expected values.
6. A copy of the log and field check-out sheets that will document the process. This log shall include a place for initial and final values read during calibration of each point and clearly indicate when a sensor or controller has passed and is operating within the contract parameters. Notification of any equipment failures shall be documented.
7. A description of the instrumentation required for testing, including a certification of calibration for each test instrument.
8. Identify which tests and systems should be completed prior to using the control system for test, adjustment, and balance work.

B. Provide the HVAC Performance Verification Supervisor complete system logic diagrams, describing the proposed system programming, with programmed attributes shown. These diagrams shall be updated with field modifications from the start-up, check-out, and prefunctional testing prior to the beginning of the functional testing of the BCS. Provide a copy of each proposed graphical interface screen with interface points shown for the entire system.

C. Prefunctional tests: verify and document the proper installation, addressing, calibration, programming, operation, and failure mode of BCS control points, sequences, and equipment. Provide a signed and dated certification to the HVAC Performance Verification Supervisor and Owner upon completion of the check-out of each controlled device, equipment, and system that installation, set-up, adjustment, calibration, and system programming is complete as specified herein and as indicated on the Drawings, except functional testing. Completed prefunctional documentation of the system verification shall be submitted to the HVAC Performance Verification Supervisor for review and approval prior to the functional testing of the BCS or its being used in the testing of other equipment or systems, or other purposes. Copies of final field check-out sheets and trend logs shall be provided to the HVAC Performance Verification Supervisor for inclusion in the Commissioning Report.

D. Functional tests: conduct and document a functional test of the complete installed BCS, as defined in Section 23 00 90, Performance Verification. Functional testing of the BCS may be conducted in phases or sections, as defined by the requirements of the Functional Test, or as approved by

the HVAC Performance Verification Supervisor. The BCS, or applicable portions of the system, shall have completed functional testing and be approved by the HVAC Performance Verification Supervisor before being used for other purposes, such as test and balance measurements, or in support of the functional testing of other systems.

1. Assist in the functional testing of equipment and systems by implementing trend logs and equipment monitoring as specified herein and as required by Section 230090, HVAC Performance Verification.

E. Meet with the testing, adjusting, and balancing contractor prior to beginning the test, adjustment, and balance process and review the test, adjusting, and balancing plan to determine the capabilities and requirements of the control system in completing the testing, adjusting, and balancing process. Provide the testing, adjusting, and balancing contractor any needed unique instruments for setting terminal units and instruct the testing, adjusting, and balancing contractor personnel in their use. Assist and cooperate with the testing, adjusting, and balancing contractor by providing a qualified technician to operate the controls as required to assist the testing, adjusting, and balancing contractor in performing his work, or alternatively, provide sufficient training for the testing, adjusting, and balancing contractor to operate the system without assistance. Verify the proper operation of affected controls at the completion of the test, adjustment, and balance procedure.

F. Seasonal Adjustment:

1. Assist the HVAC Performance Verification Supervisor with the seasonal adjustment process. During this effort the HVAC Performance Verification Supervisor will:

a. Check and verify the calibration of temperature control devices and thermostats. Test and verify control sequences for proper operation for the season.
b. Where deficient operation or defective equipment is discovered, provide corrective measures as required by the warranty provisions specified herein.

3.3 BCS

A. BCS Failure Mode:

1. BCS controls and interfaces shall be arranged so that equipment controlled by the BCS operates as indicated on the I/O summaries on failure of the BCS controller for any reason, including logic power supply failure, CPU lock-up, or interposing relay failure. Safety and operational interlocks shall remain in effect.

B. Control sequences for fire alarm system signal responses shall be independent of the BCS controller and its outputs.

C. Transient surge suppressors: install on low voltage signal or communications conductors entering the building from exterior locations, including those conductors from devices mounted on the exterior of the building. In addition, provide AC voltage power transient suppressors for BCS equipment power supplies.

D. BCS Sensors:

1. Liquid temperature sensors: fill sensor wells with thermally conductive material to assure accurate readings.
2. Current sensing relays: fan and pump status shall be sensed by a current sensing relay wired on the load side of each fan and pump. For constant speed fans and pumps, the current sensing relay trip setpoint shall be set at the motor's normal operating speed. For variable speed fans and pumps, the current sensing relay trip setpoint shall be set for the lowest operating speed, as determined by the commissioning process (typically 20%).
3. Proper calibration of sensors shall be demonstrated and documented as part of the commissioning process.
4. Sensor calibration: calibration of sensors shall be included as part of the prefunctional checklists according to the following procedures:

    a. General: verify that sensors with shielded cable are grounded only at one end.
    b. Sensors without external transmitters: take a reading with a calibrated test instrument within 6" of the sensor installation and verify the sensor reading is within the specified tolerance. If not, install offset, calibrate, or replace sensor to obtain required accuracy.
    c. Sensors with external transmitters: disconnect sensor from transmitter input and connect a signal generator in place of sensor. Using manufacturer's data, simulate minimum measured value. Adjust transmitter potentiometer zero until minimum signal is read. Repeat for the maximum measured value and adjust transmitter until maximum signal is read. Reconnect sensor. Make a reading with a calibrated test instrument within 6" of the sensor installation. Verify that the sensor reading is within the specified tolerance. If not, repeat process until specified accuracy is achieved, or replace the sensor and repeat process.
    d. Paired sensors: for sensor pairs that are used to determine a temperature or pressure difference, calibrate both sensors to a common measurement and verify they are reading within ±0.25ºF for temperature and within a tolerance equal to ±2% of the sensor reading for pressure.

E. BCS Start-up and Check-out:

1. Provide the services of control technicians at start-up to check-out the system, verify and calibrate sensors and outputs, input data supplied by the Owner, and place the system in operation. Verify proper operation of each item in the sequences of operation, including hardware and software.
2. Check-out each system for control function through the entire sequence. Check actuator travel on dampers and valves for action and extent. Verify that control dampers and valves open and close completely. Check calibration of instruments. Calculate and verify instrument setpoints.
3. Calibration and testing: calibrate sensors and monitoring inputs and verify proper operation of outputs before the system is placed on-line. Check each point within the system by making a comparison between the operator console and field device. BCS control loops, failure modes, interlocks, sequences, energy management programs, and alarms shall be debugged, tested, and stable operation verified. Control loop parameters and tuning constants shall be adjusted to produce accurate, stable control system operation. Before obtaining permission to schedule the functional test, provide written documentation of system calibration and certification that the installed complete system has been calibrated, verified, and is ready to begin testing.

F. BCS Acceptance Conditions:

1. Acceptance test: conduct final acceptance test, with the Owner on site, on the complete and total installed and operational system to demonstrate that it is functioning in accordance with requirements specified herein. Demonstrate the correct operation of monitored and controlled points as well as the operation and capabilities of sequences, reports, specialized control algorithms, diagnostics, and software.
2. System shall demonstrate the following minimum acceptable levels of performance, within the physical limitations of the controlled equipment:

    a. Control loops shall maintain stable, nonhunting, nonoscillating control, with minimum overshoot in response to transient and upset conditions.
    b. Space and air temperatures shall be maintained within ±1ºF of setpoint.
    c. Humidity shall be maintained within ±5% RH of setpoint.
    d. Chilled water system temperatures shall be maintained within ±0.5ºF of setpoint.
    e. Duct static pressures shall be maintained within ±0.05" wg of setpoint.
    f. Hydronic system pressures shall be maintained within ±2 psig of setpoint.
    g. Air and water quantities shall be maintained within ±5% of setpoint.

3. Final system acceptance will be based upon the completion of the following items:

    a. Completion of the installation of hardware and software items. Demonstrate complete operation of the system, including hardware and software, with no failures during a 5 consecutive day period. Obtain receipt from the Owner acknowledging no failures within the test period. Submit a daily log documenting failures.
    b. Satisfactory completion of functional performance testing.
    c. Satisfactory completion of the record drawings and operating and maintenance manuals.
    d. Satisfactory completion of training programs.

4. Upon final acceptance, the warranty period shall begin.

G. BCS Training:

1. Provide the HVAC Performance Verification Supervisor with a training plan for review 4 weeks before the planned training.
2. Provide designated Owner personnel training on the control system. The intent is to clearly and completely instruct the Owner on the capabilities of the control system.
3. The training shall be tailored to the needs and skill-level of the trainees.
4. The trainers shall be knowledgeable on the system and its use in buildings. The Owner shall approve the instructor prior to scheduling the training.
5. The standard operating manual for the system and any special training manuals shall be provided for each trainee, with a copy included in each copy of the operation and maintenance manual. In addition, copies of the system technical manual shall be demonstrated during training and a copy included in each copy of the operation and maintenance manuals. Manuals shall include detailed description of the subject matter for each session. The manuals shall cover control sequences and have a definitions section that fully describes relevant words used in the manuals and in software displays.
6. Copies of audio-visual materials used in the training program shall be delivered to the Owner.

7. Provide formal training sessions. Each session shall be conducted by factory-trained personnel:

   a. Training I: the first training session shall consist of 24 hours of actual training. This training may be held on-site or in the supplier's facility. If held off-site, the training may occur prior to final completion of the system installation. Provide materials and training for up to 6 persons to be designated by the Owner. Upon completion, each student, using appropriate documentation, should be able to perform elementary operations and describe general hardware architecture and functionality of the system.
   b. Training II: Building Systems: the second session shall be held on-site for a period of 24 hours of actual hands-on training after the completion of system commissioning. Provide materials and training for up to 6 persons to be designated by the Owner. The session shall include instruction on:

      1) Specific hardware configuration of installed systems in this building and specific instruction for operating the installed system, including HVAC systems, lighting controls, and any interface with security and communication systems.
      2) Security levels, alarms, system start-up, shut-down, power outage, and restart routines, changing setpoints, and alarms and other typical changed parameters, overrides, freeze protection, manual operation of equipment, optional control strategies that can be considered, energy savings strategies and setpoints that if changed will adversely affect energy consumption, energy accounting, and procedures for obtaining vendor assistance.
      3) Trending and monitoring features (values, change of state, and totalization), including setting up, executing, downloading, viewing both tabular and graphically and printing trends. Trainees shall actually set-up trends in the presence of the trainer.
      4) Every screen shall be completely discussed, allowing time for questions.
      5) Use of keypad or plug-in laptop computer at the zone level.
      6) Use of remote access to the system via telephone lines or networks.
      7) Setting up and changing a terminal unit controller.

   c. Training III: the third training session shall be conducted on-site 6 months after occupancy and consist of 24 hours of training. Provide materials and training for up to 6 persons to be designated by the Owner. The session shall be structured to address specific topics that trainees need to discuss and to answer questions concerning operation of the system.
   d. Supervisory training: provide a separate training course for supervisory personnel. This training shall briefly cover the material of the operator training session but shall address the more advanced features of the system with emphasis on the energy conservation strategies and reporting capabilities of the system and how to implement them. The training session shall be conducted by factory-trained personnel and shall be a minimum of two 8 hour days, for a total of 16 training hours. Provide materials and training for up to 6 persons to be designated by the Owner.

8. In addition to the specified BCS training, provide technically competent technicians to attend training sessions for systems and equipment that are monitored or otherwise interfaced with the BCS, to discuss the interaction of the control system to the equipment being discussed.

H. Control System Operation and Maintenance Manual Requirements:

1. In addition to documentation specified elsewhere herein, compile and organize operation and maintenance manuals in labeled 3-ring binders. The manual shall be organized and subdivided with permanently labeled indexed tabs, containing at minimum:

a. Full as-built sequence of operations for each piece of equipment.
b. Full as-built set of control drawings, including the marking of system components, sensors, and thermostats, and power sources on the as-built floor plans and mechanical drawings, identified with their control system designations.
c. Full point list. In addition to the as-built points list for the major equipment identified in the I/O summary, provide a listing of rooms served by BCS terminal controls, with the following information for each room:

1) Floor.
2) Room number.
3) Room name.
4) Air handling unit identification.
5) Reference drawing number.
6) Terminal unit tag identification.
7) Heating and/or cooling valve tag identification.
8) Minimum cfm.
9) Maximum cfm.

d. Controller/module data shall include specific instructions on how to perform and apply functions, features, and modes specified herein and other features of this system. These instructions shall be step-by-step. Indexes and clear tables of contents shall be included. The detailed technical manual for programming and customizing control loops and algorithms shall be included.
e. Control equipment component submittals and parts lists.
f. Thermostats, sensors, switches, and timers, including maintenance instructions and sensor calibration requirements and methods by sensor type.
g. Valves and valve actuators.
h. Dampers and damper actuators.
i. Full as-built documentation of software programming, including commented software program printouts, and a full print out of all schedules and setpoints after testing and acceptance of the system. Provide an electronic copy of programming and database information for this facility.
j. Warranty requirements.

3.4 THERMOSTATS

A. Mount space CO_2 sensors, space temperature sensors, and thermostats at 48" above the floor.

1. Align horizontally with adjacent light switches.
2. Final locations shall be accessible and shall be coordinated with the furniture layout and architectural layout.

B. Remote element type: mount on a vibration free surface 5' above the floor, unless specified herein to be mounted on a control panel. Provide 1 linear foot of element to sense the temperature of each ft^2 of the coil face. Install in a serpentine arrangement across the entire face of the coil.

C. Averaging and low limit safety type elements: install in a horizontal sine curve manner to sense temperatures across the entire face of the coil, and support independently from the coil by stainless steel bands or multibulb holders. Provide 1 linear foot of element for each ft² of coil area. Provide 0.5" metallic raceway or 0.375" hard copper rails for support of elements, both top and bottom, for plenum or duct width greater than 36".

D. Under window fan-coil unit thermostats: mount so that adjusting knob is accessible through access panel.

E. Provide insulated bases for thermostats and temperature sensors installed on exterior walls or walls to unconditioned spaces.

3.5 SENSOR PIPING

A. Tubing shall be concealed except in mechanical rooms.

B. Fasten tubing with clips at regular intervals and run parallel to building lines. Attach concealed tubing above suspended ceilings to structure or ductwork supports.

C. Copper bends shall be tool made. Provide unions at final connections to apparatus. Provide separation between dissimilar metals.

D. Nonmetallic tubing run in mechanical rooms and concealed in inaccessible locations shall be run in metallic raceways. Make connections to hot equipment with copper tubing.

E. Tubing installed inside control panels and equipment enclosures, and above ceilings shall be tied and supported.

F. Provide sleeves where tubing passes through concrete or masonry.

G. Test tubing at 30 psig for pressure loss of not more than 1 psig in 1 hour.

3.6 PANELS

A. Provide a panel for each BCS controller or each system not controlled by the BCS.

B. Mount the following items in the panels unless otherwise specified herein:

1. BCS controllers.
2. Relays.
3. Switches.
4. 120 V duplex convenience outlet wired from the same circuit as the BCS controller.
5. Wiring and controls.
6. Terminal blocks.

C. Wire controllers, relays, switches, and controls in the control panel to a terminal block. Line voltage and low voltage shall be separated on different terminal blocks with labels indicating voltage. Each sensor or other electrical device shall be wired back to the terminal block in the control panel. Devices in series shall be individually terminated at the terminal block, such that each side of each device is available at the control panel for troubleshooting. In addition to number markings on each conductor, conductor color shall be the same throughout each wiring run.

Wiring shall be neatly tied and routed in the control panel. Shielded wiring shall be terminated neatly, with heat shrink tubing placed over the bare end of the shield. Ground conductors over 4" long shall be insulated with tubing.

D. Provide 6" x 6"trough the width of the control panel, minimum 24" in length, above the control panel to provide an entrance for cabling and tubing into the panel, with 50% spare nipple capacity.

E. Provide 120 V power wiring for control power in the top right corner of each panel, with disconnects, power supplies, and transformers associated with the panel also located in the top right corner.

F. Each item in the panel shall be labeled and the panel labeled as to the system or equipment served.

G. Panels shall be located to avoid conflicts with ductwork, piping, equipment, the work of other trades, and building conditions. Panel locations indicated on the Drawings shall be coordinated prior to installation and adjusted to avoid conflicts.

3.7 STATIC PRESSURE SENSORS

A. Install sensors in the associated air handling unit control panel and use extended sensing lines. Provide taps for calibration purposes.

3.8 HYDRONIC PRESSURE SENSORS

A. Install sensors adjacent to measurement points, with sensing lines extended to accessible locations. Provide test ports equipped with Schrader valves in each sensing line for calibration purposes.

3.9 THERMOMETERS

A. Provide at each remote temperature sensor and element location. Do not duplicate thermometers specified in Section 231000, Piping, Valves and Accessories.

B. Mount thermometers in piping, ducts, and equipment in positions adjusted to be accessible for reading. Use angle and adjustable types where straight type would not be readable.

C. Fill thermometer wells with thermally conductive material.

3.10 CONTROL DAMPERS

A. Refer to Section 237000, Air Distribution, for installation.

B. For outdoor air damper assemblies, stage the opening of each section to prevent stratification and poor mixing of outside and return air.

3.11 SMOKE DETECTORS

A. Refer to Section 237000, Air Distribution, for installation.

3.12 CONTROL VALVES

A. Refer to Section 231000, Piping, Valves and Accessories, for installation.

B. Provide high pressure air, if necessary, for valve actuators.

3.13 WIRING

A. Materials and installation of wiring and electrical devices shall be in accordance with Division 26.

B. Control and sensor wiring shall be installed in conduits and shall be separate from AC wiring of any voltage. Conduits to devices in finished spaces shall be concealed.

C. Provide transformers or filters for operation of automatic temperature controls from building power circuits. Each BCS controller shall be served by a dedicated transformer, and no more than 10 terminal unit controllers shall be served by a single transformer.

D. Provide relays, transformers, fuses and interlock wiring as required to accomplish the sequences indicated on the Drawings.

E. Wiring for emergency fan shutdown stations shall be separate from control and sensor wiring and devices.

F. See Division 26 for 120 V, 20 A electrical branch circuits designated for control power, terminated in junction boxes. Provide power wiring from the designated junction boxes through control power transformers to BCS controllers, terminal unit controllers, smoke dampers, flow measuring devices, and other power consuming control devices.

G. Provide data outlets and associated low voltage cabling for each NAC and BCS controller as required. See Division 27 for communications cabling and outlet requirements. Coordinate the installation of new data outlets with the Owner's Information Technology staff.

H. Power for terminal unit controllers and smoke dampers shall be distributed at 24 V. For terminal units containing fans or electric heat, control power may be obtained from a control power transformer furnished with the terminal unit, except for terminal units used as part of a smoke control system.

I. Branch circuit wiring and conduit furnished under this Section for control equipment power shall be separate from other power wiring. No more than 2 BCS controller installations shall operate from a single 120 V branch circuit.

J. Low voltage control and sensor wiring shall be continuous without splicing.

3.14 AIR PRESSURE GAUGES

A. Install a gauge on each controlled device except room thermostats. Gauges may be mounted in or on the control panel if the controlled device is within sight from the panel.

B. On positive positioning devices, provide gauges for both pilot input and actuator signals.

3.15 AIRFLOW MEASUREMENT SYSTEMS

A. Install in straight duct sections, in accordance with manufacturer's recommendations and minimum straight duct length requirements.

B. Manufacturer shall provide start-up services, and demonstration testing for the Owner to verify the accuracy of each system and shall submit a certificate indicating same.

3.16 SEQUENCES

A. As indicated on the Drawings.

END OF SECTION 238000

SECTION 260010 - ELECTRICAL GENERAL

PART 1 - GENERAL

1.1 DESCRIPTION

A. These electrical general provisions specified herein apply to all Sections of Division 26.

B. Refer to the General and Supplementary Conditions and Division 01 for special requirements and conditions which apply to all Sections of Division 26.

C. This Section includes responsibilities and obligations in support of the performance verification specified in Section 260090, Electrical Performance Verification.

1.2 QUALITY ASSURANCE

A. Conform to the following:

1. National Electrical Code-2014 with South Carolina Modifications-2016.
2. International Energy Conservation Code-2009.
3. NECA 1-2015.
4. NECA 200-2016.

B. Codes, standards and regulations specified herein refer to the edition date. Revisions and addenda to these codes, standards and regulations shall be part of these specifications. Provisions of referenced codes, standards and regulations do not create duty or responsibility by the Architect or the Owner, unless otherwise specified herein.

C. Codes, standards and regulations referred to are minimum standards. Where the requirements of these specifications or drawings exceed those of the codes, standards and regulations, the drawings or specifications govern.

D. Electrical Design Coordination:

1. The power ratings of mechanical, plumbing, and fire suppression system motors and equipment and the characteristics of electrical systems serving them, as specified in other divisions, have been established as minimums which will allow that equipment to satisfactorily function while producing the capacities indicated on the Drawings or specified herein. These power ratings include a safety factor deemed appropriate to accommodate common differences between design parameters and field construction practices.
2. Reasonable efforts have been made to coordinate the electrical requirements of the equipment specified in other divisions with the electrical systems serving that equipment. Differences among manufacturers of equipment make it impossible to produce a single electrical design which will satisfy the varying electrical requirements of those manufacturers. Consequently, the Contractor shall coordinate the electrical requirements of the equipment actually furnished on this Project and provide the electrical systems required by that equipment. This coordination effort shall be completed prior to the installation of either the equipment or the electrical systems serving that equipment.

Electrical system revisions required to coordinate with the equipment actually furnished shall be provided at no additional cost to the Owner.

3. Equipment specified in other divisions:

    a. Audio-visual systems.
    b. Automatic temperature controls.
    c. Building automation system.
    d. Communications systems.
    e. Elevators.
    f. Escalators.
    g. Fire detection and alarm systems.
    h. Fire suppression systems.
    i. Fuel systems.
    j. Heating, ventilating and air conditioning systems.
    k. Plumbing systems.
    l. Power-operated doors.
    m. Security systems.
    n. Sprinkler waterflow and valve monitor switches.

E. Adhesives and Sealants:

1. Adhesives, sealants, and sealant primers used inside the building (defined as inside the weatherproofing envelope and applied on site) shall comply with SCAQMD Rule 1168-2017 for volatile organic compound content limits.
2. Aerosol adhesives shall comply with GS 36-2013 for volatile organic compound content limits.

F. Paints and Coatings:

1. Anticorrosive and antirust paints applied to interior ferrous metal shall not exceed a volatile organic compound content limit of 250 g/L per GS 11-2015.

1.3 SPACE CONDITIONS

A. Drawings are diagrammatic in nature and, unless explicitly dimensioned, indicate appropriate locations of fixtures, apparatus, equipment and raceways. Changes in the location, and offsets, of same to accommodate building conditions and coordination with the work of other trades, shall be made during the preparation of coordination drawings and prior to initial installation, without additional cost to the Owner.

B. Locations of motors, starters, equipment and apparatus as indicated on the Drawings are approximate; connections shall be made to such equipment as actually installed.

C. Provide access to equipment and apparatus requiring operation, service or maintenance throughout the life of the system.

D. Install switchboards and panelboards, such that no piping, ductwork or mechanical equipment is installed in the space equal to the width and depth of the equipment from floor to structure above. In addition, switchboards, panelboards, variable frequency drives, transformers, and starters shall be installed such that the working space in front, rear and/or side (where rear and/or side access is required to work on equipment) is clear of piping, ductwork, or mechanical equipment.

Dimensions of the working space shall be a minimum depth of 42" horizontally, the width of the equipment or 30", whichever is greater, and the height of the equipment or 78", whichever is greater. Minimum depth shall be increased to 60" for equipment rated over 600 V.

E. Do not install pad-mounted transformers less than 15' from any doorway or building structure (exterior walls, walkways, overhangs, balcony or windows). Orient the transformer such that the access area is facing away from the building.

1.4 ENVIRONMENTAL AIR-HANDLING SPACES

A. Electrical power conductors installed in environmental air-handling spaces shall be approved for installation in plenum areas.

B. Communications, data, control, and signal cable not in conduit or enclosed wireways shall be approved for installation in plenum areas.

C. Busway installed in spaces above or behind access panels used for environmental air shall be feeder type with no provisions for plug-in connections.

1.5 ASBESTOS MATERIALS

A. Materials containing asbestos or any trace of asbestos related materials shall not be used on this Project.

1.6 DEFINITIONS

A. Exposed raceways are those which can be seen when the base building and tenant fit-up is complete without opening or removing access doors or panels or accessible ceiling components.

B. Other raceways are considered to be concealed.

1.7 CONTINUITY OF EXISTING SYSTEMS

A. Perform work at such time and in such manner as to cause minimum inconvenience to the Owner and as approved by the Architect. No allowance will be made for lack of knowledge of existing conditions.

1.8 TEMPORARY SERVICES

A. Temporary utilities shall be in accordance with requirements specified herein.

B. Immediately after award of contract, determine the time of demolition of the existing site and the time of excavation for the new building, and be ready to:

1. Arrange with the Architect for making new connections to existing service.
2. Remove existing equipment and wiring.
3. Protect existing raceways in the path of new construction.

1.9 PROVISION FOR FUTURE ADDITIONS

A. The design contemplates future additions. Provisions for these additions are indicated on the Drawings.

1.10 RELATED WORK DESCRIBED IN OTHER DIVISIONS

A. Cutting, coring, waterproofing, and patching of walls, floors, ceilings, roofs and structure of existing building.

B. Installation of access panels in wall and ceiling construction.

C. Painting, except as specified herein.

D. Demolition, including removal of fixtures, apparatus and equipment.

1.11 SUBMITTALS

A. Within 15 days after notice to proceed, submit a schedule indicating the proposed submission date of each submittal specified herein. Schedule shall anticipate the submittal review time, the possible need for resubmittals, and the time required for fabrication, shipping and integration into the construction sequence. Architect will advise of any conflicts in reviewing submittals that the proposed schedule presents.

B. Submittals shall be prepared in a line-by-line format corresponding to these Specifications and shall indicate compliance with each requirement specified herein and indicated in the Drawings.

1. In addition to any other transmittal or cover sheet used, fill out and attach to each individual submittal a copy of the Cover Sheet for Submittals to Newcomb & Boyd included at the end of this Section.
2. Indicate manufacturer's installation instructions.
3. Indicate deviations, if any, including any from the manufacturer's installation instructions.
4. Reproductions or electronic versions of design drawings shall not be used in the preparation of shop drawings.
5. Resubmittals that are required to address review comments shall include a cover transmittal with a written explanation of how each review comment has been addressed.
6. Submittals not specifically required, or not complying with the format requirements, will be returned unreviewed.
7. Shop drawings and submittals shall be provided in portable document format (PDF). PDF files containing multiple drawings or components shall include an index of the file contents and electronic bookmarks.

C. Electrical submittals shall include the following:

1. Architectural dimming control systems, including wattage and voltage ratings, dimming load schedules, controls, dimming modules, dimming panels, dimming power boosters, and wiring diagrams.
2. Building wire and cable.
3. Performance Verification Supervisor qualifications.
4. Coordination drawings, with dimensions and elevations of electrical conduit 2" and larger, cable trays, busways, equipment, and recessed luminaires, coordinated with the work of

other trades, including HVAC, plumbing, fire suppression, structural, and architectural, minimum 1/4" = 1'-0" scale.

5. Dry-type transformers.
6. Electrical equipment room drawings, with dimensions and elevations, for each riser closet and major electric and telephone/data room showing equipment, risers, and code required clearances, minimum 1/4" = 1'-0" scale. Drawings shall be submitted prior to or concurrent with distribution equipment submittals.
7. Emergency power supply system, including generator decrement curve and available fault current at the generator terminals.
8. Floor boxes.
9. Grounding equipment.
10. Individual circuit breakers.
11. Lighting control devices.
12. Lightning protection system.
13. Luminaires, including:

    a. Data including specified options, photometrics, mounting or suspension devices, and associated details.
    b. LED driver data.

14. Overcurrent protective devices.
15. Panelboards.
16. Raceways.
17. Short circuit and overcurrent protective device coordination study.
18. Surge protective devices.
19. Switchboards, including equipment nameplate designations.
20. Time switches.
21. Wiring devices.

1.12 EQUIPMENT AND INSTALLATION REQUIREMENTS

A. Motor quantities, sizes and equipment wattage ratings specified in other divisions or indicated on the Drawings are the minimum requirements. Motor quantities, sizes and equipment wattage ratings less than those specified in other divisions or indicated on the Drawings are not acceptable. Larger motor sizes and equipment wattage ratings may be provided if necessary to meet the prescriptive requirements specified in those divisions. Where multiple motors or motor sizes or equipment wattage ratings larger than specified in those divisions or indicated on the Drawings are furnished, provide and coordinate the corresponding increased number or capacity of feeders and other electrical equipment serving them, at no additional cost to the Owner.

B. Equipment and materials, except as otherwise specified herein, shall be new and shall be of the customary standard and quality furnished by the designated manufacturer for that catalogue number.

C. Materials and equipment shall be UL listed, and shall bear the UL listing mark on products for which standards have been established and for which listing is regularly furnished by UL.

1.13 SHORT CIRCUIT AND OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

A. Submit a short circuit and overcurrent protective device coordination study prepared in accordance with IEEE 242-2001 and IEEE 399-1997 by the switchboard manufacturer at the time of final submittal of the switchboard submittals. Studies shall be prepared under the supervision and approval of a licensed professional electrical engineer skilled in performing and interpreting power system studies. Do not release the switchboard for construction until the study is submitted and approved.

1. The short circuit study shall show that electrical equipment including switchgear, switchboards, panelboards, motor control centers, busways, switches, and overcurrent protective devices in the electrical distribution system are applied within their short circuit and withstand current ratings.
2. The short circuit and overcurrent protective device coordination study shall include:

    a. Time current curves, with different color for each curve, plotted on full scale log-log graph paper for overcurrent devices, starting characteristics of motors, transformer full load current, magnetizing current and withstand parameter curves, cable damage curves, engine-generator set fault current and decrement curves, and motor starting characteristics and damage points. Curves for adjustable devices shall be shown adjusted to afford maximum coordination with upstream and downstream devices, including devices provided by the electric utility system.
    b. Source impedance data, including electric utility system and motor fault contribution characteristics.
    c. One-line diagram showing equipment designations, protective device ampere ratings and associated designations, cable size and lengths, transformer kVA and voltage ratings, motor and engine-generator set kVA ratings, available fault at each bus, bus withstand ratings, and device interrupting ratings.

3. The sources of fault current for the study shall include the utility's single-line-to-ground fault and three-phase bolted fault with X/R ratio for each fault component and fault current contributions from engine-generator sets.
4. The interrupting capacity of overcurrent devices shall equal or exceed the maximum fault current level where they are installed in the system. Except as specified herein, the system shall be fully rated in that the ability of the device to interrupt a fault at its terminals shall not depend on the characteristics of an overcurrent device upstream.
5. Where minimum interrupting capacities are indicated on the Drawings, the value is the minimum symmetrical AIC required. Where interrupting capacities are not indicated for a particular device, the interrupting capacity of the next device upstream shall be used.
6. Where the short circuit study indicates a fault level different from that indicated on the Drawings, describe the variance and include back-up information and calculations.
7. A schedule of adjustable devices indicating proper dial and tap settings to achieve the plotted characteristics shall be submitted with the study.

8. Short circuit and overcurrent protective device coordination study shall be submitted in the form of 1 set of original reproducibles, 3 copies thereof, and an electronic copy in PDF format.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATION

A. Apparatus shall be by one manufacturer, except where specified herein otherwise.

B. Steel vibration bases for transformers shall be of welded construction with cross members to form an integral support platform. Steel members shall be designed to match supported equipment. Perimeter members shall have a minimum depth equal to 10% of the longest dimension of the base, not to exceed 14".

C. Inertia bases: the weight of each inertia base shall be the weight of the equipment mounted thereon and shall incorporate vibration isolator mounting brackets, prelocated equipment anchor bolts and pipe sleeves, No. 4 reinforcing bars welded in 6" on center each way, and height-saving brackets or welded steel pockets to ensure a minimum 2" clearance. Inertia bases shall be a minimum of 6" thick.

D. Where isolators are exposed to weather, springs shall be powder- or neoprene-coated and other parts hot-dipped galvanized or zinc-plated.

E. Isolators shall conform to the following:

1. Type FS - Free-standing, laterally stable, unhoused spring type with leveling bolts for bolting to the equipment. Spring diameter shall be not less than 0.8 of the compressed height of the spring. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Springs shall be complete with neoprene or fiberglass noise isolation pads, minimum 0.25" thick, bonded to the baseplate.

    a. Manufacturer: Kinetics Noise Control FDS, Mason SLF, Vibration Eliminator OST, VMC Group AW/AWH, or Vibro-Acoustics FS.

2. Type NH - Double-deflection neoprene or natural rubber hanger type, with neoprene or natural rubber grommet between hanger rod and housing. Neoprene or natural rubber element shall have neoprene- or natural rubber-coated metal surfaces.

    a. Manufacturer: Kinetics Noise Control RH, Mason HD, Vibration Eliminator C, VMC Group HR, or Vibro-Acoustics NH.

3. Type NS - Sandwich pad type, with minimum 0.25" thick ribbed or waffled neoprene pad bonded to each side of 16 gauge plate. Isolator pads shall be selected for less than 80% maximum rated load.

    a. Manufacturer: Kinetics Noise Control NG, Mason WSW, Vibration Eliminator P, VMC Group Multi-Layer Shear-Flex, or Vibro-Acoustics 400 NP.

2.2 SEISMIC AND WIND RESTRAINTS

A. Seismic force design shall be determined in accordance with the following seismic design criteria:

1. Seismic Design Category: C.
2. Risk Category: II.
3. Component Importance Factor, I_P: 1.0.

B. Provide restraint devices as required for vibration isolated and nonvibration isolated electrical components. Provide calculations to determine restraint loadings for specific equipment to be installed resulting from seismic forces on equipment. Seismic restraint calculations shall be signed by a licensed engineer in the employ of the seismic restraint device manufacturer.

C. For roof-mounted equipment and components both the seismic acceleration and wind loads shall be calculated, and the highest load shall be utilized for the design of the seismic restraints and vibration isolators.

D. Exceptions for electrical components listed within the applicable project building code may be utilized. However, use of exceptions shall be noted with submitted seismic restraint calculations.

E. Provide restraint devices as necessary for luminaires in suspended ceiling systems as required by ASTM E580/E580M-2017.

F. Floor-Mounted Restraints:

1. All-directional external seismic restraints for floor-mounted components shall consist of interlocking steel assemblies restrained when engaged under seismic motion by elastomeric material with a minimum thickness of 0.25". The minimum air gap between interlocking assemblies shall be 0.125".
2. Restraints for neoprene vibration isolators shall consist of Type DN isolators with the addition of welded steel housings to resist seismic forces.
3. Restraints for free-standing floor springs shall consist of Type FS isolators with the addition of welded steel housings to resist seismic forces. Restraints shall allow a maximum movement of 0.25" in all directions.
4. Manufacturer: Kinetics Noise Control, Mason, VMC Group, Vibration Eliminator, or Vibro-Acoustics.

G. Suspended Restraints:

1. Restraints for vibration isolated suspended equipment, conduit, and raceways shall consist of galvanized or stainless steel aircraft cables with end connection fittings designed to swivel in order to ensure proper cable alignment and avoid bending of cable.
2. Restraints for nonvibration isolated suspended equipment, conduit, and raceways shall consist of steel angle or unistrut with anchor bolts and end connection fittings designed to swivel to the final installation angle.
3. Manufacturer: B-Line, International Seismic Application Technology, Kinetics Noise Control, Mason, Tolco, VMC Group, Vibration Eliminator, or Vibro-Acoustics.

2.3 CONCRETE

A. Normal weight concrete (145 pcf) using Type I Portland Cement, 1" maximum size coarse aggregate to provide a minimum 28 day compressive strength of 3000 psig.

2.4 GROUT

A. Nonshrink type, conforming to ASTM C1107/C1107M-2017 when tested at fluid consistency. Grout shall exhibit zero bleeding at every age when mixed to fluid consistency. Minimum 28 day compressive strength, when mixed to fluid consistency, shall be 7000 psig.

B. Manufacturer: Cormix, or Master Builders.

2.5 ACCESS PANELS - BUILDING

A. Refer to Section 083100, Access Door and Panel.

2.6 SLEEVES

A. Wall sleeves shall be galvanized rigid metal conduit or electrical metallic tubing with bushings.

B. For floor slabs above grade, plastic core form block-outs shall be used.

2.7 PENETRATION SEALS

A. Firestops:

1. Refer to Section 078400, Fire Stopping.

B. Expansion Seals:

1. Waterproof, modular, mechanical expansion type consisting of synthetic rubber grommets or interlocking links shaped to continuously fill the annular space between the penetrating item and the opening. Sizing of links and sleeve shall be determined by the manufacturer.
2. Manufacturer: Calpico Pipe Linx, Metraflex MetraSeal, or Thunderline Link Seal.

C. Seal Assemblies:

1. Seal assemblies shall consist of a frame, compression mechanism, and insert modules. Assemblies shall be waterproof and shall be designed to allow easy addition or deletion of penetrating items.
2. Seal assemblies for multicable penetrations of fire and smoke rated construction shall comply with the requirements of firestops as specified herein.
3. Manufacturer: Nelson Multi-Plug.

2.8 NETWORK CABLES, CONNECTORS AND EQUIPMENT

A. General:

1. Cable construction, insulation, and jacket shall comply with the requirements for the application for which it is used. Provide type CM or CMG for general use; type CMP for plenum use; and CMR for riser use.
2. Cables and conductors installed in enclosures or raceways underground or in slabs on grade shall be UL listed for use in wet locations.

B. RS-232 Cables:

1. Two twisted pairs, #22 AWG, stranded (7x30) tinned-copper conductors, each pair individually shielded with aluminum foil-polyester tape to provide 100% shield coverage.
2. Pairs shall be cabled on common axis with #24 AWG, stranded (7x32) tinned-copper drain wire.
3. Flame resistance: nonplenum-rated cable shall comply with UL 1581-2001. Plenum-rated cable shall comply with NFPA 262-2015.

C. RS-485 Cables:

1. Two unshielded twisted pairs, #22 AWG, stranded (7x30) tinned-copper conductors.
2. Flame resistance: nonplenum-rated cable shall comply with UL 1581-2001. Plenum-rated cable shall comply with NFPA 262-2015.

D. Control Cables:

1. Multiconductor, color-coded type, #22 AWG or larger conductors (sized for voltage drop), stranded tinned-copper for energy limited control circuits. Multiconductor, color-coded type, #14 AWG or larger conductors (sized for voltage drop), stranded tinned-copper for other control circuits.
2. Flame resistance: nonplenum-rated cable shall comply with UL 1581-2001. Plenum-rated cable shall comply with NFPA 262-2015.

E. Network Cables:

1. UL listed and CSA certified.
2. Category 5e cables shall meet TIA/EIA 568.1D-2015 requirements for category 5e cable.
3. Additional Cable Performance Requirements:

    a. Minimum power sum ACR: 9 dB at 155 MHz.
    b. Maximum attenuation: 21 dB at 100 MHz per 100 m.
    c. Minimum power sum near end crosstalk: 36 dB at 100 MHz.

F. Surge Protective Devices (SPDs):

1. This SPD specification applies to low voltage signal or communications cabling only. See Section 266710, Surge Protective Devices for other SPD applications.

2. SPDs shall incorporate silicon avalanche technology, shall operate bidirectionally, and have a turn-on and turn-off time of less than 5 nanoseconds. Additional minimum requirements include:

   a. Communication or Signal Conductor Transient Suppressors:

      1) SPDs shall be UL listed in accordance with UL 497B-2004.
      2) Maximum single impulse current conductor-to-conductor or conductor-to-ground: 10000 A, 8 x 20 µs waveform, or 200 A, 10 x 1000 µs waveform.
      3) Pulse life rating: 3000 A, 8 x 20 µs waveform, 2000 occurrences, or 50 A, 10 x 1000 µs waveform, 200 occurrences.
      4) Maximum clamping voltage at 100 A, 10 x 1000 µs waveform, with the peak current not to exceed the normal applied voltage by 150%, except for coaxial cable suppressors with peak current, the maximum clamping voltage shall not exceed the normal applied voltage by 200%.
      5) Failure mode: fail short.

   b. Manufacturer: Advanced Protection Technologies, Ditek, Emerson, Lightning Eliminators & Consultants, or Transtector.

2.9 UNDERGROUND WARNING TAPE

A. Tape shall be acid and alkali resistant polyethylene film tape, 6" wide with minimum thickness of 0.004", specifically designed for marking and locating of underground utilities.

B. Tape shall be manufactured with integral wires, foil backing or other means to enable detection by metal detectors when the tape is buried up to 18" deep. The metallic core of the tape shall be encased in a protective jacket or provided with other means to protect it from corrosion.

C. Tape color shall be as specified below and shall bear a continuous printed inscription describing the specific utility:

Utility	Color
Electric	Red
Telephone/Data	Orange

D. Manufacturer: Carlton Industries, Empire Level, Seton, or Stranco.

2.10 IDENTIFICATION MATERIALS

A. Conduit markers: self-adhesive vinyl tape, minimum 3 mil thick x 1.5" wide, color-coded orange unless otherwise indicated on the Drawings.

B. Emergency system markers: self-adhesive vinyl or plastic-coated cloth tape, approximately 1.5" x 2.5" with red background, printed as follows: "Contains Emergency Circuits - Do Not Install Conductors Within This Enclosure That Are Not Part of the Emergency System - Reconnect and Reenergize All Emergency Circuits As Soon As Possible."

C. Tags: preprinted or partially preprinted accident prevention and operational tags, on plasticized card stock with matte finish for writing, approximately 3.25" x 5.625", with brass grommets and wire fasteners, and appropriate wording.

D. Signs: 14" x 10" size, 0.04" thick aluminum base with baked enamel finish for indoor or outdoor use.

E. Nameplates and Labels:

1. White core plastic laminate with engraved lettering.
2. Nameplate background color shall be black for normal power equipment and red for emergency power equipment.
3. Nameplates for individual devices shall have 0.25" high letters.
4. Nameplates for panelboards, switchboards, variable frequency drives, circuit and motor disconnects, dry-type transformers, and equipment shall have 0.5" high letters.
5. Labels shall have minimum 0.25" high letters.

2.11 MISCELLANEOUS

A. Diagram framing system: 0.125" thick acrylic with satin finish aluminum frames.

2.12 PAINTING

A. Paint for high temperature equipment shall be high temperature resistant, designed for the temperatures at which the equipment will operate.

PART 3 - EXECUTION

3.1 PROTECTION OF EQUIPMENT AND MATERIALS DURING CONSTRUCTION

A. Provide protective covers, skids, plugs or caps to protect equipment and materials from damage or deterioration during construction.

B. Store equipment and material under cover, and off the ground or floors exposed to rain.

C. For outdoor storage, protective covers of 10 mil thick black sheet plastic shall be fitted over equipment and materials. Covers shall be reinforced to withstand wind and precipitation. Set equipment and material on skids or platforms of height to avoid damage or deterioration from spattering and ground water.

D. Provide dust and debris protection for motors, fixtures, and equipment operated during construction.

3.2 EXISTING EQUIPMENT AND SYSTEMS

A. General:

1. The existing installation shall remain as is except as otherwise indicated on the Drawings or specified herein. Perform work to tie in the new work with the existing work and to adapt the existing work to the changes in the building and systems.

2. Remove equipment, apparatus, and exposed wiring and raceways rendered useless due to changes.
3. Existing fixtures, equipment and apparatus which are removed and not reused in the new work shall be turned over to the Owner.
4. Material and equipment which has been removed and not accepted by the Owner shall become the property of the Contractor and shall be removed from the site.
5. Existing electrical equipment, including lamps and ballasts, removed and not reused shall be handled and disposed of in accordance with applicable state and federal regulations.
6. Material and equipment which has been removed shall not be used in the new work, except as specified herein.
7. Where existing raceways and equipment are indicated on the Drawings, size and location shall be verified prior to bidding.
8. Provide circuit continuity for existing wiring devices and equipment outside the renovation area served from or through the renovation area.
9. Verify the load on modified or reused existing circuits to ensure that the ratings of the overcurrent protection devices are not exceeded. A true RMS ammeter shall be used. Notify the Architect of any overload conditions in writing within 5 working days of the load verifications.

B. Luminaires:

1. Exercise care in removing luminaires which are to be reused so they are not damaged, and protect fixtures which are to remain in place while work is in progress.
2. Reinstall removed luminaires at new locations where indicated on the Drawings. Reinstalled luminaires shall be cleaned, ballasts and defective parts replaced, and new lamps installed.
3. Maintain existing exterior lighting on the site in operation during construction. Provide temporary power connections to ensure continued operation.

3.3 EQUIPMENT AND INSTALLATION REQUIREMENTS

A. Cut and repair walls, floors and ceilings for the installation of the electrical work.

B. Exterior building walls below grade shall not be pierced by hanger bolts.

C. Except where specific instructions are included herein, install and connect equipment in accordance with the manufacturers' instructions and recommendations.

D. Refer to manufacturer's or equipment supplier's shop drawings for exact type, number, location, dimensions and size of connections to equipment, including but not limited to:

1. Fire protection equipment.
2. Heating, ventilating, and air conditioning equipment, including power supplies to automatic temperature control systems.
3. Plumbing equipment.
4. Vertical transportation equipment.

E. Provide final connections to electrically powered equipment provided under this and other Divisions of these specifications and by the Owner.

F. In unfinished areas designated for future build out, install conduit and equipment tight against the structure to maximize the future ceiling height.

G. Coordinate the location of electrical equipment in elevator machine rooms with the approved elevator machine room shop drawings.

3.4 SHORT CIRCUIT AND OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

A. Obtain information required for the study from the utility company and the equipment manufacturers.

B. Protective devices shall be set and calibrated as recommended by the final approved fault current and coordination study.

3.5 VIBRATION ISOLATION

A. General:

1. Select and locate vibration isolation equipment to give uniform loading and deflection, according to weight distribution of equipment.
2. Vibration isolators shall be installed and connected, as specified herein, or as indicated on the Drawings, in accordance with the manufacturer's written instruction and certified submittal data.
3. There shall be no direct contact of isolated conduit or equipment with shaft walls, floor slabs, partitions, piping, ductwork, structural elements, or any other nonisolated items.
4. Prior to startup, clean out all foreign matter between base, isolator, equipment, and mounting surfaces. Verify that there are no rigid connections between equipment and building structure that degrade the vibration isolation systems specified herein.
5. Where recommended by the manufacturer, isolator baseplates shall be bolted to the structure or foundation. Bolting shall incorporate neoprene bushings and washers.
6. Isolator hangers shall be installed with the housing a minimum of 2" below but as close to the structure as possible. Where isolator hangers would be concealed by inaccessible acoustical subceiling, install the hangers immediately below the subceiling for access.
7. Vibration isolators shall not cause any change in position of equipment or conduit resulting in stresses or misalignment.
8. Any conflicts with other trades that will result in direct contact with isolated equipment or conduit shall be brought to the attention of the Architect prior to installation.
9. After installation, manufacturer shall verify that vibration isolation systems are installed and operating properly, and shall submit a certificate so stating. Verify that isolators are adjusted, with springs perpendicular to bases or housing, adjustment bolts are tightened up on equipment mountings, and hangers are not cocked.

B. Equipment Isolation:

1. Isolated equipment mounting systems shall permit equipment motion in all directions.
2. Provide height saving brackets where recommended by the manufacturer for equipment stability, or operating height requirements.
3. Engine-generator sets not tank-mounted shall be mounted on Type FS isolators with a minimum static deflections of 1" 2".

4. Floor-mounted transformers under 750 kVA shall be mounted on Type NS isolators with a minimum static deflection of 0.1".
5. Suspended transformers shall be supported with Type NH isolators with a minimum static deflection of 0.1".

3.6 SEISMIC AND WIND RESTRAINTS

A. Restraints shall be installed after the equipment is mounted, connected, and operating to ensure that no contact occurs during normal equipment operation.

B. Installation of seismic restraints shall not cause any change of position of equipment, conduit, or raceways, resulting in stress and misalignment.

C. No rigid connections between equipment, conduit, or raceways and the building structure shall be made that degrade the vibration isolated system specified herein.

D. Equipment that is internally vibration isolated and restrained shall have its entire unit assembly seismically attached to the structure.

E. Do not brace a system to two different structures, such as a wall and a ceiling.

F. Luminaires in suspended ceilings shall have cable restraints as required.

G. After installation, manufacturer shall verify that seismic and wind restraints are installed and operating properly, and shall submit a certificate so stating.

3.7 FOUNDATIONS

A. Provide concrete foundations for floor-mounted or grade-mounted motor starters, switchboards, transformers, dimming panels, engine-generator sets, elevator equipment, and other similar equipment.

1. Interior foundations: shall accommodate seismic anchors, and shall be a minimum of 4" high.
2. Exterior foundations: minimum 8" thick pad, minimum 4" above surrounding grade with the exception of engine-generator sets which shall be a minimum of 6" above surrounding grade.

B. Foundations shall be continuous and shall have beveled edges and smooth float finish. Foundations shall be reinforced with No. 3 bars a maximum of 12" on center each way, and held in place with dowel rods at each corner anchored in the slab. Dowel rods shall not penetrate the slab waterproofing.

C. Roughen and clean exposed slabs before pouring foundations. Apply bonding agent to surfaces in contact.

D. Foundations shall extend beyond the equipment footprint in each direction, including appurtenances, vibration isolators, and motors as follows: exterior - 6"; interior - 1", but not less than 1.5 times the seismic anchor embedment depth from the point of anchoring.

E. Exterior foundations shall be supported on natural ground with organic material under pad removed. The subgrade shall be compacted to 90% modified proctor maximum dry density, ASTM D1557-2012e1, to a depth of 12". If the compaction density cannot be achieved with the existing soil, the existing subgrade shall be removed to a depth of 12" and replaced with clean backfill and compacted as specified above. A 4" thick granular subbase of sandy gravel or crushed stone shall be compacted with vibratory compactors. Dampen the subbase prior to concrete placement. At the time of placement, the subbase shall not contain standing water.

F. Fill voids between baseplates and foundations, and level equipment, with grout.

3.8 ACCESS PANELS - BUILDING

A. Where electrical work is concealed by walls or ceilings, or is inaccessible, provide an access panel to provide access for service and maintenance.

B. Electrical work located above ceilings is considered accessible if the ceiling is the accessible type and is arranged for access to the equipment.

C. Fire rated access panels shall be provided in fire barriers, with ratings to match the construction fire rating.

D. Access doors providing access to equipment access doors shall allow for service and maintenance of the intended equipment.

E. Installation of access panels is specified under another Division.

3.9 SLEEVES

A. Provide where conduits pass through elevated floor slabs if conduits are not a part of the slab pour, and for future cable or conduit risers.

1. Install in raised foundations at least 2" high.

B. Provide where communications and other cables, not installed in conduits, pass through walls and elevated floor slabs.

C. Wall sleeves shall extend 4" from each side of the wall.

D. Openings through slabs for busway risers shall be finished with a 4" wide x 2" high curb around the opening.

E. Sleeves shall be secured in place. Provide insulating bushings on both sides of sleeves for cables.

F. Provide ground bushings on both sides of sleeves containing ground conductors.

3.10 PENETRATION SEALS

A. General:

1. Install in accordance with the manufacturer's published instructions to achieve ratings and classifications specified herein. A copy of these instructions shall be maintained and available on site.

B. Firestops:

1. Close and firestop penetrations through fire- and smoke-rated construction. Materials used to seal these penetrations shall continue the construction’s fire and smoke resistance ratings uninterrupted and shall maintain an effective barrier against the spread of flame, smoke, water and hot gases.
2. Install after installation of raceways.

C. Expansion Seals:

1. Install to seal single conduit or cable penetrations of walls below grade.

D. Seal Assemblies:

1. Install to seal the penetration of walls below grade by multiple cables in the same opening.

3.11 NETWORK CABLES, CONNECTORS AND EQUIPMENT

A. General:

1. Make joints and connections with 60/40 resin-core solder or mechanical connectors. Temperature controlled soldering irons rated at least 60 W shall be used for soldering work.
2. Terminal blocks, boards, strips, and connectors shall be provided for cables which interface with racks, cabinets, consoles, enclosures, and equipment modules.
3. No cable shall be installed with a bend radius less than that recommended by the cable manufacturer.
4. Unused cables shall be dressed at each end in heat-shrink tubing and marked as unused.
5. Heat-shrink tubing shall be used to insulate and dress the ends of outdoor wires and cables, including a separate tube for the ground or drain wire.
6. No cables shall be wired with a polarity reversal between connectors, at either end. Special care shall be taken when wiring to ensure that constant polarity is maintained.

B. Network Cables:

1. Network cables shall be installed from each power monitoring device to the network outlet located adjacent to the equipment. The total length of this cable and the cable serving the outlet shall not exceed 295'.
2. Observe the bending radius and pulling strength requirements of the cables during handling and installation. Each run of cable between the power monitoring device and the network outlet serving the equipment shall be continuous without joints or splices.
3. Cables shall be routed at least 2' from fluorescent ballasts and at least 40" from electric motors or other high level sources of EMI.
4. Cabling routed above ceilings shall be in conduit.

5. Provide temporary protection of cables before termination. Cables shall not be left lying on the floor. Bundle and use cable ties to provide protection.
6. Provide clutch or shear pin protection for cables during cable pulling to ensure cable pulling tension is not exceeded.
7. Jacks shall be wired per the pair assignments indicated in the TIA/EIA 568.1D-2015 designation T568A or T568B wiring plan. Coordinate wiring to match communications outlets.
8. Network cables shall be installed and terminated in accordance with the manufacturer's recommended procedures.

C. Connectors:

1. Provide strain relief on connectors.
2. Provide blank coverplates for boxes intended for future use, unless otherwise indicated on the Drawings.
3. Insulate cables from receptacle faceplates.

D. Surge Protective Devices:

1. Install on low voltage signal or communications conductors entering the building from exterior locations, including those conductors from devices mounted on the exterior of the building.

3.12 PAINTING

A. Except where otherwise specified herein, painting shall be done under another Division. Surfaces shall be left clean and free from oil.

B. Equipment factory finishes damaged or deteriorated during construction shall be repaired to match original finish.

C. Where galvanizing is broken during fabrication or installation, recoat exposed areas with zinc-rich paint.

D. Exterior ferrous equipment and supports shall be painted 2 coats of rust preventive paint, color selected by the Architect.

E. Exposed interior ferrous equipment, and exposed nongalvanized ferrous accessories and metal shall be prepared and painted 1 coat of corrosion resisting paint prior to other painting or identification, or 2 coats of corrosion resisting paints if no other painting is specified herein.

3.13 EXCAVATION AND BACKFILLING

A. Determine exact location of existing underground utilities before excavation.

B. Excavation shall be no longer or deeper than necessary. Backfill material shall be free from rocks and debris.

C. Compact backfill as the excavation is filled.

D. Excavation, shoring, bracing, backfilling, compaction, cutting and patching of hardscape, and restoration of landscape shall conform to Division 31, Earthwork.

3.14 COORDINATION

A. Provide offsets, transitions, and fittings to coordinate the work of each trade with that of other trades, including HVAC, plumbing, fire suppression, structural, and architectural.

3.15 PHASING

A. Install work in phases as specified by the Architectural Documents.

3.16 UNDERGROUND WARNING TAPE

A. During backfilling, install tape continuously at 4" to 6" below finished grade, above buried power, communications, or signal cables, conduits, and duct lines.

B. Install multiple markers where cables are installed in groups exceeding 18" width.

3.17 CLEANING

A. Luminaires:

1. Remove dirt, dust, and grease, and polish reflector and trim surfaces, and clean lens.

B. Equipment and Equipment Rooms:

1. Remove dust, dirt, rust, stains, and temporary covers.
2. Foreign matter shall be blown, vacuumed, flushed, or cleaned out of and from equipment, luminaires, raceways, devices, switches, controls and panelboards.
3. Clean and polish identification plates.
4. In equipment rooms, clean equipment, conduit, and room surfaces from dust and dirt and maintain in a clean condition from date of substantial completion until final completion of work and corrective work.
5. Remove excess material from the project site.

3.18 IDENTIFICATION

A. General:

1. Identification shall consist of upper case letters.
2. Where identification is applied to surfaces which require a finish, identification shall be installed after surface has been finished.

B. Conduit Markers:

1. Install on conduits and raceways exposed or above ceilings at connections to junction boxes, pull boxes, equipment, each side of wall, floor, and roof penetrations, manhole and handhole entries, and at 50' intervals along straight runs.

2. On parallel conduits (grouped), markers shall be placed on each conduit in line with each other. Markers shall be positioned in such a manner as to ensure visibility.

C. Box Color-Coding:

1. Paint connectors, couplings, bushings, hubs, entire conduit within 6" of a box, and panelboard backboxes for the different systems as listed below:

System	Color
Normal Power	Silver (Unpainted)
Emergency Power (NEC Article 700)	Yellow with Label
Legally Required (NEC Article 701)	Orange
Optional Standby Power (NEC Article 702)	Orange
Fire Alarm	Red

D. Emergency system markers: install markers on boxes and enclosures, including transfer switches, engine-generator sets, and panels for emergency circuits. In addition, identify in indelible marker, emergency branch circuit panel and circuit numbers for branch circuits contained within each outlet box, on the cover of each box.

E. Cable identification: install cable identification on each communication or signal cable.

F. Warning Signs:

1. Switchboards, panelboards, and control panels: install a warning sign on equipment enclosure in clear view which states, "Warning – Arc Flash and Shock Hazard – Appropriate Personal Protective Equipment Required." Signs shall be 5" wide by 3.5" high or larger.

G. Danger signs: install in areas constituting a danger for persons in or about the Project.

H. Nameplates and Labels:

1. Install engraved nameplates at or on each circuit breaker, circuit and motor disconnect, motor controller, panelboard, switchboard, lighting control panel, dry-type transformers, special apparatus, and communications and signal system, unless equipment is specified herein with its own self-explanatory identification. Text shall match terminology and numbering of the construction documents and submittals as close as practicable, and shall indicate equipment controlled as well as upstream distribution device and branch circuit or feeder designation.
2. Nameplates shall not cause interference with operation and maintenance of equipment. Attach nameplates with rustproof screws.

I. Wiring devices: refer to Section 261430, Wiring Devices, for emergency marking and labeling requirements.

J. Junction boxes: refer to Section 261300, Boxes for labeling requirements.

K. Panelboards: install type written directories describing the load served by each circuit. Identify spaces and spares in pencil. Install on back of panelboard doors.

L. Provide a sign at the normal service, switchboard, and emergency power supply system disconnect switch indicating other services and feeders supplying the building and the location of each.

M. Provide a sign at the normal service switchboard indicating the type and locations of the on-site emergency power source.

N. Provide a sign at the service switchboard indicating the maximum available fault current. The sign shall indicate the date the fault-current calculation was performed.

O. Label each ground connection at the main grounding busbar as indicated on the Drawings.

3.19 OPERATION AND MAINTENANCE DOCUMENTATION PACKAGE

A. These operation and maintenance manual requirements supplement operation and maintenance manual documentation requirements of other Sections of these specifications.

B. Operation and maintenance documentation, in hardback 3-ring loose-leaf binders except full size drawings and CDs, shall cover the electrical systems. Documentation shall include the following: operations and maintenance documentation directory; emergency information; operating manual; maintenance manual; test reports; and construction documents.

C. The operation and maintenance documentation package shall be submitted as one comprehensive package to the Owner 3 months before systems start-up, and shall be updated, revised and completed at completion of construction.

D. Documentation shall be typewritten and shall contain, at a minimum, the following information.

1. Introduction:

    a. Project name, contractors' and subcontractors' names, addresses, and telephone and facsimile numbers. Indicate the portion of work for which each subcontractor was responsible.
    b. Index.

2. Operations and Maintenance Documentation Directory:

    a. Explanation of the identification system used, including lists of systems, equipment and component identifiers and names.

3. Emergency Information:

    a. Information for technical and nontechnical personnel about actions recommended during emergency situations to protect life and property and to minimize disruption to the building occupants. Emergencies shall, at a minimum, include:

        1) Fire.
        2) Security breach.
        3) Power failure.
        4) Emergency power system failure.

4. Operating Manual:

    a. General Information:

        1) Building function.
        2) Building description.
        3) Operating standards and logs.

    b. Technical Information:

        1) System description.
        2) Operating routines and procedures.
        3) Routine operational testing program and procedures.
        4) Special procedures.
        5) Basic troubleshooting.

5. Maintenance Manual:

    a. Descriptions (specifications) of the equipment and components.
    b. Description of function, as applicable: the function of the equipment, procedures before start-up, functional parameters (input, output) at the design load and at part loads, and performance verification procedures.
    c. Recommended maintenance procedures and their recommended frequency for this Project.
    d. Name, address and contact of at least one qualified service company.
    e. Recommended list of spare parts, part numbers, and the place(s) from which they can be obtained.
    f. Original purchase order number; date of purchase; name, address, and the telephone number of the vendor; and warranty information.
    g. Installation information.
    h. Any other information needed for the preparation of documents supporting the management of operation and maintenance programs.

6. Test Reports and Certifications:

    a. Copies of tests and certifications performed during manufacture and construction including, but not limited to, the following:

        1) Overcurrent protective device coordination study.
        2) Engine-generator set factory test report.
        3) Engine-generator set oil sample analysis.
        4) Lightning protection inspection certificate.
        5) Dry-type transformer test reports.
        6) Receipt for spare fuses.
        7) Certification of architectural dimming control systems installation.
        8) Receipt of O&M documentation package.
        9) Receipt for instruction of operating personnel.
        10) Emergency power supply system on-site test report.
        11) Switchboard test reports.
        12) Ground resistance test.

7. Construction Documents:

   a. Record drawings.
   b. Approved submittals, including revised shop drawings indicating field and as-installed conditions.
   c. Equipment identification charts and schedules.
   d. Warranty certificates.
   e. Inspection certificates.
   f. Performance verification report.

E. Submit a receipt signed by the Owner acknowledging receipt of the operation and maintenance documentation package.

3.20 DIAGRAMS

A. Frame and mount the following information:

Information	Location
One-line diagrams of the building electrical system.	On the wall in the Main Electrical Room
Overcurrent protective device schedule.	On the wall in the Main Electrical Room.

B. Diagrams shall be type written or computer generated.

C. Diagrams shall be as-built, and shall include interfaces and interlocks with other equipment.

3.21 RECORD DRAWINGS

A. Refer to Section _____, _____.

B. Upon completion of the Project, submit marked-up design drawings indicating field and as-installed conditions, and shop drawings incorporating changes made during construction for raceways and equipment. Submit the following:

1. 1 set of bound prints.
2. Full size PDFs on CDs.

3.22 MAINTENANCE

A. Equipment operated prior to the date of substantial completion shall be maintained in accordance with manufacturers' recommendations.

3.23 INSTRUCTION OF OPERATING PERSONNEL

A. Conduct formal instruction sessions for operating personnel. Conduct two similar sessions. The first session shall be conducted at the time of start-up and check-out, and the second session shall be approximately 2 months later. Sessions shall be a minimum of 2 days duration for basic

electrical systems, and as specified herein for other systems and equipment. Sessions shall be conducted at the site.

B. Prepare and submit a syllabus describing an overview of the program, describing how the program will be conducted, when and where meetings are to be held, names and company affiliations of lecturers, description of contents and outline for each lecture, and recommended reference material and outside reading. Obtain direction from the Owner on which operating personnel shall be instructed in each system. Proposed training schedules, materials, and lesson plans shall be submitted to the Owner for review.

C. Sessions shall include:

1. General familiarization and operating procedures for the entire electrical installation.
2. Routine maintenance procedures for equipment.
3. Specific operating and maintenance procedures for:

   a. Switchboards.
   b. Emergency power supply system.

D. Factory-trained technicians shall give operating and maintenance instructions on the following systems and equipment:

System/Equipment	Minimum Session Duration, hours
Architectural dimming control systems	4
Emergency power supply system	8
Occupancy sensors	2
Switchboards	4

E. Provide a complete record copy of all training materials, handouts, and other printed materials used in each training session.

F. Training shall occur after testing is complete, unless approved otherwise by the Architect or Owner.

G. Obtain receipt acknowledging completion of each item of instruction.

END OF SECTION 260010

COVER SHEET FOR

SUBMITTALS TO NEWCOMB & BOYD

Project: _____ Date: _____

Item: _____ Submittal Number: _____

Manufacturer: _____ Model: _____

Specification Paragraph and/or Drawing Number: _____

Capacity: _____

Electrical Characteristics (including identification of all separate connections or services required): _____

_____

_____

_____

Accessories: _____

_____

_____

_____

Options: _____

_____

_____

_____

Deviations (if any; if none, state so): _____

_____

General Contractor Approval: _____

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SECTION 260090 - ELECTRICAL PERFORMANCE VERIFICATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other electrical systems are specified in other Sections of Division 26.

B. Performance verification is an ongoing process and shall be performed throughout construction. Performance verification verifies that systems are operating in a manner consistent with the Construction Documents.

C. This Section covers electrical systems performance verification, as required to demonstrate that the equipment and systems of Division 26 are ready for safe and satisfactory operation, as defined by the Construction Documents. Performance verification shall include, but shall not be limited to, identification of equipment, cleaning, lubrication, start-up, check-out, testing and adjusting of systems, preparation of equipment and systems documentation and of maintenance and operation manuals, Owner training, and preparation of record drawings.

D. Performance verification shall conclude with the completion of required deferred testing, training, and system documentation as specified herein and required to demonstrate the proper operation of the electrical equipment and systems provided by this Division.

E. Verify, at a minimum, the performance of the following systems and equipment:

1. Section 261150, Underground Ducts, Manholes and Handholes.
2. Section 261200, Building Wire and Cable, 600 Volt.
3. Section 261430, Wiring Devices.
4. Section 261700, Circuit and Motor Disconnects.
5. Section 262000, Emergency Power Supply System:
    a. Engine-generator sets.
    b. Automatic transfer switches.
6. Section 264020, Service Entrance.
7. Section 264400, Switchboards.
8. Section 264500, Grounding.
9. Section 264510, Lightning Protection System.
10. Section 264600, Dry-Type Transformers.
11. Section 264710, Panelboards:
    a. Lighting and appliance branch circuit panelboards.
    b. Distribution panelboards.
12. Section 264750, Overcurrent Protective Devices.
13. Section 264760, Individual Circuit Breakers.
14. Section 265100, Luminaires.
15. Section 265910, Lighting Control Devices.
16. Section 266710, Surge Protective Devices.

1.2 QUALITY ASSURANCE

A. Provide an Electrical Performance Verification Supervisor with 10 years experience in electrical contracting. The Electrical Performance Verification Supervisor shall become familiar with the Owner's project requirements and the requirements of the performance verification process as defined in this Section. The Electrical Performance Verification Supervisor shall coordinate and execute the required performance verification activities.

B. The Electrical Performance Verification Supervisor shall review submittal data for conformance with the requirements of the Project, shall monitor compliance with the requirements specified herein for storage and protection of equipment during construction, shall authorize the initial starting of equipment and systems in a manner to avoid damage to equipment, shall oversee start-up, testing, and shall document that the scheduled and specified performance requirements of each system have been accomplished.

C. Conform to the following:

1. ASHRAE Guideline 0.2-2015, Commissioning Process for Existing Systems and Assemblies.
2. ASHRAE Guideline 4-2008 (RA 2013), Preparation of Operating and Maintenance Documentation of Building Systems.
3. NECA 90-2015.

1.3 PERFORMANCE VERIFICATION

A. The Electrical Performance Verification Supervisor shall be responsible for scheduling, supervising, and coordinating and executing the start-up, testing, and performance verification activities as specified herein. Include and itemize the cost of performance verification in the contract price, and in each purchase order or subcontract written, include requirements for submittal data, performance verification efforts and documentation, operations and maintenance data, and training as specified herein.

B. Electrical performance verification shall take place in three phases. Performance verification requirements for each phase are as follows:

1. Construction Phase:

a. Attend a performance verification scoping meeting and additional such meetings, initially scheduled monthly until prefunctional testing of equipment and systems begins, and weekly thereafter during the construction phase to facilitate the performance verification process. The Electrical Performance Verification Supervisor shall coordinate meeting attendance.
b. Report in writing to the Architect, Commissioning Authority at least as often as performance verification meetings are scheduled, concerning the status of his activities as they affect the performance verification process, the status of each discrepancy identified during the prefunctional and functional testing process, explanations of any disagreements with the identified deficiencies, and his proposed resolution and schedule for correction of the deficiency.
c. Provide documentation of installed systems and equipment, and develop functional testing procedures. This documentation shall include detailed manufacturer installation, start-up, operating, troubleshooting and maintenance procedures; full

details of any Owner-contracted tests; full factory testing reports, if any; and full warranty information, including responsibilities of the Owner to keep the warranty in force. In addition, the installation, start-up and check-out materials that are actually shipped inside the equipment and the actual field check-out sheet forms to be used by the factory or field technicians shall be submitted to the Architect.

d. Develop and submit to the Architect for review and comment, prior to equipment or system start-up, a complete start-up and initial check-out plan using manufacturer's start-up procedures and prefunctional checklists for the performance of the equipment to be verified.
e. Assist in clarifying the proposed operation and control of equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
f. Prepare the specific functional test procedures as specified herein and review the proposed functional test procedures to ensure feasibility, safety, and equipment protection, and provide necessary written alarm limits to be used during the tests. Obtain Architect approval for proposed functional test procedures.
g. Prepare a preliminary schedule for performance verification activities, including equipment start-up, and testing, adjusting and balancing start and completion, and update the schedule during the construction period, as appropriate. Notify the Architect immediately when the performance verification activities not yet performed or not yet scheduled will delay construction.
h. Provide start-up and prefunctional testing for equipment and execute the electrical-related portions of the prefunctional checklists for the verification of the performance of all the equipment during the start-up and initial check-out process.
i. Perform and document start-up and system operational check-out procedures, providing a copy to the Architect.
j. Correct noncompliance items before beginning functional testing. Discrepancies and problems shall be remedied before functional testing.

2. Acceptance Phase:

a. Place equipment and systems into operation and continue their operation during each working day of the testing and performance verification activities, as required.
b. Provide skilled technicians to execute starting and prefunctional testing of equipment and to execute the functional tests for each individual piece of equipment and system. Technicians shall be available and present during the agreed upon scheduled tests and for sufficient duration to complete the necessary tests, adjustments and problem solving.
c. Perform functional testing for specified equipment and interpret the test data, as necessary.
d. Correct deficiencies (differences between specified and observed performance) as identified and interpreted by the Electrical Performance Verification Supervisor and interpreted by the Architect and retest the equipment, as required to demonstrate proper operation and performance.
e. Prepare operation and maintenance manuals as specified, including clarifying and updating the original sequences of operation to as-built conditions.
f. Maintain marked-up record drawings and produce final record drawings of project drawings and contractor-generated coordination drawings.
g. Provide specified training of the Owner's operating personnel.
h. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

3. Warranty Period:

a. Execute deferred functional testing.
b. Correct deficiencies and make necessary adjustments to operations and maintenance manuals and as-built drawings system or equipment modifications made during the warranty period and those identified in any deferred functional performance testing.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Standard testing equipment required to perform start-up, initial check-out, prefunctional, and required functional performance testing shall be provided by the contractor for the equipment or system being tested.

B. Test equipment shall be of the quality and accuracy required to test and/or measure system performance with the tolerances specified and shall have been calibrated within the last 12 months, or as specified herein. Equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates available on request.

1. Accuracy of sensors shall be at least twice that of the instrumentation being tested.

PART 3 - EXECUTION

3.1 SUBMITTALS

A. Submit additional documentation as required to support the performance verification process. This additional submittal documentation shall include, at a minimum, the proposed start-up and initial check-out procedures, and prefunctional checklists.

3.2 START-UP PLAN AND PREFUNCTIONAL TESTING

A. Prefunctional testing shall be required for each piece of equipment to ensure that the equipment and systems are properly installed and ready for operation, so that functional testing may proceed without delays. Follow the approved start-up, initial check-out, and prefunctional testing procedures. Sampling strategies shall not be used for prefunctional testing. The prefunctional testing for equipment and subsystems of a given system shall be successfully completed and documented prior to functional testing of the system.

B. Procedures for performance verification shall include:

1. Start-up and initial check-out plan: develop the detailed start-up and prefunctional testing plans for equipment and systems that are to be performance verified, as specified herein. Review the proposed procedures and prefunctional testing documentation to ensure that there is written documentation that each of the manufacturer-recommended procedures have been completed.

2. The start-up and initial check-out plan shall consist, as a minimum, of the following:

    a. The manufacturer's standard written start-up and check-out procedures copied from the installation manuals and manufacturer's normally used field check-out sheets. The plan shall include checklists and procedures with specific boxes or lines for recording and documenting the checking and inspections of each procedure and a summary statement with a signature block at the end of the plan.
    b. First-run checklist for equipment, including:

        1) Equipment properly set.
        2) Adjustment of vibration isolators.
        3) Equipment properly connected.
        4) Completion of initial lubrication procedures.
        5) Wiring properly connected.
        6) Electrical overload relays appropriate for load.
        7) Electrical accessories properly installed and adjusted.
        8) Controls, safeties, and time switches properly set.
        9) Verification of direction of motor rotation after final electrical connections by jogging motor.
        10) Measurement of amperage draw of electric motors and comparison with nameplate rating and with overload heater ratings.
        11) Monitoring of temperature build-up in motors and bearings.

    c. Contractor-developed prefunctional checklists.

3. Prior to energizing, test cables and wiring for continuity, shorts, and circuitry, and correct short circuits, opens, and errors in circuiting. Field test circuits phase-to-phase, phase-to-neutral, phase-to-ground, and neutral-to-ground.
4. Overcurrent Protective Devices:

    a. Set field-adjustable devices to dial and tap settings as scheduled in the approved overcurrent protective device coordination study subsequent to installation of units.
    b. Prior to energizing overcurrent protective devices, test devices for continuity of circuitry and for short circuits. Correct malfunctioning units.

5. Start-up equipment and check-out operation in accordance with manufacturer's published procedures and with the procedures specified herein.

    a. Submit report on equipment start-up and check-out with data from recorded findings.

6. In addition to other requirements specified herein, manufacturer shall provide services to start-up, check-out, and test the following equipment and systems:

    a. Emergency power supply systems.
    b. Switchboards.

7. Time switches: set for operation as directed by the Owner.
8. Emergency Power Supply System:

    a. Upon completion of the installation, the emergency power supply system shall be tested to ensure conformity to the requirements of the NFPA 110-2016, both in

power output and in function. The authority having jurisdiction and the Owner shall be given advance notification of the time the final test will be performed in order that the authority may witness these tests. The tests shall include performance test, full load test and cycle crank test, and shall be conducted and recorded as described in NFPA 110-2016.

9. Switchboards:

   a. After complete installation, a certified electrical testing firm shall provide complete switchboard testing, including:

      1) Check for tightness of bolted connections.
      2) Check for bus bar bracing.
      3) Check that contact and joint resistances in switches and circuit breakers are within manufacturer's tolerances.
      4) Check for installation and connection of equipment and circuits, and calibration or adjustment of meters, relays, remote controls, and other devices to ensure operation.
      5) Test to determine that circuit breaker trip devices are operating and adjusted.
      6) Test by high current injection method the ground fault protection of the switchboard devices, including selectivity. Certified reports shall be submitted indicating device settings, test current, and each device's measured tripping time, in cycles. In addition, the report shall include the name of the testing firm, date of the testing, and any deviations observed and corrective actions taken during the testing period.

10. Panelboards:

   a. Prior to energizing, measure the resistance between the neutral bus and ground bus for lighting and appliance branch circuit panelboards. The measurement shall be made with the feeder neutral disconnected. If the resistance is less than 1 megohm test each branch circuit for continuity, short circuits, or circuiting errors. Correct branch circuit problems. A final measurement of the panelboard shall be made and recorded after problems have been corrected.

11. Power Monitoring Equipment:

   a. Upon completion of the installation, the power monitoring equipment shall be tested to verify the following:

      1) Correct installation of current and potential transformers.
      2) Correct voltage, phase and frequency settings.
      3) Building network and/or building automation system connectivity.

12. Grounding:

    a. Ground resistance shall be measured by a licensed professional engineer in accordance with IEEE 81-2012. Measurements shall be made with the grounding system isolated from the utility neutral. Results of the tests shall be submitted in a certified test report, bearing the seal of the test engineer. The certified test report shall include the following minimum data:

        1) Project name, date and location of test.
        2) Instrument serial number and type used.
        3) Sketch, showing layout of ground system and locations of test spikes.
        4) Measured ground resistance.

13. Luminaires:

    a. Luminaires shall be operational at the time of substantial completion.
    b. Replace lamps that fail within 30 days after the date of substantial completion at no additional cost to the Owner.

14. Lighting control systems: field-test circuits, phase-to-phase, phase-to-neutral, phase-to-ground, and neutral-to-ground. Check continuity, switches, and for short circuits and perform additional tests recommended by the manufacturer. Correct short circuits, opens and errors in circuiting.

    a. Adjust and set as directed by the Architect, including the light levels of each zone in each scene and set up of control accessories.
    b. Start-up, calibrate and test daylighting control systems per manufacturer's written installation instructions.

        1) Controls shall be calibrated after room finishes and furniture are installed. Room finishes and furniture shall include, but not be limited to, paint, carpet, ceiling tiles, shades or blinds, and large artwork. Window treatments shall be installed and operable.
        2) Controls shall be calibrated under consistent daylight conditions. Controls shall not be calibrated under overcast or intermittent cloud cover sky conditions.

C. Identify which trade is responsible for executing and documenting each of the line item tasks and note that trade on the form. Each form may have more than one trade responsible for its execution.

D. The Architect reserves the right to witness the above described tests, checks and inspections. Notify the Architect at least 10 days prior to the date scheduled for the tests.

E. Four weeks prior to start-up, schedule equipment and systems start-up and check-out and notify the Architect in writing. The execution of the prefunctional checklists, start-up and check-out shall be directed and performed by the Contractor, in accordance with manufacturer's published procedures. The Architect shall be present for the start-up, check-out, and prefunctional testing of the first unit of each type of equipment, and any other tests he designates.

F. Sensor calibration: calibration of sensors associated with a given piece of equipment or system shall be included as part of the prefunctional testing and listed on the appropriate test checklists and reports for that system.

G. Completed start-up, check-out, and prefunctional test forms shall be completed and submitted to the Architect for review. List outstanding items of the initial start-up and prefunctional procedures that were not completed successfully, at the bottom of the procedures form or on an attached sheet. The procedures form and any outstanding deficiencies shall be provided to the Architect within 2 days of test completion. The Architect shall review the Contractor's start-up and prefunctional testing reports and shall submit either a noncompliance report or an approval form to the Contractor. The Contractor shall correct items that are deficient or incomplete in the checklists and tests in a timely manner, and shall notify the Architect as soon as outstanding items have been corrected and resubmit an updated start-up report and a statement of correction on the original noncompliance report. When requirements are completed, the Architect shall recommend approval of the start-up and prefunctional testing of each system and schedule the functional testing of the equipment or system.

H. Complete start-up and prefunctional testing for a system before functional testing of that system may proceed.

3.3 RETESTING OF EQUIPMENT AND/OR SYSTEMS

A. Provide labor and materials required for retesting of any functional test found to be deficient.

B. Prior to retesting, submit required data indicating that the deficient items have been completed and/or corrected to the Architect for approval and rescheduling of the functional test. If during the retesting it becomes apparent that the deficient items have not been completed and/or corrected as indicated in the data provided by the Contractor, the retesting shall be stopped. Costs for the design team to further supervise the retesting of a functional test shall be the responsibility of the Contractor.

3.4 DEFERRED TESTING

A. Schedule and coordinate, with the approval of the Architect, any required tests delayed until building construction is completed, required building occupancy or loading, or other conditions are suitable for the demonstration of equipment or system's performance, as specified herein. Deferred testing shall be executed, documented, and deficiencies corrected as specified herein for functional testing. Adjustments or corrections to the operation and maintenance manuals and as-built documents required by the results of the testing shall be made before the seasonal testing process is considered complete.

3.5 TESTING DOCUMENTATION, NONCONFORMANCE, AND APPROVALS

A. List outstanding items of the initial start-up and prefunctional procedures that were not completed successfully, at the bottom of the functional test procedure forms or on an attached sheet. Procedure forms and any outstanding deficiencies shall be provided to the Architect within 2 days of test completion. The Architect shall review the Contractor's start-up and prefunctional test reports and shall submit either a noncompliance report or an approval form to the Contractor. The Contractor shall work with the Architect to correct and retest deficiencies or uncompleted items. Correct items that are deficient or incomplete in the checklists and tests in a timely manner, and shall notify the Architect as soon as outstanding items have been corrected and resubmit an updated start-up report and a statement of correction on the original noncompliance report. When requirements are completed, recommend approval of the start-up and prefunctional testing of each system and schedule the functional testing of the equipment or system.

B. As functional performance testing progresses and deficiencies are identified, work with the Architect to resolve the issues.

3.6 OPERATION AND MAINTENANCE DOCUMENTATION PACKAGE

A. The Electrical Performance Verification Supervisor shall compile and prepare documentation for equipment and systems covered in Division 26 and deliver this documentation for inclusion in the operation and maintenance manuals prior to the training of the Owner's personnel.

3.7 INSTRUCTION OF OPERATING PERSONNEL

A. The Electrical Performance Verification Supervisor shall schedule, coordinate, assemble and deliver the documentation of the training required by this Division.

3.8 FUNCTIONAL TESTING

A. Functional test requirements for the demonstration of proper system and equipment operation shall be defined by the Electrical Performance Verification Supervisor. Execution of these tests and demonstrations of the required performance shall be the responsibility of the Contractor.

B. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems or subsystems at the discretion of the Architect and Electrical Performance Verification Supervisor. Beginning system testing before full completion of construction shall not relieve the Contractor from fully completing the system, including prefunctional checklists.

C. Functional testing shall be completed and approved by the Architect before the Project will be considered substantially complete.

END OF SECTION 260090

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SECTION 26 0500-FUELING SYSTEM ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. The "General Electrical Work" section describes the general materials and construction methods that apply to fueling electrical systems installed by the Contractors.

B. Contractor shall furnish and install all work in accordance with the following requirements, insofar as it applies to his work. Contractor shall consult the Scope of Work and the Drawings for a description of all work required.

C. The electrical contractor shall have five years of experience with installation of gasoline fueling system including controls, sensor wiring/panels and installing systems in a Class 1 Division 1 and Class 1 Division 2 zones.

D. Nothing in these specifications or on the contract drawings is to be construed to permit work not conforming to all applicable codes, regulations, vendor instructions and installation manuals.

E. The electrical contractor is to review all equipment installation manuals prior to starting any work.

1.2 DESCRIPTION OF WORK

A. This Section includes materials and methods necessary for electrical work shown, specified or required, including, but not necessarily limited to:

1. Raceways and fittings;
2. Conductors;
3. Wire and cable connectors;
4. Trenching and backfilling for electrical work;
5. Splicing;
6. Testing;
7. Cutting, patching, fitting, and providing and sealing penetrations through structures.

1.3 ELECTRICAL STANDARDS

A. The equipment and material required for the electrical construction of this project, and the installation of same, shall conform to the latest edition of the California Electrical Code, National Electrical Code, Local Electrical Code; and local governing codes. Where there is a difference between codes and this specification, the most rigid requirements shall apply. Where there is a conflict between these specifications and the standards, the most severe shall apply.

B. Clarification of any differences between the standards, codes, drawings and/or specifications will be made by the Owner.

C. Electrical materials and equipment, as listed by National Recognized Testing Laboratories, which will be installed as a part of this project, must bear the Underwriters inspection label.

Approval to use non-listed material must be obtained from the Owner in writing prior to material purchase.

D. Installation of the fueling system shall confirm specifically to the NEC chapter 514.

PART 2 - PRODUCTS

2.1 RACEWAYS

A. Manufacturer

1. Electrical fittings, etc., shall be Thomas & Betts, Steel City, Appleton, OZ, or equal. For convenience only, one name or number is used herein to indicate type and quality of item or product required.

B. Materials

1. Rigid Steel Conduits: Schedule 40, threaded, hot-dip galvanized.

a. Bushings: T & B series 1222 to 1232, insulated; T & B TIGB series, grounding; or equal.
b. Underground Duct: Carlon Plus 40 Rigid non-metallic Polyvinyl chloride, or equal, as manufactured by Stauffer Chemical, AMCO, or equal.

c. For PVC ducts: Couplings shall be PVC, sealed with solvent cement. Bends of 30, 45, 60 and 90 degrees shall be manufactured. Lesser bends shall be made by heating with hot air or other approved means and bonding duct to a minimum radius of 915mm, without flattening or loss of X-section.
d. Factory Standard Galvanized Steel: Galvanized per applicable ASTM standards, wrapped with Scotch wrap.

2.2 WIRE AND CABLE (600V)

A. Wiring and conductors shall be 600 volt stranded copper equal to Type THHN/THWN/MTW, 90^{o}C, in sizes as required and/or as indicated on the drawings. Wire fill in conduits shall be based on 40% maximum fill unless specifically approved by the AHJ prior to installation.

B. THHN type wire can be used only in aboveground dry location where applicable. For underground installation, THWN wire should be used.

C. The minimum conductor size permitted is 12 AWG for power and 14 AWG for control wiring conductors. The size of conductors which are not indicated on the drawings shall be of a carrying capacity such that the voltage drop shall not exceed two percent for feeders to the final distribution panels, and three percent for power or lighting branches.

D. Feeders and power branch circuit wiring conductors #2 and larger shall have rubber or thermosetting type polyethylene insulation, such as AGeneke@ or AVulkene@ and shall have Local Recognized Testing Laboratories rated insulation thickness as required for this classification. Rubber insulated conductors shall have a neoprene jacket when used in underground raceway installations.

E. Wire and cable shall be as manufactured by Rome Cable, Cerro Corporation, General Electric, American Insulated Wire, Triangle PWC, Power Conductor Division of Essex Group, Collier Insulated Wire, Okonite, or as approved by Owner.

2.3 CABLE AND WIRE CONNECTIONS (600V)

A. Cable and wire connections for splicing or terminating shall be made with compression deforming type copper connectors (except when wire other than copper is specified) as manufactured by Burndy Corporation, Thomas & Betts Corporation, Teledyne Penn-Union Electric, or as approved by Owner.

B. Connectors for cable size 250 kcmil and larger shall be long barrel type for double compression. Soldered connections will not be permitted. Lugs shall be sized for individual conductors. The use of oversize lugs with more than 1 wire is not allowed.

C. Twist-on insulated connectors may be used if they are resistant to vibration and are in the proper sizes. Twist-on connectors shall be as manufactured by Electrical Products Division of 3M Company, Thomas & Betts Corporation, Ideal Industries, Inc., or as approved by Owner.

D. Terminal connectors shall have the hole sizes and spacing in accordance with NEMA Standards. Terminal connectors will not be required for connections to the circuit breakers in the lighting and/or receptacle panels.

E. Connections made with non-insulated connectors shall be insulated with three (3) layers of plastic tape, each layer being half lapped. Plastic tape shall be No. 33 + as manufactured by Electrical Products Division of 3M Company.

F. All underground cable splices inside splice pull boxes shall utilize 3M cold shrink 8420 Series connector insulators manufactured by Electrical Productions Division of 3M Company, or Owner approved equal.

2.4 CABINETS AND ENCLOSURES

A. Sheet Metal - For cabinets for Panelboards and Pull boxes: Galvanized sheet steel; with protective priming coat and finish coat of enamel on all sides; both inside and outside of cabinets and boxes; not less in thickness than National Electric Code standard for dimensions of cabinets.

B. Face Plates and Trim for Panelboards: Stretch-leveled sheet metal.

C. All terminal cabinets to have terminal strips and all wiring in panelboards, terminal cabinets, splice boxes and j-boxes shall be labeled/tagged.

2.5 SUPPORT SYSTEMS

A. As manufactured by B-Line, Unistrut or approved equal.

B. All new hardware in manholes or underground pull boxes shall be stainless steel.

C. Multiple Runs: Support on Unistrut P-1000 channel with P2558 series conduit clamps or equal.

2.6 CONDUIT JOINTS

A. Conduit joints shall be cut square, threaded, reamed smooth, and drawn up tight to a shoulder in conduit bodies, or butt to butt in standard threaded couplings. Thread less conduit bodies, connectors or couplings will not be permitted. Conduit bends or offsets shall be made uniform with standard factory elbows or by benders approved by the Owner.

B. Conduit shall be as manufactured by Triangle PWC, Inc., Wheatland Tube Company, or as approved by the Owner.

C. Conduit joints used in Class I, Division 1 locations shall be explosion-proof. Threaded joints shall be made up of at least five threads fully engaged. All associated fittings shall be U/L listed for the application.

2.7 PULL BOXES AND JUNCTION BOXES

A. Boxes shall be NEMA 4/NEMA 3r and shall be made of Acode@ gauge steel of sufficient size to accommodate the cable. Pull boxes longer than 20 inches shall be provided with insulated cable supports. Cast aluminum pull boxes with conduit bosses shall be used for exterior locations.

2.8 BUSHINGS, LOCKNUTS, HUBS AND SEALING FITTINGS

A. Conduit terminations at all NEMA 12 enclosures shall be made with oil tight hubs as manufactured by Myers Electric Products, Inc.; Thomas & Betts Corporation, or as approved by Owner.

B. Bushings and Locknuts used in Class I, Divisions 1 and 2 locations shall be of a type approved for the conditions and use.

C. If any Owner furnished equipment has NEMA 1 general purpose sheet metal enclosures, then bushings and double locknuts shall be used for conduit termination. An insulating type bushing shall be provided for size smaller than 12 inches; sizes larger than 13 inches shall be provided with an insulted metallic type bushing. A grounding type bushing shall be provided at each conduit termination where there are concentric or eccentric knockouts.

D. Bushings and locknuts shall be as manufactured by O.Z./Gedney Company, Thomas & Betts Corporation, Appleton Electric Company, or as approved by Owner.

E. Sealing fittings shall be used in Class I Div 1 and Div 2 zones and shall be located as required by the Local Electrical Code. Fittings shall restrict the passage of gases, vapors, or flames from one portion of the electrical installation to the other at atmospheric conditions, pressure and normal ambient temperatures. Seal fittings shall be EYS type, double coated with a nominal 2 mil urethane on both interior and exterior, before PVC coating is applied. A minimum of 40 mil PVC coating shall be bonded to the exterior. Seal fittings shall be filled with sealing compound from the same manufacture as the fittings.

2.9 EXPANSION COUPLINGS

A. Expansion couplings shall be installed in raceways at wherever they cross building expansion joints or cross between two structures with separate foundations. Conduit expansion couplings

shall be complete with copper-bonding jumper and shall be Appleton Electric Company AType XJ@, or O.Z./Gedney Company AType EX@, or as approved by Owner. Expansion couplings shall be used wherever there is a possibility of movement due to thermal or seismic action.

2.10 CONDUIT BODIES AND OUTLET BOXES

A. Outlet boxes for exposed work and/or conduit bodies shall be of the cast malleable iron type with threaded conduit hubs as manufactured by Appleton Electric Company, Killark Electric Manufacturing Company, L.E. Mason Company, Crouse-Hinds Company, or as approved by Owner.

B. Cast metal covers with gaskets shall be used for damp and outdoor installations.

C. Conduits shall be terminated flush with finished floor and pit walls with flush conduit couplings and plug or with Type ES and ESL concrete slab inserts as manufactured by L.E. Mason Company, or as approved by Owner.

D. Conduit bodies and outlet boxes used in Class I, Divisions 1 and 2 shall be of a type approved for these conditions and use.

2.11 CABLE TIES

A. Nylon cable ties shall be 10mm wide (minimum) to prevent cutting of bound cables. Cable ties shall be T&B, Panduit, Brady, 3M, or as approved by Owner.

B. Cable ties shall be spaced 12 inches on center in switchboards or panel unless otherwise noted on drawings.

2.12 CONTROL PANELS, STATIONS, AND MISCELLANEOUS DEVICES

A. Control panels shall be provided with NEMA 12/3R enclosures. Units shall be provided with I^2T rated, fused main disconnect switch interlocked with the door, and separate fuses and overloads. The operating handle shall be flange mounted. Through-the-door type operators shall not be accepted for any application. Disconnect shall be at the right hand side of all panels.

B. Enclosures in hazardous areas shall be suitable for Class 1, Division 1 or 2 locations.

C. Pushbutton and selector switches shall be heavy duty, oil-tight construction provided with silver tipped contacts rated not less than six amperes continuous at 120 volts AC. They shall have the required number of momentary or maintained type contacts, and properly marked pushbuttons of type and style in accordance with proper function of equipment to be controlled. Stop button operators shall be of the unguarded type; other operators shall be of the fully guarded type. Control stations shall be installed in oil-tight enclosures or in covers of the motor starters.

D. Push-button stations shall be furnished with push-to-test pilot lights unless otherwise indicated on the drawings. Control stations shall be as manufactured by Square D Company, or Allen Bradley Company or as approved by Owner.

E. Control Panel Doors shall be interlocked with the main disconnect device as required by NFPA 789.

2.13 FUEL SYSTEM CONTROL PANEL ENCLOSURES

A. All electrical enclosures shall be dust-tight gasketed NEMA 12/3R and without knockouts. Doors shall not exceed 36 inches in width and shall be hinged on the left hand side and shall be able to swing out 165^{o} horizontally. The thickness of sheet steel used for walls and doors of enclosures shall be as shown below:

2.14 MAXIMUM AREA OF ANY SURFACE,

A. SQ. INCHES. MAXIMUM DIMENSION, IN STANDARD GAGE

Less than 360	18	16
Less than 1200	48	14
Less than 2000	60	12
Over 2000	84	10

B. Control Panels shall contain as an integral part a main disconnecting device. The disconnecting device shall be a fused disconnect switch. Disconnect switches shall be as outlined in these specifications. Control enclosures shall be Hoffman A28 Series, Gaylord or approved equal.

C. The disconnecting device shall be a heavy duty, horsepower rated, industrial type, quick-make, quick-break switch with visible blades in the open position. It shall also be certified type tested for satisfactory clearance of a fault which may occur when closing or in the closed position (fault rated). The fault conditions are:

D. "All control and power devices shall be plainly and permanently identified with the same identification as shown on the diagrams." "Identification shall be shown by embossed or engraved characters on a plate mounted adjacent to, or on the enclosure but not on, the device."

E. Plates shall be held in place by escutcheon nails, screws or equivalent.

F. Identification plates for devices mounted inside the control enclosure may be either non-corrodible metal, a minimum of .12 inches thick, or laminated phenolic engraving stock, a minimum of 1/16” thick.

G. Identification shall be provided for all devices having foreign voltages and shall be red engraved name plate indicating where the foreign voltage may be disconnected. Transparent insulated barriers shall be provided and identified to cover all terminals of foreign voltages. The barriers shall be easily removable but captive to prevent removal from the panel.

H. All power and control wiring shall be labeled at all terminal strips, device terminals and at tap connections in junction boxes. Markings shall be 3M labels, or approved equal with clear mylar tape covering.

I. All wire and conductors shall be made stranded, annealed copper. The minimum size of conductors shall be #12 for power and #14 for control unless otherwise specified. All conductors shall be insulated for 600 volts and shall be equal to Type THHN/THWN/MTW.

J. A schematic (elementary) diagram shall be included in all panels.

K. The interior of the panel shall be white.

L. Connections between control devices shall be front wired.

M. Panel wiring shall be contained in panel wireways made of non-warping insulating material rated for the highest voltage applied to any conductor contained. The wireway shall not contain exposed metal parts. Wireway shall be the minimum 600V rating.

N. Wireway shall be Panduit, Type E or Owner approved equal.

O. Wireways, where used, shall not be filled to more than 20 percent of cross-sectional area.

P. Multiple device control panels shall be equipped with terminal blocks for all outgoing wires of #4 AWG and lesser circular mil area. Conductors larger than #4 AWG may be terminated directly at the device.

Q. All terminals shall be plainly and durably marked to correspond to the markings on the electrical diagrams. Terminal blocks shall be numbered in numbered ascending order starting from top to bottom and from left to right.

R. Relays shall be numbered in numerical sequence on the panel.

S. There shall be no exposed terminals external to control enclosures, compartments and junction box.

T. All terminal and control component connections shall be screw or bolt pressure connectors. No solder connections will be allowed.

U. All components shall be removable from the front.

V. All component wiring shall be accessible from the front.

W. Terminal boards shall be wired and mounted so that internal and external wiring does not crossover terminal boards or adjacent devices.

X. All control circuits shall be grounded at the common side of the control transformer.

Y. All exposed non-current-carrying metal parts of control enclosures, motors, conduit, control stations, resilient mounted equipment and other devices and accessories whether movable or stationary, shall be ground with metal-to-metal bearing surfaces to the building steel.

Z. The control panel shall be provided with 20 percent spare space for mounting additional components.

AA. Control Panel Enclosure exteriors, shall be primer gray, unless otherwise stated.

BB. All incoming power wiring from the electrical source shall be fused with dual element fusetrons.

CC. All push buttons and pilot lights shall be oil tight. Pilot lights shall be push-to-test, Square "D" Class 9001, Type KT-1* or Allen-Bradley 800T-PT 16*. Push buttons shall be Square "D", Class 9001, Type KR-1U with Type KA-1 contact block or Allen-Bradley 800T.

DD. Control power transformer shall be exterior mounted on top of enclosure and shall be encapsulated type NEMA 3R with bottom conduit entry only.

2.15 SAFETY SWITCHES AND DISCONNECT SWITCHES

A. Safety switches and disconnect switches shall be fusible unless otherwise noted and of ampere rating as required, or as indicated on drawings. Switches shall be heavy duty, quick-make, quick-break, three phase, three pole, or as required, in a NEMA 3R enclosure with interlocking cover, externally front operated switch lever, and provision for use of a safety padlock in the off position. Switches for motor circuits shall be horsepower rated. The safety switches shall meet the I2T rating in accordance with the General Motors Basic Electrical Standards for Industrial Equipment.

Disconnect or Switch Ampere Rating	Minimum $I^2T \times 10^3$ Withstanding
30	125
60	500
100	2,600
200	7,850
400	30,000
600	50,000

B. Switches shall incorporate an auxiliary contact when so indicated on the drawings. This contact shall break the control circuit before the switch mechanism opens the power circuit, and close the control circuit after the switch mechanism makes the power circuit. Safety switches shall be as manufactured by Cutler-Hammer Corp., Square D Company, or Allen Bradley.

C. Safety switches and disconnect switches used in Class 1 locations shall be explosion-proof.

D. Roof ventilator safety switches shall be the same as described above except that they shall be non-fusible and shall be provided with weatherproof NEMA 3R enclosures.

E. Two-speed motor safety switches shall be the same as described above except they shall be six pole.

F. All motors shall be provided with safety switch in sight of the motor location without exception.

2.16 PANELBOARDS AND LOAD CENTERS

A. Distribution panelboards for 208Y120V shall be Circuit Breaker type. Units shall be free standing with NEMA 3R enclosure, or as shown on drawings.

B. Panel front shall be provided with hinged door. Finish in manufacturer's standard gray enamel.

C. Panelboards shall be provided with copper bus, ratings as scheduled on Drawings, Copper ground bus in all panelboards shall be provided.

D. Minimum short circuit rating shall be 10,000 amps minimum symmetrical at 280 volt for all panelboards, or as shown on drawings.

E. Branches shall consist of removable and interchangeable bolt-on type circuit breakers in quantity, voltage rating, ampere rating, and number of poles as indicated on the drawings. Circuit breakers shall be industrial type, ambient compensated, thermal magnetic type automatic overload trip, and identified with a circuit number in accordance with standard practice. Circuit breakers shall be of the quick-make, quick-break, or positive-make, quick- break type. Fluorescent lighting fixtures which are to be controlled from the panelboard shall have branch circuit breakers rated and marked equal to SWD in accordance with Underwriters Laboratories, Inc. requirements. Multi-pole circuit breakers shall be installed to serve loads which are connected phase-to-phase. Bailed single-pole breakers are not allowed. Five locking devices shall be provided with each panel. Locally switched areas, receptacle, and night light circuits shall be provided with locks.

F. The entire assembly shall be front accessible and shall consist of main lugs or main device as shown on the plans.

G. Feeder devices 150-ampere frame through 1200 ampere frame shall be panel-mounted-type construction. Devices over 1200-ampere frame or main devices shall be individually mounted when required.

H. Main horizontal bus bars shall be mounted with all three phases arranged in the same vertical plane. Bus sizing shall be based on NEMA standard temperature rise criteria of 65 degrees C over a 40 degrees C ambient.

I. Provide a full capacity neutral bus.

J. A copper ground bus (minimum ¼” x 2”), shall be furnished firmly secured to each vertical section structure, and shall extend the entire length of the switchboard.

K. All hardware used on conductors shall be high-tensile strength and zinc-plated. All bus joints shall be provided with conical spring-type washers.

L. Small wiring, necessary fuse blocks and terminal blocks within the switchboard shall be furnished as required. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer's wiring diagrams.

M. Mechanical-type terminals shall be provided for all line and load terminations suitable for copper or aluminum cable rated for 75 degrees C of the size as indicated on the drawings.

N. Lugs shall be provided in the incoming line section for connection of the main grounding conductor. Additional lugs for connection of other grounding conductors shall be provided as indicated on the drawings.

O. All control wire shall be equal to Type SIS, bundled and secured with nylon ties. Insulated locking spade terminals shall be provided for all control connections, except where saddle-type terminals are provided integral to a device. All current transformer secondary leads shall first be connected to conveniently accessible short-circuit terminal blocks before connecting to any other device. All groups of control wires leaving the switchboard shall be provided with terminal blocks with suitable numbering strips. Provide wire markers at each end of all control wiring.

P. Standard metal raceways, trim, and doors shall be constructed of "code" gauge sheet steel. Trim shall be complete with concealed full length piano hinges, door with concealed flush hinges, flush catch with keyed lock and an oversize directory frame on inside of door with a plexiglas cover.

Q. Directories designating the light fixtures and outlets controlled by each branch circuit in the lighting panel shall be placed in each panel cabinet. The required information shall be neatly typewritten.

PART 3 - EXECUTION

3.1 CONDUIT

A. Conduit – Definition

1. The term Aconduit@ as used in these specifications refers to rigid steel SCH 40 conduit, or PVC type installed underground.

B. Conduit – Typical

1. Install in a manner as hereinafter specified, rigidly secured in position without sagging, by means of pipe clamps or metal cleats.
2. Structural members shall in no case be drilled, bored or notched in such a manner that it will impair their structural value. Cut holes, if required, with core drill and only with approval of Owner.
3. Provide all necessary sleeves and chases where conduits pass through floors and walls. Any other necessary openings and spaces shall be arranged for in proper time to prevent unnecessary cuttings. After conduits are installed, fill and seal all remaining openings around conduits, where
4. they pierce floors or slabs, and finish to match adjacent surfaces. Do all necessary cutting in connection with the work and make all repairs in a manner satisfactory to Owner.

C. Underground Conduits

1. Install a ground conductor where required for power systems.
2. Excavate trenches for all underground conduits to depth shown. Where depths are not indicated, bury conduits not less than 36 inches below finish grade. Grade trenches so that conduit lines will drain to exterior pull boxes with a fall of not less than 3 inches per 100 feet. Required depth is from finish grade to top of conduit.

3. All underground conduits installed in or on sand or gravel fill under slab on grade shall be rigid PVC. Conduit shall have at least 3 inch river sand enveloped all around.
4. All buried rigid steel conduits shall be half-lapped wrapped to 6 inch above finish grade with 10 mil tape.
5. Backfill trenches with aggregate material and compact to 90% compaction.
6. All conduits running through the footings shall have a sleeve 2" diameter larger than conduit (1" clear around conduit). End of conduit shall be sealed with flexible sealant.

D. Type of Conduit

1. Rigid steel SCH 40 shall be used for all work.
2. PVC schedule 40 shall be used for all conduits in slabs or site work not under buildings or in Class I Div 2 areas.

E. Conduit Installation

1. Paint all exposed conduit installation to match adjacent surface and all joints in rigid steel conduit with rust-resisting paint.
2. Install all conduits with code radius bends; where more than four radiuses are required, install pull boxes. Cover conduits with T & B 1460 to 1465 series capped bushing; protect during construction; blow out and swab before wires are pulled. Ream all conduit ends after cutting. Install 70 lbs nylon cord in all empty conduits. (Plug or cap spare conduits at dead ends.)
3. Running threads are prohibited. Where necessary for connecting conduits, install AErickson@ couplings.
4. Secure all conduits entering pull boxes or switchgear with lock-nuts and non-metallic bushings at the end of the conduit.
5. Run exposed conduit parallel or at right angles to the center lines of columns and beams.
6. Where any conduit (or wiring) crosses a building separation or expansion joint, provide for conduit system movement. Similar to OZ Gedney Type AX8.
7. In Class I, Division 1 and 2 locations, conduit seals shall be located in accordance with the latest edition of NEC adopted by the Local Authority, respectively and as shown on the drawings. Sealing compounds shall be of a type approved for the conditions and use. Manufacturer shall be Appleton Electric Company, Crouse-Hinds Company, or as approved by Owner. All seals shall be Local Recognized Testing Laboratories listed.
8. Provide design/build conduit supports as needed.

3.2 INSTALLATION OF WIRE

A. Draw no wire into any conduit until all work of any nature that may cause injury is completed; take care in pulling in wires that no damage occurs to insulation of wire. Use Gel-Lub or Polywater J for pull-in lubrication. Yellow 77 is not acceptable.

B. Make up all splices in pull boxes with connectors as specified herein under Splices and Terminations.

END OF SECTION

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SECTION 261100 - RACEWAYS

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other electrical systems are specified in other Sections of Division 26.

B. This Section covers raceways for electrical, telephone, data, fire alarm, communications, and security wiring.

C. This Section includes responsibilities and obligations in support of the performance verification specified in Section 260090, Electrical Performance Verification.

1.2 QUALITY ASSURANCE

A. Conform to the following:

1. NECA 101-2013.
2. NECA 102-2004.
3. NECA 111-2003.

B. Conduit sizes specified herein or indicated on the Drawings refer to the standard trade sizes, are for identification purposes only, and are not actual dimensions.

PART 2 - PRODUCTS

2.1 ELECTRICAL METALLIC TUBING

A. Galvanized steel.

B. Connectors and couplings shall be malleable iron or steel, galvanized or cadmium-plated, compression or set screw type.

C. Connectors shall have insulated throats.

D. Manufacturer: Allied Tube & Conduit, Republic Conduit, Western Tube & Conduit, or Wheatland Tube.

2.2 FLEXIBLE METAL CONDUIT

A. Galvanized steel.

B. Connectors shall be of the twist-in, insertion or totally enclosed clamp type, galvanized malleable iron or steel, with insulated throats.

C. Manufacturer: Alflex, American Flexible Conduit, Cerro Wire & Cable, or Steelflex Electro.

2.3 LIQUIDTIGHT FLEXIBLE METAL CONDUIT

A. Extra flexible type, neoprene-jacketed.

B. Connectors shall be watertight, of the twist-in, insertion type, galvanized malleable iron or steel, with insulated throats.

C. Manufacturer: Alflex, American Flexible Conduit, International Metal Hose, or Universal Metal Hose.

2.4 RIGID AND INTERMEDIATE METAL CONDUIT

A. Galvanized steel.

B. Connectors and couplings shall be threaded galvanized malleable iron or steel.

C. Locknuts shall be of the type with sharp edges that bite into enclosure where connected.

D. Plastic insulating bushings shall be high temperature type.

E. Sealing bushings shall have galvanized malleable iron locking ring with molded neoprene sealing ring with predrilled holes to accommodate each individual conductor, stainless steel screws and washers, PVC-coated pressure discs, and factory-installed lay-in grounding conductor lugs.

F. Hub fittings shall be 2-piece, insulated throat, liquidtight type of steel or malleable construction.

G. Manufacturer: Allied Tube & Conduit, Republic Conduit, Western Tube & Conduit, or Wheatland Tube.

2.5 RIGID NONMETALLIC CONDUIT

A. Rigid nonmetallic conduit shall be rigid polyvinyl chloride, nonburning, high impact, schedule 40.

B. Couplings and connectors shall be rigid polyvinyl chloride, high impact, schedule 40.

C. Cement for connections of conduit shall be approved by the conduit manufacturer.

D. Manufacturer: Cantex, Carlon, Plastiline, or Queen City Plastics.

2.6 ACCESSORIES

A. Pull lines: minimum tensile strength of 200 lb. Pull lines in nonmetallic conduit shall be galvanized steel wire.

B. Expansion fittings: concretetight with ground continuity.

1. Manufacturer: Appleton, Crouse-Hinds, or O-Z/Gedney.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install conductors in raceways, unless otherwise specified herein.

B. Raceways shall be concealed above ceilings, in walls, floors, or underground. Raceways shall be exposed where indicated on the Drawings or as specified herein.

C. Unless otherwise indicated on the Drawings or specified herein, minimum raceway size shall be 0.75". Minimum raceway size for telephone, communications, and data cable shall be 1". 0.375" flexible connections to recessed luminaires are acceptable.

D. Install the raceway systems, where indicated on the Drawings, complying with manufacturer's written instructions.

E. The raceway installation shall follow the layout indicated on the Drawings. Changes in the location, and offsets to accommodate building conditions, and coordination with the work of other trades, including equipment, piping and ductwork, shall be made prior to initial installation, without additional cost to the Owner. Offsets in conduit are not indicated on the Drawings and shall be furnished.

F. Unless otherwise indicated on the Drawings, route raceways tight to the underside of the structure and above ceilings. Offset raceways below obstructions.

G. Where raceways must pass through structural members, obtain approval from the Architect regarding location and size of openings prior to drilling.

H. Raceways that pass through expansion joints shall be provided with expansion fittings.

I. Raceway penetrations through the roof shall be made with prefabricated fittings. Coordinate with the roof system manufacturer.

J. Raceways shall be run parallel with or at right angles to the building walls.

K. Lateral raceways in masonry shall not exceed 0.75".

L. Raceways shall be secured in place and protected to prevent damage to the work during construction. Refer to Section 261900, Supporting Devices for support requirements and methods.

M. Open ends of raceways shall be taped or capped after installation to prevent entry of dirt and debris during construction prior to pulling wire.

N. Installation of raceways shall be complete and shall be blown-out and swabbed clear of water and trash prior to pulling wire.

O. Running threads shall not be used for threaded connections on intermediate metal or rigid metal conduit. Conduit threading shall be limited such that the joint is watertight and that not more than 1-1.5 threads are exposed after conduit is tightened in fittings or threaded box openings.

P. Exposed threads or field-cut edges of conduits shall be immediately coated with a galvanizing compound after installation.

Q. Make connections to motors, not near walls or columns, with a vertical rigid metal conduit, minimum size 0.75" attached to floor and ceiling. Wiring shall be carried into and out of this conduit by means of condulets and flexible conduit.

R. Install junction or pull boxes to avoid excessive runs or bends. Several such boxes are indicated on the Drawings. The locations shown may be varied and additional boxes installed. Refer to Section 261300, Boxes for specific box types and requirements.

S. Provide pull lines in empty raceways. At each end, leave 12" of slack coiled in the box, or at the end of the conduit where boxes are not installed, and secure at each end.

T. The exact routing of new exposed raceways shall be approved by the Owner and Architect before installation.

3.2 ELECTRICAL METALLIC TUBING

A. Electrical metallic tubing shall be installed for:

1. Raceways in concrete and masonry construction above grade, in hollow spaces in columns and walls, and above ceilings.
2. Exposed raceways in unfinished areas.

B. Electrical metallic tubing stubbed-up from floor slabs or down from ceiling plenums and not connected to an enclosure shall terminate with an insulated throat connector.

3.3 FLEXIBLE METAL CONDUIT

A. Flexible metal conduit shall be installed for:

1. Connections to recessed luminaires, maximum 72" length.
2. Connections to motors.
3. Connections to electrical equipment subject to movement or vibration.
4. Connections to equipment in dry locations mounted on vibration isolators, and to dry-type transformers mounted on external vibration isolators, minimum length of 18" or 12 times the nominal diameter of the conduit, whichever is larger.

3.4 LIQUIDTIGHT FLEXIBLE METAL CONDUIT

A. Liquidtight flexible metal conduit shall be installed for:

1. Connections to motors in damp or wet locations.
2. Connections to electrical equipment subject to movement or vibration where exposed to rain, spray, or a corrosive atmosphere.
3. Connections to equipment subject to oil or grease.
4. Connections to fire pumps and auxiliary equipment.

3.5 RIGID AND INTERMEDIATE METAL CONDUIT

A. Rigid and intermediate metal conduit shall be installed for:

1. Exposed raceways outside of the building.
2. Exposed raceways serving fire pumps, jockey pumps, and fire pump control equipment.
3. Exposed telecommunications entrance conduit.
4. Exposed service entrance conduit.
5. Conduits containing emergency power supply system signal and control wiring.
6. Applications not otherwise specified herein.

B. Conduit shall be secured to metal enclosures using hub fittings.

C. Insulated bushings or fittings shall be installed at connections to cabinets and boxes. Terminate stub-ups not attached to enclosures with an insulated throat grounding bushing.

D. Commercial pipe joint compound shall be applied to the male threads on threaded joints and fittings.

E. Connections shall be wrenchtight, and where subject to ground water, rain or spray shall be watertight.

F. Field treat conduit and fittings buried in earth or gravel with one of the following:

1. 2 coats of asphaltum.
2. Spiral wrapped, half-lapped, 20 mil plastic tape.

3.6 TELEPHONE AND DATA RACEWAYS

A. Service raceways shall be installed as indicated on the Drawings and shall be coordinated with the service provider.

B. Raceways terminated at wood backboards shall be turned-up out of the floor slab to 12" above the finished floor if routed from below, and turned down and terminated 12" above the top of the backboard if routed from above.

C. Install in accordance with TIA 569-D-1-2016.

3.7 RIGID NONMETALLIC CONDUIT

A. Rigid nonmetallic conduit shall be used for exterior underground and specific applications where indicated on the Drawings.

B. An insulated copper grounding conductor shall be installed in each plastic conduit unless prohibited by local codes or utility company. Grounding conductors shall be bonded to grounded metal enclosures or devices at origin and at each outlet. Refer to Section 264500, Grounding for specific requirements and methods.

C. Rigid nonmetallic conduit shall not be stubbed up above the finished floor for attachment to boxes, outlets, or equipment. A transition to rigid metal conduit shall be made a minimum of 18" horizontally from each stub-up.

3.8 RACEWAY SLEEVES AND SEALING

A. Provide sleeves and fire stopping for raceways penetrating floors and partitions as specified in Section 260010, Electrical General.

B. Install conduit sealing bushings on conduits that penetrate slabs or walls below grade.

C. Conduits entering refrigerated spaces, and hazardous areas, shall be installed with sealing fittings listed for the specific application to prevent entrance of moisture and explosive substances.

D. Raceways installed between luminaires and outlets exposed to weather and interior conditioned space shall be sealed with nonhardening elastic duct sealant at the last outlet in the conditioned space.

END OF SECTION 261100

SECTION 261150 -UNDERGROUND DUCTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other electrical systems are specified in other sections of Division 26.

B. This Section covers underground ducts to form underground raceway systems for power and signal conductors.

C. Underground warning tape is specified in Section 260010, Electrical General.

D. This Section includes responsibilities and obligations in support of the performance verification specified in Section 260090, Electrical Performance Verification.

1.2 QUALITY ASSURANCE

A. Conform to the following:

1. ACI 318-2014.
2. ASTM C478-2015a.
3. NECA/NEMA 605-2005.
4. National Electrical Code-2014 with South Carolina Modifications-2016.

PART 2 - PRODUCTS

2.1 CONDUITS:

A. As specified in Section 261100, Raceways.

2.2 MISCELLANEOUS

A. Sealing devices: malleable iron, watertight, gland type with integral flanges and pressure bushings at each end.

B. Spacers: rigid, PVC type.

C. Concrete: as specified in Section 260010, Electrical General, except 28 day compressive strength shall be 4000 psig.

D. Innerduct liners: corrugated high density orange polyethylene, with an inner diameter of 1".

PART 3 - EXECUTION

3.1 GENERAL

A. Unless indicated otherwise on the Drawings, the following types of construction shall be used:

1. Electrical service and circuits exceeding 5 kV or 800 A:

a. Concrete-encased nonmetallic rigid conduit.

2. Telephone and data service:

a. Concrete-encased nonmetallic rigid conduit.

3. Electrical circuits other than those specified above:

a. Rigid metal conduit without concrete encasement.

4. Telephone and data conduits:

a. Rigid metal conduit without concrete encasement.

B. Excavation and backfill: as specified in Section 260010, Electrical General.

C. Concrete formwork, and reinforcing: shall conform to Division 03, Concrete.

3.2 DUCT LINE INSTALLATION - GENERAL

A. Slope ducts to drain towards manholes and handholes, and away from buildings and equipment entrances. Minimum pitch shall be 4" per 100'. Where it is not possible to avoid a trap or low point in a duct which is not concrete encased, provide a 0.5" hole drilled in the bottom of the conduit at the low point and a crushed stone sump below the conduit. If possible, install the sump above the high water table elevation. Otherwise prevent the accumulation of water within the conduit.

B. Offset ducts to avoid conflicts with existing underground obstructions.

C. Curved sections in duct lines shall consist of long sweep bends with a minimum radius of 50' in the horizontal and vertical directions. Manufactured bends with a minimum radius of 48" shall be limited to building entrances and stub-ups to equipment.

D. The portion of underground conduit run under building slabs shall be rigid galvanized steel or concrete-encased nonmetallic rigid conduit. Rigid galvanized steel used shall be extend a minimum of 5' outside the building or slab foundation where a transition to concrete-encased nonmetallic rigid conduit for the electrical service occurs. Stub-ups to equipment mounted on outdoor concrete slabs shall be rigid galvanized steel. Install insulated grounding bushings on the terminations of metallic conduit.

E. Keep ducts clean of dirt, sand, or gravel during construction, and sealed with tapered plugs upon completion of each portion of the work.

F. Upon completion of the duct line installation, pull a flexible mandrel through each conduit to loosen particles of dirt, sand, or foreign material. Mandrels shall be not less than 12" long, and shall have a diameter 0.5" less than the inside diameter of the conduit. A brush with stiff bristles slightly larger than the conduit diameter shall then be pulled through each duct to remove the loosened particles.

G. Seal ducts and conduits at building entrances, and at outdoor terminations for equipment, with a nonhardening compound.

H. Conduits shall be terminated in end bells, spaced approximately 9" on center at the face of manhole walls for 4" conduits, and proportionately spaced for other sizes. The change from regular conduit spacing to end bell spacing shall start 10' from the face of the manhole wall and shall be made in such a way that the slope of any conduit shall not be less than that of the main bank and no trap will be formed. New conduit entrances into existing manholes and building walls shall enter at locations consistent with grading requirements and existing entrances and shall be waterproofed.

I. Joints in conduits and fittings shall be made watertight. Threaded portions of conduits that are not to be encased in concrete, and adjoining ends of conduits, couplings and fittings, shall be heavily coated with asphaltum after installation. Connections between conduits of different types shall be made using adapters and methods recommended for the purpose by the conduit manufacturers.

J. Where an underground conduit enters the building through a membrane-waterproofed wall or floor, a sealing device shall be provided. Where a concrete envelope is required the sealing device shall be on the inside only. Devices shall be securely anchored into masonry construction. Membrane waterproofing shall be secured to the device in a permanently watertight manner.

K. Conduits entering a building shall be sealed at the first termination with oakum or a plastic expansible compound.

L. Where an underground conduit, not concrete encased, enters the building through a nonwaterproofed wall or floor, provide a sleeve made of schedule 40 galvanized pipe. The space between the conduit and the sleeve shall be filled with plastic expansible compound or an oakum and lead joint on each side of the wall or floor. Sealing devices specified herein are acceptable in lieu of sleeves.

M. Conduits shall be straight between manholes or upturned elbows. Where bends are unavoidable in nonmetallic conduits, they may be made by assembling couplings at a slight angle, provided the watertight seals are not broken and the resulting radius is not less than 100'. For radii less than 100', 5º angle couplings or 5º factory-made bend sections shall be used.

N. Multiple conduit runs, direct burial or concrete encased, shall be supported on preformed, nonmetallic separators. Spacing between exterior surfaces of conduits generally shall be not less than the following: 3" between conduits containing cables operating at similar voltage, and 6" between signal conduit and any power conduit in the same envelope. Spacing between separators shall be close enough to prevent sagging of conduits or breaking of couplings or watertight seals and to keep deformation of conduit at the separators to 0.1" or less. Separators shall be secured with cords where necessary. No tie wires, reinforcing rods or other metallic materials shall be placed in direct contact with conduits, either individually or in groups.

O. Multiple conduit runs shall be arranged substantially as indicated on the Drawings, but minor changes in location or cross sectional arrangement shall be made as necessary to avoid

obstructions. Where conduit runs cannot be installed as shown because of conditions not discoverable prior to digging of trenches, notify the Architect. Underground conduits shall be coordinated with other outside utility work. Existing outside utilities shall be maintained in operation unless otherwise directed.

P. Where conduits cross under existing roadways, walks or other paved areas, rigid metallic conduits may be driven under such areas in lieu of installing the conduits in trenches. After installation of conduit, existing paved or grass areas which have been disturbed in any way shall be restored to their original condition. Where the Drawings indicate spare conduits under existing roadways, walks, and other similar paved areas, ends of conduits shall be capped 5' beyond the pavement. The ends of these conduits shall be marked by the placement of 6" diameter by 18" long concrete monuments set flush in ground permanently identified "Spare Conduit".

3.3 CONCRETE-ENCASED DUCTS

A. Spacers shall be installed maximum 5' on center, and shall support and maintain uniform spacing of the duct assembly a minimum of 3" above bottom of the trench during the concrete pour.

B. Extend the concrete envelope encasing the ducts at least 3" beyond the outside walls of the outer conduits.

C. Where new ducts, conduits, and concrete envelopes are to be joined to existing manholes, handholes, ducts conduits, and concrete envelopes, make joints with fittings and fabricate the concrete envelopes to ensure smooth transitions.

D. Envelopes may be poured directly against the sides of the trenches if the cut is clean, even and free of loose material. Forms are required where the soil is not self-supporting. Loose dirt and extraneous material shall be removed from the trenches before and during pouring of concrete. Concrete shall be carefully spaded during pouring to eliminate voids under and between the conduits and honeycombing of the exterior surfaces. Power driven tampers or agitators shall be specifically designed for the application.

E. Each run of envelope between manholes shall be poured in one continuous operation. Where more than one pour is necessary, each pour shall terminate in a vertical plane, and 0.75" reinforcing rod dowels shall be provided at each corner of the duct line and between exterior conduits, 1.5" from the exterior surface, extending 18" into the concrete on each side of the joint.

F. Where an envelope is installed over disturbed earth, across other conduits or pipe lines, or under paved areas such as roads, driveways, or parking areas, it shall be reinforced. Reinforcement shall also be provided where envelopes connect to manhole and building walls. Where envelopes are terminated for future extension, dowels shall be provided as specified herein for joints between pours.

1. Reinforcement at connections to buildings, manholes, and handholes shall extend 10' from the point of connection.
2. Reinforcement at conduit and pipe line crossings and at crossing of areas of disturbed earth shall extend 10' beyond the crossing.
3. Envelopes reinforced under paved areas shall include envelopes within 10' of the paved areas.

4. Minimum reinforcement shall consist of No. 4 steel reinforcing bars located longitudinally 1.5" inside the envelope surfaces at each of the four corners of the concrete envelope with No. 3 steel reinforcing ties located 2' on center.

    a. In multiconduit ducts, additional intermediate reinforcing bars shall be located in a single layer 1.5" above the bottom of the concrete envelope. Locate intermediate reinforcing bars in each space between the conduits in the lowest row.
    b. In multiconduit ducts under paved areas, additional intermediate reinforcing bars shall be located in a single layer 1.5" above the bottom of the concrete envelope and in a single layer 1.5" below the top of the concrete envelope. Locate intermediate reinforcing bars in each space between the conduits in the lowest row and in the highest row.

G. The top surface of electrical ducts containing conductors of systems rated 300 V to ground or higher shall be painted red for permanent duct bank identification.

3.4 DIRECT BURIAL DUCTS

A. Field treat metallic conduit and fittings buried in earth or gravel as specified in Section 261100, Raceways.

B. Install direct burial conduits only where direct burial is indicated on the Drawings.

END OF SECTION 261150

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SECTION 261200 - BUILDING WIRE AND CABLE, 600 VOLT

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other electrical systems are specified in other Sections of Division 26.

B. This Section covers building wire, cable, and associated connection devices and accessories rated for 600 V.

C. Wiring for communications and alarm systems is covered in other Sections of Division 26.

D. This Section includes responsibilities and obligations in support of the performance verification specified in Section 260090, Electrical Performance Verification.

1.2 QUALITY ASSURANCE

A. Specified conductor size refers to American Wire Gauge (AWG).

B. Conform to the following:

1. National Electrical Code-2014 with South Carolina Modifications-2016.

PART 2 - PRODUCTS

2.1 GENERAL

A. Conductors #10 AWG or smaller shall have outer covering color-coded to indicate phase, neutral, and ground conductors. Colors shall be as follows:

Conductor	208/120 V Systems	480/277 V Systems
Phase A	Black	Brown
Phase B	Red	Orange
Phase C	Blue	Yellow
Neutral	White	Gray
Ground	Green	Green
Isolated ground	Green/Yellow	Green/Yellow

2.2 CONDUCTORS

A. Conductors shall be copper. Sizes indicated on the Drawings or specified herein refer to copper conductor sizes.

B. Conductors shall be a minimum of #12 AWG solid unless otherwise specified herein. Conductors #8 AWG and larger shall be stranded.

C. Insulation shall be type THHN/THWN-2 or XHHW-2, 600 V, rated at 90°C.

D. Luminaire wiring shall be high temperature fixture or machine tool wire.

E. Lay-in luminaires equipped with UL listed 72" flexible metal conduit and connector assemblies shall be prewired with minimum #18 AWG conductors in the flexible assembly.

F. Conductors shall have size, grade of insulation, voltage, and manufacturer permanently marked on the outer cover at intervals not exceeding 24".

G. Manufacturer: Aetna, Cerrowire, Colonial, Encore, General Cable, Pirelli, Southwire, or United Copper Industries.

2.3 CONNECTION DEVICES FOR COPPER CONDUCTORS

A. For splices and taps on conductors #10 AWG and smaller, connection devices shall be twist-on or crimp pressure type.

B. Splices, taps and bus bar terminations of conductors #8 AWG and larger shall be made with compression, crimp type connection devices.

C. Manufacturer: 3M, Ideal, Panduit, or Thomas & Betts.

2.4 ACCESSORIES

A. Electrical tape: high voltage splicing, filler, and vinyl plastic electrical type.

1. Manufacturer: 3M, Anixter Brothers, or Plymouth.

B. Connection covers: plastic type.

1. Manufacturer: Ideal, Panduit, or Thomas & Betts.

C. Pulling compound: shall not deteriorate conductors or insulation.

D. Identification tape: color-coded, self-adhering, 1" wide type.

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

A. Install in each raceway a minimum of 3 #12 AWG conductors, including ground conductors, unless otherwise specified herein or indicated on the Drawings.

B. Branch Circuit Homeruns:

1. For 120 V, 20 A circuits 75' or greater provide #10 AWG homerun conductors.
2. For 277 V, 20 A circuits 150' or greater provide #10 AWG homerun conductors.

C. Install wiring, cables, and connection devices in accordance with the manufacturer’s instructions.

D. Install conductors in raceways unless specifically indicated otherwise on the Drawings.

E. Conductors in one raceway shall be installed at one time, using pulling compound.

F. Conductors in panelboards, switchboards, and control cabinets shall be grouped and laced with nylon tie straps.

G. No more than three branch circuit homeruns shall be installed in a conduit.

H. Connect each circuit of a multicircuit home run to a different phase at the panelboard.

I. 120 V Single-phase line-to-neutral branch circuits shall be provided a separate dedicated neutral conductor for each branch circuit. Multiwire branch circuits with shared or common neutrals are not acceptable.

J. Where multiple single-phase line-to-neutral branch circuits are spliced within a common box or enclosure each phase and neutral conductor shall be identified with corresponding panel and circuit number at each splice.

K. Support cable risers. See Section 261900, Supporting Devices for specific supporting methods.

L. Termination of more than 1 conductor in a single terminal is not acceptable except where the terminal is approved by the manufacturer for such application.

3.2 COPPER CONNECTION DEVICES

A. Dies for compression tools shall be as recommended by the manufacturer for each conductor size involved.

B. Connectors shall exert positive pressure to the conductors.

3.3 CONNECTIONS TO MECHANICAL EQUIPMENT

A. Locations of motors, equipment, and apparatus indicated on the Drawings are approximate and connections shall be made to such equipment where actually installed.

3.4 JOINT COVERING

A. Cover electrical connections with successive layers of high voltage filler putty or splicing tape, varnished cambric tape, and vinyl plastic electrical tape to cover rough edges and to provide insulation equal to that of conductor insulation.

3.5 IDENTIFICATION

A. Switch legs shall be color-coded the same as phase conductors.

END OF SECTION 261200

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SECTION 261300 - BOXES

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other electrical systems are specified in other Sections of Division 26.

B. This Section covers outlet boxes, junction and pull boxes, and conduit bodies.

C. This Section includes responsibilities and obligations in support of the performance verification specified in Section 260090, Electrical Performance Verification.

1.2 QUALITY ASSURANCE

A. Outlet boxes, junction and pull boxes, and conduit bodies shall be UL listed. Equipment installed in hazardous locations or corrosive atmospheres shall be listed for the specific application.

B. Conform to the following:

1. National Electrical Code-2014 with South Carolina Modifications-2016.

PART 2 - PRODUCTS

2.1 GENERAL

A. Boxes shall be the type, size and configuration required for its specific use, location, device or luminaire, and number, size, and arrangement of raceways connecting thereto.

2.2 OUTLET BOXES

A. Construction: code-gauge galvanized steel, unless otherwise specified herein or indicated on the Drawings.

B. Where installed in hazardous locations, or exposed to corrosive atmosphere, rain or spray, boxes shall be corrosion resistant cast metal with threaded entrances, removable covers, gaskets, and corrosion resistant screws.

C. Recessed boxes in gypsum board walls or columns shall be 4" or 4.688" square, 2.125" deep with plaster rings.

D. Surface-mounted boxes on walls or columns shall be 4" square, 2.125" deep, with no plaster rings or knock-outs.

E. Switch boxes with only one conduit entrance shall be single gang.

F. Boxes for devices recessed in metal door jambs shall be sheet metal partition boxes sized for the application.

G. Recessed boxes in masonry walls shall be square cornered masonry boxes or standard 4" square boxes fitted with square cornered tile covers of proper depth for block. Both type boxes shall be 2.125" minimum depth.

H. Recessed boxes in ceilings shall be 4" octagonal or square, 2.125" depth.

I. Recessed boxes in concrete shall be UL approved for the application.

J. Through-wall type boxes are not acceptable.

K. Recessed wall telephone and data boxes shall be 4" square, 2.125" deep with single-gang device plaster covers and coverplates.

L. Provide specially designed boxes where required for special devices.

M. Boxes containing low voltage and line voltage devices or multiple 277 V switches, supplied from different phases, shall have metal barriers.

N. Boxes for surface-mounted luminaires shall have fixture studs.

O. Manufacturer: Appleton, Crouse-Hinds, Hubbell, O-Z/Gedney, Raco, or Thomas & Betts.

2.3 FLOOR BOXES

A. Boxes in slabs above grade shall be 4.688" square, 2.125" deep, galvanized steel with flush knockouts on sides and bottom.

1. Boxes shall be concretetight and fully adjustable.
2. A leveling plate with screws at each corner shall be factory welded to the bottom for rough leveling. Adjusting rings mounted to the top shall provide a 0.5" vertical or angular adjustment of the top after concrete pour and installation of wiring devices.

B. Boxes in slabs on grade shall be zinc-coated cast iron with integral threaded conduit openings.

1. Boxes shall be watertight, fully adjustable, and constructed to prevent the entrance of surface and sub-surface water.
2. Boxes shall have a minimum of 2 integral leveling screws for rough leveling. Adjusting rings shall provide a minimum 0.75" vertical or angular adjustment of the top after concrete pour and installation of wiring devices.

C. Provide a cap to protect the adjusting ring during concrete pour.

D. Floor plates finish as selected by Architect, configuration as indicated on the Drawings.

E. Carpet flanges finish shall be selected by Architect.

F. Manufacturer: Crouse-Hinds, Hubbell, Thomas & Betts, or Wiremold.

2.4 JUNCTION AND PULL BOXES

A. Boxes shall be galvanized sheet metal unless otherwise indicated on the Drawings or specified herein, of dimensions required for the number and size of connecting raceways and wiring.

B. Boxes shall have removable blank covers. Covers on recessed ceiling boxes shall be round. Covers on recessed wall boxes shall be size and finish as used on electrical outlets. Refer to Section 261430, Wiring Devices.

C. Boxes installed in hazardous locations or corrosive atmospheres, rain or spray, shall be corrosive-resistant cast metal with threaded entrances, removable covers, gaskets and corrosion-resistant hardware.

D. Manufacturer: Appleton, Crouse-Hinds, O-Z/Gedney, Raco, or Thomas & Betts.

2.5 CONDUIT BODIES

A. Conduit bodies shall be corrosion resistant cast-metal type, shape and size to suit the location and installation.

B. Conduit bodies shall have threaded conduit-entrance ends, removable covers, gaskets and corrosion-resistant hardware.

C. Manufacturer: Appleton, Crouse-Hinds, Hubbell, or O-Z/Gedney.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install boxes at each luminaire, device, and outlet.

B. Coordinate box installation with wiring or cable and raceways.

C. Coordinate box installation with other trades so boxes will remain accessible.

D. Outlet boxes shall not be installed back-to-back. Maintain minimum 24" separation between outlet boxes on opposite sides of rated walls, or classrooms, and minimum 6" separation in nonrated walls.

E. Install boxes level, plumb, and square to the structure.

F. Anchor boxes in place. Refer to Section 261900, Supporting Devices.

G. Provide knockout closures to cap unused open knockout holes.

H. The approximate locations of outlets are indicated on the Drawings. The exact locations shall be determined at the building. The right is reserved to change the location of any switch, luminaire, or other outlet box in any room before it is permanently installed, without additional cost to the Owner.

3.2 OUTLET BOXES

A. Install outlet boxes at each electrical, alarm, and signal outlet at heights above the finished floor, measured to the centerline of the outlet, as indicated on the Drawings.

B. Outlet boxes for flush-mounted devices that are not provided with plaster rings or tile covers shall be set so that the face of the outlet box is recessed 0.125" into the finished wall.

C. Outlet boxes for flush-mounted devices provided with plaster ring or tile covers shall be set so that the face of the plaster ring/tile cover is recessed 0.125" into the finished wall.

D. Adjust mounting heights of boxes in masonry walls to minimize cutting and patching of masonry.

E. Install outlet boxes in one vertical line where indicated adjacent on the Drawings but at different mounting heights.

F. Wall Telephone and Data Outlets:

1. Install a raceway from each outlet box to the cable tray, backboard or cabinet indicated on the Drawings. Provide a pull line and insulating bushings on both ends of each raceway.
2. Install outlet and pull boxes in accordance with TIA 569-D-1-2016.

3.3 FLOOR BOXES

A. Install floor boxes according to manufacturer's recommendations.

B. Complete floor box installation, except for final height adjustment, before concrete pour.

C. Install carpet flanges for carpet.

D. Refer to Architectural Drawings for exact locations.

3.4 JUNCTION AND PULL BOXES

A. Covers on ceiling outlet boxes shall be painted to match the ceiling.

B. Install exposed junction or pull boxes only in unfinished spaces, unless indicated otherwise on the Drawings.

C. Do not use pull boxes as turn points.

D. Shall be permanently labeled indicating the panel, circuit, and voltage information.

END OF SECTION 261300

SECTION 261430 - WIRING DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other electrical systems are specified in other Sections of Division 26.

B. This Section covers switches, receptacles, device faceplates, weatherproof covers, emergency power off switches, and poke-through fittings.

C. This Section includes responsibilities and obligations in support of the performance verification specified in Section 260090, Electrical Performance Verification.

1.2 QUALITY ASSURANCE

A. Conform to the following:

1. National Electrical Code-2014 with South Carolina Modifications-2016.

PART 2 - PRODUCTS

2.1 GENERAL

A. Like products shall be by the same manufacturer.

B. Switches shall comply with UL 20-2010 and Federal Specification W-S-896G-2014.

C. Receptacles shall comply with UL 498-2017 and Federal Specification W-C-596H-2014.

2.2 TOGGLE SWITCHES

A. Except as otherwise indicated on the Drawings or specified herein, switches shall be flush type, 120/277 V, 20 A, totally enclosed with toggles colored gray for use on normal power circuits and red for use on emergency power circuits.

B. Single-Pole Wall Switches:

1. Manufacturer: Hubbell HBL1221, Leviton 1221-2, or P&S PS20ACl.

C. Three-Way, Single-Pole, Double-Throw Wall Switches:

1. Manufacturer: Hubbell HBL1223, Leviton 1223-2, or P&S PS20AC3.

D. Four-Way, Double-Pole, Double-Throw Wall Switches:

1. Manufacturer: Hubbell HBL1224, Leviton 1224-2, or P&S PS20AC4.

E. Wall switches with pilot lights shall have an LED pilot lamp and red toggle.

1. Manufacturer: Hubbell HBL1221PL, Leviton 1221-PL, or P&S PS20AC1RPL.

F. Wall switches for projection screen control shall be 3-position, double-pole, double-throw, maintained contact, with positive center off. Switches shall be rated for 20 A at 120 V.

1. Manufacturer: Hubbell HBL1386, Leviton 1286, or P&S 1222.

2.3 KEY-OPERATED SWITCHES

A. Except as otherwise indicated on the Drawings or specified herein, switches shall be flush type, 120/277 V, 20 A, with factory supplied key in lieu of toggle, gray color.

B. Single-Pole Wall Switches:

1. Manufacturer: Hubbell HBL1221L, Leviton 1221-2L, or P&S PS20AClL.

C. Three-Way, Single-Pole, Double-Throw Wall Switches:

1. Manufacturer: Hubbell HBL1223L, Leviton 1223-2L, or P&S PS20AC3L.

D. Four-Way, Double-Pole, Double-Throw Wall Switches:

1. Manufacturer: Hubbell HBL1224L, Leviton 1224-2L, or P&S PS20AC4L.

2.4 RECEPTACLES

A. Except as otherwise indicated on the Drawings or specified herein, receptacles shall be duplex type, 125 V, with one-piece solid brass mounting strap with rivetless integral ground contacts, colored gray for use on normal power circuits and red for use on emergency power circuits.

B. Duplex Receptacles:

1. Manufacturer, 15 A: Hubbell HBL5262, Leviton 5262, or P&S 5262A.
2. Manufacturer, 20 A: Hubbell HBL5362, Leviton 5362, or P&S 5362A.

C. Ground fault circuit interrupter (GFCI) receptacles shall be UL 943-2016 compliant, 20 A, self-testing, tamper resistant, weather resistant, feed-through type.

1. Manufacturer: Hubbell GFR5362SG, Leviton GFWT2, or P&S 2097TRWR.

D. Weather Resistant Receptacles:

1. Manufacturer, 15 A: Hubbell 5262WR, Leviton TWR15, or P&S WR5262.
2. Manufacturer, 20 A: Hubbell 5362WR, Leviton TWR20, or P&S WR5362.

E. Simplex receptacles shall be 20 A.

1. Manufacturer: Hubbell HBL5361, Leviton 5361, or P&S 5361.

F. Surge protective devices (SPD) receptacles shall be 20 A, with audible alarm and LED indicator.

1. Manufacturer: Hubbell HBL5362SA, Leviton 7380, or P&S 5362SP.

2.5 DEVICE FACEPLATES

A. Faceplates for flush wall outlets (switch, receptacle, telephone, and signal) shall be type 302 satin finish stainless steel.

B. Provide a clear extra-strength adhesive-backed tape label with 0.25" high uppercase letters on each emergency system receptacle which indicates, as a minimum, the panelboard and circuit number supplying that receptacle. Additional information for specific receptacles shall be provided if indicated on the Drawings.

C. Manufacturer: Hubbell, Leviton, or P&S.

2.6 WEATHERPROOF COVERS

A. Weatherproof covers shall be die cast aluminum, designed for wet location protection whether the attachment plug is inserted or removed. Covers shall be NEMA 3R rated when used with the appropriate weatherproof outlet box. Covers shall meet OSHA lockout/tagout requirements.

2.7 POKE-THROUGH FITTINGS

A. Complete assembly consisting of finished service fitting flush with the floor, fire rated insert containing intumescent organic material, and junction box for connection of power systems below the floor. Where poke-through fittings are used for communication and data cables in conduit located below the floor, those service openings shall be provided with conduit adapters below the floor.

B. Assemblies shall be UL listed with the utilized quantity and type of power and data conductors.

C. Flush Fittings:

1. Flush with the floor, with a maximum thickness of 0.625", and with a 20 A duplex receptacle with protective cover centered above the core. Provisions for four category 6 communications jacks shall be provided and separated from the power raceway. Fittings shall be 2 hour rated.
2. Carpet flanges shall be die cast aluminum alloy with textured two stage 3 mil thick epoxy paint, or stamped aluminum with anodized finish, color as selected by the Architect.
3. Fire-rated inserts shall have a retainer for securing the device in the slab. Power and communications isolation shall be continued through the device with the power raceway terminating in an accessible junction box below the floor.
4. Where used to provide hard wired connections to furniture or equipment, provide conduit adaptor for connecting each raceway to the furniture or equipment.
5. Manufacturer: Hubbell Scrubshield 4x4 Flush series, Steel City Thomas & Betts FPT series, or Wiremold Walker RC3 series.

D. Additional Fittings:

1. Provide, for future use, extra poke-through fittings in quantity equal to 10% of the quantity of units furnished.
2. Abandonment plugs shall be furnished, for future use, in boxes to the Owner, in quantity equal to 10% of the quantity of units furnished. Abandonment plugs shall have the same fire rating as the fittings.

2.8 EMERGENCY POWER OFF (EPO) SWITCHES

A. Fully guarded, push button type with 2 normally open momentary contacts.

PART 3 - EXECUTION

3.1 GENERAL

A. Devices shall be installed flush in the wall on which they are located when served by concealed conduit. Where necessary to conceal the conduit or flush mount the device box, masonry or plaster shall be channeled and patched.

B. Devices shall be surface mounted where their connecting raceways are indicated on the Drawings exposed.

C. Duplex receptacles shall generally be 15 A rated. Where a 20 A branch circuit serves a single duplex receptacle, the receptacle shall be 20 A rated. Duplex receptacles in corridors, equipment rooms, and communication rooms shall be 20 A rated.

D. Weather resistant receptacles shall be installed in damp or wet locations.

E. Where 2 or more switches, wall box dimmers, indicating devices, control and communications outlets, or receptacles are indicated on the Drawings at the same location, they shall be ganged and covered with 1 faceplate.

F. Bond receptacle ground straps to outlet boxes with 6" long green insulated #12 AWG copper jumpers.

G. Provide an insulated ground from the grounding screw of isolated ground duplex receptacles to the branch circuit panelboard isolated ground bus or the grounding conductor terminal of the applicable derived system.

H. Install device faceplates and adjust outlets to achieve a flush fit with no gaps.

I. Vertically mounted receptacles shall be installed with the ground pin up. Horizontally mounted receptacles shall be installed with the ground pin to the left.

3.2 EMERGENCY POWER OFF SWITCHES

A. Install at the generator as indicated on the drawings to stop the generator.

3.3 POKE-THROUGH FITTINGS

A. Install in accordance with the manufacturer's instructions.

B. Install devices and make connections in the service fittings.

C. Provide wiring as indicated on the Drawings below the slab and make connections.

END OF SECTION 261430

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SECTION 261480 - CONNECTIONS TO MOTORS AND EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other electrical systems are specified in other Sections of Division 26.

B. This Section covers connections to electric current consuming equipment, and includes installation and connection of associated control devices in the power circuit.

C. This Section includes responsibilities and obligations in support of the performance verification specified in Section 260090, Electrical Performance Verification.

1.2 QUALITY ASSURANCE

A. Conform to the following:

1. NECA 230-2016.
2. National Electrical Code-2014 with South Carolina Modifications-2016.

1.3 EQUIPMENT LOCATIONS

A. Locations of motors, starters, equipment and apparatus as indicated on the Drawings are approximate; connections shall be made to such equipment as actually installed.

B. Coordinate the locations of starters or other control devices with the equipment being controlled in accordance with local code requirements. The installed location of motors, equipment, and associated ductwork shall be considered to ensure clearance, access, and sight requirements.

1.4 RELATED WORK DESCRIBED IN OTHER DIVISIONS

A. Refer to other Divisions of these specifications for equipment requiring electrical connections.

PART 2 - PRODUCTS

2.1 MATERIALS

A. See other Sections of Division 26 for materials and equipment.

PART 3 - EXECUTION

3.1 WIRING

A. Provide power wiring to equipment requiring electrical power specified in all Divisions of these specifications. Power wiring is defined as wiring in the electrical circuit between the source of power and the current consuming device, and includes the mounting and installation of starters,

variable frequency drives and associated DV/DT output filters, and other control devices and interlock contacts controlling loads for which no magnetic starter or contactor is provided.

B. Provide control wiring to equipment requiring electrical control specified in all Divisions of these specifications. Refer to Divisions 21, 22, and 23 for control wiring provided under each Division.

C. Make final connections to equipment such that loads are balanced across phases in branch circuits, feeders, and panelboards. Where multiple units are connected to the same branch circuit or feeder, packaged equipment incorporating both single phase and three phase loads shall be connected such that the single phase loads are balanced as closely as possible across the phases of the three phase branch circuit or feeder serving the equipment.

END OF SECTION 261480

SECTION 261700 - CIRCUIT AND MOTOR DISCONNECTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other electrical systems are specified in other Sections of Division 26.

B. This Section covers circuit and motor disconnects.

C. Disconnects provided with mechanical equipment are specified in Division 23.

D. Refer to Section 264750, Overcurrent Protective Devices, for fuses.

E. This Section includes responsibilities and obligations in support of the performance verification specified in Section 260090, Electrical Performance Verification.

1.2 QUALITY ASSURANCE

A. Conform to the following:

1. National Electrical Code-2014 with South Carolina Modifications-2016.

PART 2 - PRODUCTS

2.1 ENCLOSURES

A. Enclosures shall be surface mounted, unless indicated otherwise on the Drawings.

B. Type of enclosures specified herein or indicated on the Drawings refer to NEMA types as defined in NEMA 250-2014.

C. Enclosures shall be NEMA 1 in dry locations and NEMA 3R where exposed to rain or spray, unless indicated otherwise on the Drawings. Disconnects installed in hazardous locations or corrosive atmospheres shall be UL listed for the specific application.

2.2 DISCONNECT SWITCHES

A. Switches shall have ground and insulated neutral lugs where ground and neutral conductors are provided in the circuit.

B. Where installed ahead of elevator drives and between variable frequency drives and motors, provide electrical interlock kits to break the control circuit before the main switch blades open. Control contacts shall be one normally open and one normally closed, 120 V AC, 15 A rating.

C. Switches shall be heavy duty, motor rated, 600 V, with capacity and number of poles indicated on the Drawings. Fuse holders shall be designed to receive Class R fuses unless otherwise indicated on the Drawings.

D. Manufacturer: Eaton DH, GE TH, Siemens H, or Square D Class 3110.

E. Nonfusible type for motor loads 2 hp or smaller or nonmotor loads connected to a 20 A or smaller circuit shall toggle type switches, or UL listed for each specific type load.

1. Manufacturer: Crouse-Hinds, GE, Leviton, Square D, or Westinghouse.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Disconnects shall be installed where specified herein, indicated on the Drawings, or required by manufacturer's written instructions.

B. Install combination disconnect/motor starters furnished under other Divisions.

C. Provide control wiring for electrical interlocks between elevator drives and motor disconnects.

D. Provide control wiring for electrical interlocks between drives and variable frequency motor disconnect switches.

E. Coordinate disconnect installation with raceways, wiring, and equipment.

F. Anchor disconnects. Refer to Section 261900, Supporting Devices for specific requirements.

3.2 LOCATION

A. Coordinate location of disconnects with equipment being controlled.

B. When used as disconnecting means, locate as near as practicable to the load controlled.

C. When used for branch circuit protection, disconnects shall be located as near as practicable to the supply end of the conductors being protected.

D. Disconnects used with motor-driven appliances, or motors and controllers shall be located within sight of controller, unless indicated otherwise on the Drawings.

E. Disconnects shall be installed in accessible locations.

3.3 FUSIBLE DISCONNECTS

A. Fusible disconnects shall not be mounted in ceiling plenums.

B. Fuses shall be installed in fusible disconnects as specified in Section 264750, Overcurrent Protective Devices.

END OF SECTION 26 1700

SECTION 261900 - SUPPORTING DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other electrical systems are specified in other Sections of Division 26.

B. This Section covers supporting devices.

C. This Section includes responsibilities and obligations in support of the performance verification specified in Section 260090, Electrical Performance Verification.

1.2 QUALITY ASSURANCE

A. Conform to the following:

1. National Electrical Code-2014 with South Carolina Modifications-2016.

PART 2 - PRODUCTS

2.1 BEAM CLAMPS

A. Galvanized steel, with tapped holes in base and face for bolts or hanger rods.

B. Manufacturer: Appleton, Efcor, or Kindorf.

2.2 CABLE TIES

A. One-piece, nylon, with a 90º insertion angle.

B. Manufacturer: 3M, Ideal Industries, Panduit, or Thomas & Betts.

2.3 CONDUIT SUPPORTS

A. Galvanized steel straps or hangers, or spring steel type hangers or clamps.

B. Manufacturer: Appleton, Caddy, Raco, or Thomas & Betts.

2.4 CABLE SUPPORTS

A. Galvanized malleable iron with multiple segment plugs.

B. Manufacturer: Appleton, Crouse-Hinds, or O-Z/Gedney.

2.5 CHANNEL STRUT SYSTEMS

A. Galvanized steel, 14 gauge minimum, with factory-punched attachment holes. Straps for the support of conduit shall be designed so that the attachment nut is captive on the shoulder of the strap when tightened. Attachment nuts shall be designed to provide a surface on the turned down edge while making positive contact with the side walls of the channel. Nuts, bolts, straps, and accessories shall be protected with same finish as channels.

B. Manufacturer: B-Line Systems, Kindorf, Midland-Ross, or Unistrut.

2.6 WOOD BACKBOARDS

A. Exterior grade, 0.75" thick, B-C UL listed fire-resistant plywood tested in accordance with UL 723-2008 Category BUGV. Flame spread rating shall be 25 or less.

PART 3 - EXECUTION

3.1 GENERAL

A. Anchor or support raceways, cables, and electrical equipment as specified herein.

3.2 BEAM CLAMPS

A. Beam clamps may be used for support of raceways, enclosures, panelboards or equipment where attached to or from fixed steel supports or structures. Beam clamps fastened to steel supports not horizontal or vertical shall be provided with a swing connector. Beam clamps fastened to structures in a horizontal position (where bolt is horizontal) shall not be used for support of equipment exceeding 10 lb.

3.3 CABLE TIES

A. Cable ties shall be provided for securing, grouping and organizing conductors or cables in panelboards, switchboards, wireways, or enclosures.

3.4 CABLE SUPPORTS

A. Install cable supports in vertical runs at intervals required by codes.

3.5 CHANNEL STRUT SYSTEMS

A. Use channel strut systems for support of multiple runs of conduit, enclosures, panelboards, and equipment.

B. Support channel strut from minimum 0.375" steel rods when not directly fastened to structure.

3.6 CONDUIT SUPPORTS

A. Use straps, clamps, or hangers to support individual runs of conduit.

B. Spring steel hangers or clamps may be used to support conduit from steel except where exposed to rain or moisture.

C. Secure conduit support devices to structure with wood screws on wood, toggle bolts on hollow masonry, lead anchors on solid masonry or concrete, and machine bolts and beam clamps on steel. Threaded studs driven in by a powder charge and provided with lock washers and nuts may be used in lieu of lead anchors where approved by the Architect.

D. Support conduits, secured to surfaces exposed to water or spray, by straps or hangers, utilizing clamp backs or spacers made for the purpose which hold conduit off surface.

E. Provide PVC-coated straps and spacers for plastic-coated conduit.

F. Conduits shall not be supported from ceiling suspension systems.

G. Conduit supports shall not be welded to steel structures.

H. Install riser clamps for vertical conduits as required by codes.

3.7 WOOD BACKBOARDS

A. Install wood backboards where 2 or more disconnect switches, individual circuit breakers, or equipment are installed, and where indicated on the Drawings or specified herein.

B. Anchor wood backboards to walls with lag bolts on wood, toggle bolts on drywall or hollow masonry, and lead anchors on solid masonry or concrete.

C. Paint backboards with 2 coats of fire-inhibiting gray enamel on both sides and all 4 edges before installation of equipment.

D. Backboards installed on walls in telephone/data rooms or walls dedicated to communications equipment shall be 8' high minimum, unless indicated otherwise on the Drawings. Lower edge of 8' backboards shall be set at floor level. Width shall be as indicated on the Drawings.

E. Coordinate size of backboards for other equipment with equipment mounted thereon.

END OF SECTION 261900

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SECTION 262000 - EMERGENCY POWER SUPPLY SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other electrical systems are specified in other Sections of Division 26.

B. This Section covers the emergency power supply system, including an engine-generator set with controls and control panel, remote alarm annunciator, automatic transfer systems, and accessories to automatically supply power during a utility power failure.

C. Emergency power supply system installation and performance shall meet NFPA 110-2016, Level 1, Type 10 applications.

D. Vibration isolation is specified in Section 260010, Electrical General.

E. This Section includes responsibilities and obligations in support of the performance verification specified in Section 260090, Electrical Performance Verification.

1.2 QUALITY ASSURANCE

A. Conform to the following:

1. 40 CFR 63 Subpart ZZZZ-2017.
2. NECA/EGSA 404-2014.
3. UL 2200-2012.
4. National Electrical Code-2014 with South Carolina Modifications-2016.

1.3 RECORD DRAWINGS

A. In addition to the requirements specified in Section 260010, Electrical General, include:

1. Generator starting characteristics showing voltage drop not exceeding 15% for the Fire Pump with across-the-line starting.
2. Equipment outlines, showing front and side plan views, electrical power one-line diagram, and equipment ratings.
3. Schematic drawings.
4. Wiring diagrams.
5. Interconnection wiring diagram, showing field interconnections between engine-generator sets, switchboards, automatic transfer switch systems, annunciators, and day tanks.
6. Material lists, cross referenced to schematics for component identification.
7. Narrative sequence of operation description, detailing operating modes.
8. Ladder diagram and program listing for programmable controller with each logic rung's purpose clearly defined, including identification of inputs and outputs.
9. Generator decrement curve, damage curve, and available fault current at the generator terminals.

1.4 SERVICE

A. Manufacturer shall maintain a local parts and service facility, within 50 miles of this Project, which shall have inventory to cover not less than 80% parts service within 24 hours and 95% within 48 hours. Further, the facility shall have a factory-trained service representative to furnish installation, test, and start-up supervision necessary for final approval and acceptance, as well as to perform maintenance, oil sample analysis, and repairs on components.

1.5 SERVICE CONTRACT

A. Make available to the Owner a service contract which, as an option, may be accepted. The contract shall be for the complete services rendered over a period of 1 year beginning at completion of the Contractor's 1 year warranty, and shall include, but not be limited to, the following:

1. Manufacturer's recommended procedures for weekly inspection and maintenance.
2. Quarterly inspection to review the weekly maintenance records being kept by the Owner and train any new operating personnel. Inspection shall include scheduled oil sampling. A system load test shall be included.
3. Annual inspection shall include the above items except that the engine-generator sets shall be run under 100% load. Provide load banks, electrical connections, and fuel for these tests. Test shall be for minimum of 4 hours.
4. Work shall be done during normal business hours. Should any work, by its nature, be required to be performed after business hours, the Owner shall be responsible for any overtime charges. Provide a written estimate of any potential overtime charges and obtain written prior approval before proceeding.

1.6 WARRANTY

A. In addition to other warranties specified herein, equipment shall be guaranteed against defective parts and workmanship under terms of the manufacturer's standard warranty for a period of not less than 5 years from date of initial start-up of the system and shall include parts, labor, and travel time.

PART 2 - PRODUCTS

2.1 ENGINE-GENERATOR SETS

A. General:

1. Engine-generator sets shall be factory assembled and tested, and shall be mounted on a structural steel frame with vibration isolators.
2. Power rating: engine-generator sets shall have standby rating. Rating shall be based on operation at rated rpm when equipped with operating accessories, including air cleaners, lubricating oil pump, fuel transfer pump, fuel injection pumps, jacket water pump, governor, alternating current generator, radiator fan, and exciter regulator.

B. Exterior Enclosures:

1. Metal non walk-in weatherproof type. Enclosures shall be factory assembled and wired, and shall have the following features:

   a. A minimum of 2 each interior luminaires and convenience receptacles. Luminaires shall be vaportight.
   b. Access doors, minimum 2. Doors shall be fully gasketed with forged aluminum hinges with stainless steel pins and nylon bushings. Doors shall have stainless steel handles, padlock provisions, plated 3-point locking mechanisms, and panic bar interior openers.
   c. Exterior steps shall be provided to access doors where bottom of door is 18" or higher above finished grade.
   d. Interior walls and ceiling covered with acoustical material, finished with mill finished perforated aluminum panels.
   e. Stainless steel bird screens on exterior openings.
   f. Lifting eyes, maximum 6.
   g. Minimum of 1 dry-type fire extinguisher.
   h. Enclosures shall consist of a roof, 2 sidewalls, and 2 end walls of prepainted aluminum stressed-skin monocoque construction and shall include provisions for an internally mounted exhaust silencer. Exterior finish shall be prepainted aluminum with color selected by the Architect.
   i. Intake and discharge louvers shall be constructed of aluminum and shall be sized to allow full load operation of the engine-generator set at specified site conditions without deration.
   j. Manufacturer: same as engine-generator set manufacturer, or Altorfer Power Systems, Chillicothe Metal Company, or Pritchard-Brown.

C. Natural Gas Engines:

1. Water-cooled, inline or vee compression diesel type designed to operate on natural gas.
2. Engines shall be equipped with flexible fuel connections, fuel, lube oil, and intake air filters, crankcase emission filtration system, lube oil cooler, service meter, gear-driven water pump, and instruments, including a fuel pressure gauge, water temperature gauge, and lubricating oil pressure gauge. Engine cooling system shall be pretreated to prevent internal corrosion.
3. Governors: shall maintain isochronous frequency regulation from no load to full rated load. Steady state operating band shall be ±0.25%. Governors shall include provisions for remote speed adjustment.
4. Protective devices:

   a. Safety shutoffs shall include high water temperature, low oil pressure, electrical overspeed, low fuel, and engine overcrank.
   b. 24 V gas safety shutdown solenoid valve.

5. Radiators:

   a. Engine-mounted, with fan, designed for operation at ambient temperature of 110°F.

6. Silencers: cylindrical style selected with companion flanges equal or greater in size to the connecting pipe, and flexible stainless steel bellows-type exhaust wye connector and fittings as required. Silencers shall be sized such that the maximum allowable backpressure

for the engine-generator set is not exceeded as installed, including exhaust piping upstream of silencer, wye fitting, silencer, and exhaust piping downstream of silencer. Silencers shall be residential grade and have a minimum noise reduction of 25 dBA.

7. Automatic Starting System:

   a. Starting motors: 24 V electric starting system with positive engagement drive and capacity to crank the engine at a speed which shall start the engine under operating conditions. Starting pinion shall disengage automatically when the engine starts. Starting system shall incorporate an automatically reset circuit breaker for antibutt engagement.
   b. Automatic controls: fully automatic start-stop controls shall be provided in the control panel. Controls shall include one 45 s continuous cranking cycle with lockout and manual reset feature.
   c. Jacket water heaters: 2 engine-mounted thermal circulation tank-type immersion water heaters incorporating an adjustable thermostatic switch shall be furnished to maintain engine jacket water at 90°F in a still air ambient temperature of 10 60°F. Heaters shall be 208 V, 1-phase, 60 Hz each.
   d. Batteries and Battery Chargers:

      1) Batteries shall be lead-acid storage type. Battery set shall be rated by the battery manufacturer in accordance with requirements of engine manufacturer. Battery rack, cables, and clamps shall be provided. Batteries shall be capable of cranking the engine for 45 seconds at 32°F.
      2) Chargers shall use transistor-controlled magnetic amplifier circuits to provide continuous taper charging and shall maintain rated output voltage within ±1% from no load to full rated load. Chargers shall be the dual rate type (float and equalize) with a minimum rating of 10 A. Chargers shall be furnished in a NEMA 1 enclosure with a DC ammeter and DC voltmeter, and shall include malfunction alarm contacts for use in conjunction with remote annunciator.

8. Oil sample analysis kit: shall include 1 sample extraction gun, 10 bottles, 10 postage paid mailers, and instructions.

D. Controls:

1. Control Panel:

   a. A control panel shall be provided and shall contain the following devices and provide the following functions:

      1) A control switch labeled Automatic-Off-Run to perform the following functions:

         a) Automatic: start and stop the engine-generator set automatically by the closing and opening of a remote contact.
         b) Off: stop the engine-generator set.
         c) Run: manually start and run the engine-generator set.

   b. Separate visual indication and common audible alarm shall be provided for:

      1) Overcrank.
      2) Low coolant level.

3) Low coolant temperature.
4) Anticipatory high coolant temperature.
5) High coolant temperature.
6) Anticipatory low oil pressure.
7) Low oil pressure.
8) Overspeed.
9) Control switch not in automatic position.
10) Contacts for local and remote common alarm.
11) Air shutdown damper (when used).

c. Separate visual indication shall be provided for:

1) Generator supplying load.
2) Utility supplying load.
3) Low battery voltage.
4) High battery voltage.
5) Battery charger AC failure.

d. Switches shall be provided for:

1) Alarm silence.
2) Lamp test.
3) Emergency stop.

e. Controls shall shut down and lock out the engine-generator set under the following conditions:

1) Overcrank.
2) Overspeed.
3) Low oil pressure.
4) High coolant temperature.
5) Air shutdown damper (when used).
6) Remote emergency stop.
7) Low coolant level.

f. A clock exerciser shall be provided in the control panel.

2. Remote Alarm Annunciator:

a. A battery-powered remote annunciator shall be provided to operate outside of the generator room at the location indicated on the Drawings. The annunciator shall indicate the alarm condition of the engine-generator set as follows:

1) Individual visual signals shall indicate:

a) Generator supplying load.
b) Utility supplying load.
c) Battery charger malfunctioning.

2) Individual visual signals plus a common audible signal shall warn:

a) Low oil pressure.

b) Low water temperature.
c) High water temperature.
d) Low fuel main tank.
e) Overcrank.
f) Overspeed.
g) Ground fault indication.
h) Remote emergency shutdown.

3) Switches shall be provided for:

a) Lamp test.
b) Alarm silence.

3. Remote Emergency Manual Stop Station:

a. Provide a remote manual stop pushbutton station in weatherproof enclosure with lift cover and audible and silent remote alarm signal to the remote alarm annunciator panel when the lift cover is raised for engine-generator set shutdown.
b. Manufacturer: Eaton, Pilla, or Square D.

E. Generators:

1. Type: 3-phase, single-bearing, synchronous type, wet wound, tropicalized, and shall comply with NEMA MG 1-2016, Part 22. Class H insulation shall be used on the stator and rotor, and both shall be further protected with an asphalt modified epoxy on end coils. Generators shall include a resettable thermal protector and fuse for exciter/regulator protection against extended low power factor loads and faults. Generator rotors shall be dynamically balanced within 0.0005" peak-to-peak amplitude displacement at both ends of shafts and shall sustain 25% overspeed.
2. Regulators: 3-phase sensing RMS voltage regulators, automatic volts-per-hertz type, solid state exciter/regulator, shock-mounted inside generator. Voltage regulation shall be ±1% from no load to full rated load. Accessible voltage drop, voltage level, and voltage gain controls shall be included in the module. Voltage level adjustment shall be a minimum of ±10%. Modules shall include the following protective features:

a. Current limit circuits shall restrain the exciter field current while allowing full forcing voltage to be applied to obtain rapid response during transient conditions or service overloading on the generator.
b. A time delay circuit shall sense the current limit operation and interrupt field current to the generator after 10 s.

3. Devices:

a. 3.5", 90° scale, 2% accuracy instruments:

1) Ammeter.
2) Voltmeter.
3) Frequency meter.
4) Wattmeter.

b. Running time meter.

c. Heavy duty meter control switches for:

1) Voltmeter, 7-position.
2) Ammeter.

4. Permanent magnet pilot excitor: generators shall incorporate a permanent magnet pilot excitor feature to provide isolation of the excitor from the generator stator windings to prevent irregularities of voltage wave form caused by load conditions. Permanent magnet pilot excitor shall also provide for a minimum of 300% rated current for 10 seconds during short circuit conditions for selective tripping of downline protection devices on a load short circuit.
5. Provide a unit-mounted circuit breaker as indicated on drawings.

a. Breaker shall be equipped with an electronic trip unit with the following front panel adjustments:

1) Long time pick-up.
2) Long time delay.
3) Short time pick-up.
4) Short time delay.
5) Instantaneous pick-up.
6) Ground fault alarm.

F. Factory Tests:

1. Engine-generator sets shall be factory tested before shipment. Tests shall be as follows:

a. Warm-up and Adjustments:

1) Warm-up at synchronous speed with 1.0 power factor electrical load.
2) Final high idle speed adjustment, voltage level adjustment, and voltage gain adjustments.
3) After adjustments, the following shall be recorded:

a) Generator speed.
b) Frequency.
c) Power.
d) Line-to-line voltages.
e) Average voltage.
f) Frequency stability.
g) Voltage stability.
h) Overshoot.
i) Fan power.
j) Engine-generator set efficiency at test speed and 1.0 power factor, fuel density, inlet air temperature, inlet air pressure, inlet air restriction, fuel temperature in injection pump housing, and total running time.

2. Upon completion of the tests, the manufacturer shall submit 6 sets of the certified test reports demonstrating test procedure compliance and data recorded. In addition, an oil sample shall be taken during the test at full and partial load, then laboratory analyzed for signs of unusual wear. Testing shall be performed on the actual serial number units assigned for delivery to this Project.

G. Manufacturer: Caterpillar, Cummins-Onan, or Kohler.

2.2 AUTOMATIC TRANSFER SWITCH SYSTEMS

A. General:

1. Each system shall be the product of one manufacturer. Automatic transfer switches shall include a 2-way bypass isolation switch where indicated on the Drawings. Each system shall comply with NEMA ICS 10-2005 Part 1 and UL 1008-2014, and shall be rated for total system load.
2. Construction: each system shall be supplied completely assembled in a NEMA 1 enclosure. Systems shall be completely factory assembled and tested prior to shipment. Power interconnections shall be silver-plated copper bus bar. Control interwiring shall be provided with disconnect plugs. A visual position indicator shall be provided to indicate bypass-isolation switch position. Pilot lights shall indicate availability of power sources and automatic transfer switch position. Switches shall include a detailed instruction plate.
3. Performance: switch performance shall meet or exceed the following requirements and, if so requested by the Architect be verified by certified laboratory test data.

    a. Temperature rise: measurements shall be made after the overload and endurance tests.
    b. Withstand and closing ratings: rated to withstand the available RMS symmetrical short circuit current at the switch terminals with the upstream over-current protection. When protected by molded case circuit breakers, switches shall have the following minimum withstand and closing ratings:

Ampere Size	Symmetrical Amperes RMS at 480 V AC
30	10000
70-150	22000
260-400	42000

        1) When protected by Class J or L current limiting fuses, automatic transfer switches rated 70 A through 4000 A shall be designed for use where the available fault current is up to 200000 symmetrical amperes RMS at 480 V AC.

    c. Dielectric: measurements shall be made at 1960 V RMS minimum following the withstand current rating test.
    d. Transient withstand: control panel shall pass the voltage surge withstand test per IEEE C37.90.1-2012 and the voltage impulse withstand test per NEMA ICS 1-2000 (R2005, R2008, R2015).

4. Manufacturer, automatic transfer switches: ASCO 7000 series.
5. Manufacturer, automatic transfer and bypass switches: ASCO 7000 series.

B. Automatic Transfer Switches:

1. Electrical operation shall be accomplished by a momentarily energized solenoid operating mechanism which receives power from the source to which the load is being transferred. Operating transfer time shall be a maximum 0.17 s. Each position shall be mechanically locked.

2. Operation shall be inherently double-throw whereby contacts move simultaneously and with no programmed delay in a neutral position. An overload or short circuit shall not cause the switch to go to a neutral position.
3. Inspection of contacts, movable and stationary, shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. A manual operating handle shall be provided for maintenance purposes. The maintenance handle shall permit the operator to stop the contacts at any point throughout the entire travel to inspect and service the contacts.
4. Switches shall have switched neutrals and shall have fully rated neutral transfer contacts which shall momentarily interconnect the neutrals of the sources and load during the transfer/retransfer operation. The neutrals shall remain so interconnected until the line contacts close on the alternate source. Line and neutral contacts shall be driven by a single main operator.
5. Automatic transfer switches shall include separately mounted control panels with adjustable solid state sensing and timing functions, and the following operational characteristics:

    a. Time delay on momentary dips in normal source (0.5 s to 6 s) factory set at 1 s delay in transfer switch and engine starting signals.
    b. Time delay on transfer to emergency for controlled loading for generator (0 min to 1 min), factory set at 0 min.
    c. Time delay on retransfer to normal (0 min to 30 min), factory set at 15 min. Automatic bypass if emergency source fails and normal source is available.
    d. Toggle switch to manually bypass time delay on retransfer.
    e. Close differential voltage sensing of normal source phases (pick-up adjustable from 85% to 100% of nominal and dropout adjustable from 75% to 98% of pick-up), factory set to pick-up at 95% and drop out at 85% of nominal.
    f. Independent single phase voltage (85% to 100%) and frequency (90% to 100% pick-up) sensing of the emergency source to prevent premature transfer, factory set to pick-up at 90% of nominal voltage and 95% of nominal frequency.
    g. Test switch, momentary type, to simulate failure to normal source.
    h. Pilot lights to indicate switch position.
    i. Auxiliary contacts, 1 closed on normal and 1 closed on emergency, rated 10 A, 480 V.
    j. Time delay and sensing functions shall be adjustable over the ranges specified herein and shall operate with minimum drift, not to exceed ±1% of set frequency, ±2% of set voltage, and ±10% of set time delay, over the temperature range of -5°F to 160°F. The control panel shall be provided with a protective cover and an isolation plug in the wiring harness to disconnect the control wiring between the control panel and the main transfer panel. The control panel shall not draw more than 15 VA continuously under normal operating conditions.
    k. Contacts that close when normal source fails for initiating engine starting, rated 10 A, 32 V DC.
    l. Load disconnect control circuit with 2 sets of single-pole, double-throw contacts that operate 3 s prior to transfer in either direction and reset upon expiration of a preadjusted time delay after transfer of the automatic transfer switch. Adjustable 1 s to 300 s. Contacts shall be rated 10 A, 480 V, 10 A, 32 V DC.
    m. Load shed control circuit shall operate from a normally closed set of remote contacts so that upon opening the remote contacts, the automatic transfer switch load shall remain connected to the normal source or shall be transferred to the normal source regardless of the normal power source condition.

C. Bypass-Isolation Switches:

1. A 2-way bypass-isolation switch shall provide manual bypass of the load to either source and permit isolation of the automatic transfer switch from source and load power conductors. Main contacts shall be manually driven.
2. Bypass to the load-carrying source shall be effected without any interruption of power to the load.
3. The bypass handle shall provide 3 operating modes: bypass-to-normal; automatic; and bypass-to-emergency. The operating speed of the bypass contacts shall be the same as that of the associated automatic transfer switch and shall be independent of the speed at which the manual bypass handle is operated. In the automatic mode, the bypass contacts shall be out of the power circuit.
4. The isolation handle shall provide 3 operating modes: closed, test, and open. The test mode shall permit testing of the entire emergency power system, including the automatic transfer switches. The open mode shall completely isolate the automatic transfer switch from source and load power conductors. When in the open mode, it shall be possible to withdraw the automatic transfer switch for inspection or maintenance without removal of power conductors.
5. When in the test or open modes, the bypass switch shall function as a manual transfer switch allowing transfer and retransfer of the load between the 2 available sources without the feedback of load regenerated voltage to the transfer switch.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's recommendations.

B. Install 2 remote alarm annunciator panels where indicated on the Drawings, including interconnecting wiring and conduit.

C. Install generator control panel at the generator.

D. Install remote emergency manual stop pushbutton external to the engine-generator set enclosure. Provide a label as specified in Section 260010, 2.10, E on the pushbutton station enclosure, stating "EMERGENCY GENERATOR STOP PUSHBUTTON".

E. Provide control wiring from transfer switches to engine-generator set controls for automatic start-stop control.

F. Provide control wiring from transfer switches to the elevator controllers for transfer switch position and load disconnect control. Refer to Division 14, Conveying Equipment for specific elevator requirements.

G. Surge tanks shall be installed at the highest points in the piping systems.

H. Fill cooling systems with 50% ethylene glycol solution.

3.2 OIL SAMPLE ANALYSIS

A. Service facility oil sample analysis laboratory shall be open to inspection during normal working hours. Laboratory shall perform oil sample analysis at no additional cost to the Owner for the kit specified hereinbefore.

B. Scheduled oil sampling shall be of the atomic absorption spectrophotometry method and shall be accurate to within a fraction of 1 ppm by weight for the following elements: iron, chromium, copper, aluminum, silicon, and lead.

C. In addition, samples shall be tested for the presence of water, fuel dilution, and antifreeze.

D. Immediate notification shall be provided to the Owner when analysis shows any critical reading. If readings are normal, a report showing that the equipment is operating within established parameters shall be provided.

END OF SECTION 262000

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SECTION 264020 - SERVICE ENTRANCE

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other electrical systems are specified in other Sections of Division 26.

B. This Section covers the installation of the electric service and service entrance equipment.

C. Switchboards used for service entrance equipment are is specified in Section 264400, Switchboards.

D. Underground ducts are specified in Section 261150, Underground Ducts.

E. Surge protective devices used for service entrance equipment are specified in Section 266710, Surge Protective Devices.

F. This Section includes responsibilities and obligations in support of the performance verification specified in Section 260090, Electrical Performance Verification.

1.2 DEFINITIONS

A. The utility referred to herein is Duke Energy.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.1 PRIMARY SERVICE

A. The utility will furnish and install the primary service conductors, and make primary connections.

B. Furnish and install empty raceways, as indicated on the Drawings, for use by the utility in installing the primary cables.

3.2 SERVICE TRANSFORMERS

A. The utility will furnish and install the service transformers. Provide labor, materials and services required by the utility in conjunction with the installation of the service transformers.

B. Make arrangements with the utility for installation of the service transformers and the primary services. Furnish the utility advance notice of the required service date to permit the service installation to be complete and ready when needed.

3.3 SECONDARY SERVICES

A. Furnish and install the secondary service as indicated on the Drawings. Coordinate the termination of the secondary service conductors within the transformer enclosure with the utility requirements.

3.4 SERVICE METERING

A. Service meter to be located at service transformer. Coordinae metering requirements with the utility.

3.5 SURGE PROTECTIVE DEVICES

A. Install immediately downstream of main service device.

END OF SECTION 264020

SECTION 264400 - SWITCHBOARDS

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other electrical systems are specified in other Sections of Division 26.

B. This Section covers switchboards.

C. Refer to Section 264020, Service Entrance, for utility service metering transformer requirements.

D. Refer to Section 264750, Overcurrent Protective Devices, for switches, circuit breakers, and fuses.

E. Refer to Section 266710, Surge Protective Devices.

F. This Section includes responsibilities and obligations in support of the performance verification specified in Section 260090, Electrical Performance Verification.

1.2 QUALITY ASSURANCE

A. Conform to the following:

1. National Electrical Code-2014 with South Carolina Modifications-2016.
2. NECA 400-2007.

B. Codes, standards and regulations specified herein refer to the edition date. Revisions and addenda to these codes, standards and regulations shall be part of these specifications. Provisions of referenced codes, standards and regulations do not create duty or responsibility by the Architect or the Owner, unless otherwise specified herein.

C. Codes, standards and regulations referred to are minimum standards. Where the requirements of these specifications or drawings exceed those of the codes, standards and regulations, the drawings or specifications govern.

PART 2 - PRODUCTS

2.1 GENERAL

A. Switchboards shall be indoor, sectional, totally free-standing, steel-enclosed, dead front low voltage type, constructed and tested in accordance with NEMA PB 2-2011 and UL 891-2005. Where used as service entrance equipment, switchboards shall be rated and labeled for that use.

B. Switchboards shall be designed for a 3-phase, 4-wire system with voltages indicated on the Drawings.

C. Switchboards shall be front accessible, with group mounted feeder devices, and arranged as indicated on the Drawings and as specified herein. Controls and metering devices are indicated on the Drawings or specified herein.

D. Manufacturer: Square D.

2.2 ENCLOSURES AND BARRIERS

A. Switchboard sections shall be 90" high, die formed from code gauge steel, furnished with rust-inhibitive primer and baked on enamel light gray color. Exterior structural channel iron sills shall be provided at front and back, making a total height of approximately 91.5".

B. Barriers: service switchboards shall have code gauge steel, or aluminum, front-to-back and top-to-bottom on each side of main circuit breakers. Where busses pass through barriers, close the openings around the bars with insulating sheet material.

C. Doors: formed hinged type with knurled thumb screws on front sections, with ventilation grilles. Top and end plates shall be flat and screw removable.

D. Cable racks: insulated and installed in bus compartment of rear accessible switchboards on each side of each section.

E. Metering compartment: for utility's current and potential transformers, sealable and located in the entrance section of the service switchboards.

2.3 BUSSING

A. Silver-plated copper. Bussing shall be braced for symmetrical amperes fault current as indicated on the Drawings.

B. Main busses shall be the same ampacity as the maximum frame rating of the main breaker, shall extend full size the entire length of the switchboard and shall be drilled at their terminations for future extension.

C. The neutral bus shall be full size and run with the phase busses and insulated from the frame.

D. A 0.25" x 2" copper equipment ground bus shall be run through and bolted or brazed to each section frame. Provide lugs on the ground bus for connection of each main and feeder grounding conductor indicated on the Drawings and specified herein. Provide a removable 0.25" x 2" copper ground link between neutral and ground busses for service switchboards.

E. Spaces for future circuit breakers are indicated on the Drawings. The spaces shall be bussed completely including connectors, ready to receive breakers without having to install additional bus, parts, or hardware. This provision shall include ground fault relaying, control and interlock wiring, and metering.

F. Provide lugs as specified in Section 261200, Building Wire and Cable, 600 V, on the load bus of all feeder breakers, spaces, and on neutral and equipment ground busses for feeders and mains. Provide UL listed lugs on the load side of overcurrent devices where bus extensions are not used.

2.4 MAIN DEVICES

A. Insulated case circuit breakers: stationary solid state tripping, ground fault relaying type.

2.5 FEEDER DEVICES

A. Molded case circuit breakers shall be of number, frame size, interrupting capacity, and trip rating as indicated on the Drawings. Where space for a future breaker is indicated on the Drawings, buswork, mounting block and studs, concealed behind a blank cover, shall be provided.

2.6 FEEDER DEVICES FOR COORDINATION

A. Branch feeder devices indicated on the drawings shall be fusible switch units, quick make and break type, each unit in an individual compartment with interlocked door.

2.7 GROUND FAULT PROTECTION

A. Main and feeder devices 1000 A and larger in 480 V systems shall be equipped with a ground fault protection system, including control power source.

B. Feeder devices shall be equipped with ground fault protection systems coordinated with that of the main device.

C. Ground fault protection shall be fully selective such that the feeder device and not the service device shall open on ground faults on the load side of the feeder device.

D. Ground fault protection system: as specified in Section 264750, Overcurrent Protective Devices.

2.8 ENERGY-REDUCING MAINTENANCE SWITCHING

A. Circuit breakers rated or adjustable to 1200 A or higher shall be provided with Energy-Reducing Maintenance Switching provisions.

B. Energy-Reducing Maintenance Switching system: as specified in Section 264750, Overcurrent Protective Devices.

2.9 INSTRUMENTATION

A. Instruments shall be provided on fronts of switchboards:

1. Electronic power monitors with digital LCD or LED display, minimum 1% accuracy, on the load side of the main breaker. Monitors shall be microprocessor-based devices with nonvolatile memory, local display of information, and Modbus RTU and TCP/IP capabilities. Metered values (true RMS) shall include multiphase A and volts, watts, VARS, volt-amperes, watt-hours and VAR-hours, amperes and watts demand, frequency, power factor, and harmonic distortion. Modules shall be mounted on a hinged door, and provided with instrument transformers mounted in the switchboard.
2. Front accessible Ethernet ports (RJ-45 connectors) shall be provided for temporary local access. Connectors shall include protective covers tethered to avoid accidental loss or damage. Ports shall be wired to power monitors in such a way that standard "straight-

through" Ethernet cables may be used. Special "cross-over" cables shall not be required. Ports shall be provided for local access only and shall be provided in addition to the permanent Ethernet ports inside the equipment.

3. Manufacturer: Square D PM820.

2.10 NAMEPLATES

A. Provide engraved laminated white core nameplates with 0.5" high letters mounted on the front for each device. For devices with integral current limiters, provide a nameplate mounted near each set of limiters giving complete catalog ordering information. Nameplate backgrounds shall be as specified in Section 260010, Electrical General.

2.11 SURGE PROTECTIVE DEVICES

A. Provide integral surge protective devices as described in Section 266710, Surge Protective Devices.

PART 3- EXECUTION

3.1 CABLE RACKING

A. Cable installed in switchboards shall be neatly placed by feeders with cable ties and supported vertically and horizontally with rigid insulating material. Provide main and load feeder cable lashing from the point where the feeders enter the switchboard to the point where cables lace into terminals, in accordance with the manufacturer's instructions for the short circuit bracing level specified herein. Install manufacturer's lashing instructions in each vertical section.

B. Vertical cable runs in rear compartments of switchboards shall be made on insulated racks on the sides of the cubicle turning out horizontally on the same level as the loadside studs. Maximum length of unsupported cable shall be 18".

C. Only those cables intended for termination within a vertical section shall be installed within that section.

3.2 INSTRUMENTATION

A. Provide conduit and network cables to connect power monitors via Modbus TCP/IP to a data outlet located in the electrical room adjacent to the switchboard as indicated on the Drawings.

B. Provide conduit and RS-485 cables for external connections between the power monitors and the Modbus RTU serial bus as indicated on the Drawings per the manufacturer's requirements. Connections of devices to the Modbus RTU serial bus internal to the switchboard shall be completed by the switchboard manufacturer.

END OF SECTION 264400

SECTION 264500 - GROUNDING

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other electrical systems are specified in other Sections of Division 26.

B. This Section covers grounding.

C. This Section includes responsibilities and obligations in support of the performance verification specified in Section 260090, Electrical Performance Verification.

1.2 GROUND RESISTANCE

A. The resistance of the grounding system to earth shall be a maximum of 5 10 25 ohms.

1.3 QUALITY ASSURANCE

A. Conform to the following:

1. National Electrical Code-2014 with South Carolina Modifications-2016.

PART 2 - PRODUCTS

2.1 GROUND RODS

A. Copper-clad steel of diameter and length indicated on the Drawings.

2.2 GROUNDING CONDUCTORS

A. Except as otherwise specified herein or indicated on the Drawings, electrical system and equipment grounding conductors shall be insulated. Insulation shall be rated 600 V. Conductors shall be of same material as feeders and branch circuits.

B. Conductors installed underground to interconnect ground rods, copper plates, and reinforcing or structural steel and extended to equipment as grounding electrode conductors shall be bare copper and minimum #3/0 AWG.

2.3 CORROSION INHIBITOR

A. Colloidal copper suspended in a waterproof corrosion and rust inhibitor compound.

B. Manufacturer: Burndy, or Thomas & Betts.

2.4 GROUND CLAMPS

A. UL listed.

2.5 GROUND FIELD CONNECTIONS

A. Compression-type connectors, UL listed for use as grounding and bonding equipment.

1. Manufacturer: Burndy, ILSCO, or Thomas & Betts.

B. Exothermic process.

1. Manufacturer: Burndy, or Erico.

2.6 LUGS

A. UL listed for use as grounding and bonding equipment, with 2 bolt hole pads.

2.7 GROUND BUSBARS

A. Solid Copper, electro-tin plated, free from surface corrison with insulated stnadoffs and mountign brackets.

B. Sizes as indicated on the Drawings. Size 1/4" x 4" x 24" or 1/4" x 4" x 36".

C. Manufacturer: Erico or approved equal.

2.8 GROUND HUBS

A. Threaded hub with steel screws, for 1" size conduit, for wire sizes 10-3/0 AWG.

B. Manufactuer: Garvin H100, Dottie HUB100L, Thomas & Betts 3950, or OZ/Gedney GH-100G.

PART 3 - EXECUTION

3.1 EQUIPMENT GROUNDS

A. Equipment, enclosures and raceways shall be grounded.

B. A green colored or green identified grounding conductor shall be installed in raceways with the phase conductors.

C. Bond ground conductors together and to enclosures using grounding lugs at origin of circuits, at intermediate pull boxes, individual circuit breakers, disconnect switches, and to panelboards or equipment at terminations.

3.2 SWITCHBOARD AND PANELBOARD GROUNDS

A. Grounding conductors shall be connected to grounding busses provided in the equipment.

3.3 GROUND FIELD CONNECTIONS

A. Underground connections between conductors and ground rods, flat plates, structural steel, and reinforcing steel shall be made with the exothermic process. UL listed compression-type connectors with corrosion inhibitor compound shall be used on above grade ground bus connections. UL listed ground clamps shall be used for pipe connections.

3.4 GROUNDING AND BONDING CONNECTOR HARDWARE

A. Provide bolts, nuts, lock washers, flat washers, and Belleville washers (for dissimilar metals) of silicon bronze or type 316 stainless steel as recommended by the manufacturer. Tighten connections to manufacturer's recommended torque values.

3.5 GROUND BUSBARS

A. Provide labeling as required in Section 260010, Electrical General, for each ground connection.

B. Ground conductor connections to Busbar shall use lugs.

C. Metal conduit bonding jumper to Busbar shall use grounding hub.

END OF SECTION 264500

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SECTION 264510 - LIGHTNING PROTECTION SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other electrical systems are specified in other Sections of Division 26.

B. This Section covers the lightning protection system.

C. This Section includes responsibilities and obligations in support of the performance verification specified in Section 260090, Electrical Performance Verification.

1.2 QUALITY ASSURANCE

A. Conform to the following:

1. NFPA 780-2017.
2. UL 96A-2016.

B. The installer shall be UL listed and shall be certified by the Lightning Protection Institute.

PART 2 - PRODUCTS

2.1 GENERAL

A. Concealed type system, complete with equipment and connections.

2.2 FITTINGS

A. Bolted, pressure type.

2.3 CONDUCTORS AND AIR TERMINALS

A. Aluminum conductors. Class I equipment, in accordance with NFPA 780-2017.

2.4 MANUFACTURER

A. Advanced Lightning Technology, Capital, East Coast, Harger, Independent, National Lightning Protection, Robbins, or Thompson.

PART 3 - EXECUTION

3.1 GENERAL

A. Provide a lightning protection system, installed in compliance with UL or LPI-IP Lightning Protection Inspection Certificate requirements.

B. Obtain and submit a UL Master Label or an LPI-IP Master Installation Certificate.

END OF SECTION 264510

SECTION 264600 - DRY-TYPE TRANSFORMERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. General provisions and other electrical systems are specified in other Sections of Division 26.

B. This Section covers dry-type transformers.

C. Vibration isolation and seismic requirements are specified in Section 260010, Electrical General.

D. Transformers shall meet the requirement of 10 CFR 431-2017-Energy Efficiency Program for Certain Commercial and Industrial Equipment.

E. Transformer efficiency shall be measured according to 10 CFR 431-2017.

F. This Section includes responsibilities and obligations in support of the performance verification specified in Section 260090, Electrical Performance Verification.

1.2 QUALITY ASSURANCE

A. Conform to the following:

1. NECA 409-2015.
2. National Electrical Code-2014 with South Carolina Modifications-2016.

PART 2 - PRODUCTS

2.1 TRANSFORMERS (600 V NOMINAL OR LESS)

A. Ventilated, 480 V, 3-phase, delta primary, 208/120 V, 3-phase, 4-wire, wye-connected secondary unless otherwise indicated on the Drawings, with full capacity standard taps in primary winding.

B. Transformers shall be manufactured and tested in accordance with UL 1561-2011.

C. Insulation: 220°C.

D. Temperature rise: 115°C.

E. Coils and core shall be mounted on vibration isolators.

F. Enclosures shall be UL listed for indoor installation unless indicated otherwise on the Drawings for outdoor installation.

G. Manufacturer: Acme, Eaton, GE, Powersmiths, Siemens, Square D, or Uptegraff.

PART 3 - EXECUTION

3.1 GENERAL

A. Ground the secondary neutral.

B. Install transformers on vibration isolators. See Section 260010, Electrical General for requirements.

C. Adjust transformer taps for proper system voltage.

D. Adjust internal vibration isolators of the coils and core.

END OF SECTION 264600

SECTION 264710 - PANELBOARDS

PART 1 - GENERAL

1.1 DESCRIPTION:

A. General provisions and other electrical systems are specified in other Sections of Division 26.

B. This Section covers lighting and appliance branch circuit panelboards and distribution panelboards.

C. Refer to Section 26 47 50, Overcurrent Protective Devices for circuit breakers.

D. Refer to Section 26 67 10, Surge Protective Devices for surge protective devices.

E. This Section includes responsibilities and obligations in support of the performance verification specified in Section 26 00 90, Electrical Performance Verification.

1.2 QUALITY ASSURANCE:

A. Conform to the following:

1. NECA 407-2015.
2. NEMA PB 1-2011.
3. National Electrical Code-2014 with South Carolina Modifications-2016.
4. UL 50-2015.
5. UL 67-2009.

PART 2 - PRODUCTS

2.1 BUS MATERIAL:

A. Buswork shall be copper.

2.2 CABLE CONNECTIONS:

A. Cable connection lugs shall be UL listed for use with the type of material to which they are connected.

2.3 TYPE MAINS:

A. Main lugs or main breakers shall be provided as indicated on the Drawings.

2.4 GROUND BUS:

A. Provide ground bus bars in cabinets.

2.5 CIRCUIT BREAKER PANELBOARDS:

A. Protective devices in panelboards shall be molded case thermal-magnetic, with bolt-on type automatic circuit breakers of frame types, number poles, trip ratings and quantities as indicated on the Drawings and as specified herein.

B. Main and branch breakers shall be rated for the fault current level indicated on the Drawings, minimum 10000 A RMS symmetrical for 208 V or 120 V AC, and 14000 A RMS symmetrical for 480 V or 277 V AC. Each breaker shall be fully rated for the fault current available at its point of application.

C. Circuit breakers rated or adjustable to 1200 A or higher shall be provided with Energy-Reducing Maintenance Switching provisions as specified in Section 26 47 50, Overcurrent Protective Devices.

D. Spaces for future breakers shall be equipped with hardware to accept breakers, and shall be bussed to accept a minimum 60 A breaker without revisions, unless otherwise indicated on the Drawings.

E. Multipole breakers shall have internal common trip.

2.6 FUSIBLE COORDINATION PANELBOARDS:

A. Branch circuit protective devices shall be mechanically interlocked fuse and disconnect assemblies, bolt-on type, with number of poles, amperage ratings, and quantities as indicated on the drawings and as specified herein.

B. Devices shall provide open fuse indication via permanently installed indicating light.

C. The main disconnect, if scheduled, shall be a quick-make, quick-break device.

D. Overcurrent Protection:

1. All overcurrent protective devices shall have a minimum UL listed interrupting rating of 300 kA interrupting rating of 200 kA.
2. Branch circuit overcurrent protection shall be 600 V AC UL listed minimum 300 kA and minimum 300 kA IR finger-safe fuse with Class CF (equivalent to Class J) performance characteristics.
3. Main overcurrent protective devices shall be 600 V AC UL listed minimum 300 kA IR and minimum 200 kA IR Class J fuses or Class CF (equivalent to Class J) performance fuses.
4. Where panelboard main fuses are installed, fuse in panelboard branch circuit shall selectively coordinate with main fuses for all overcurrent up to 200 kA.

2.7 CABINETS:

A. Cabinets shall be galvanized code thickness steel with door and trim finished in gray enamel or lacquer. Mounting shall be flush or surface as indicated on the Drawings. Doors shall have combination latch and cylinder lock and shall be hinged door-in-door type. Locks shall be keyed alike. Gutter space shall be in accordance with UL 67-2009, except that cabinets enclosing a through-feeder shall have an additional 4" width in the gutter on the feeder side.

2.8 SURGE PROTECTIVE DEVICES:

A. Provide surge protective devices in panelboards where indicated on drawings.

2.9 LABELING:

A. Panelboards shall be UL listed as "Suitable for Use as Service Entrance Equipment" and labeled as such by the manufacturer where so used.

2.10 MANUFACTURER:

A. Circuit breaker panelboards shall be by the same manufacturer as switchboards.

1. Square D NQ, NF, or I-Line.

B. Fusible coordination panelboards shall be by the same manufacturer as switchboards.

1. Square D.

PART 3: EXECUTION

3.1 ELEVATION:

A. Unless otherwise indicated on the Drawings, install top of panelboard cabinets 78" above the finished floor.

3.2 SUPPORT:

A. Panelboards shall be anchored to the building structure.

3.3 SPARE FUSES:

A. Furnish 20% or minimum of six fuses of each rating and type of fuse installed in fusible coordination panelboards.

B. Furnish a minimum of one spare fuse cabinet for spare fuse storage.

3.4 MULTIWIRE BRANCH CIRCUITS:

A. Group conductors within panelboards.

B. Install handle ties on individual single-pole circuit breakers serving multiwire branch circuits.

END OF SECTION 264710

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SECTION 264750 - OVERCURRENT PROTECTIVE DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION:

A. General provisions and other electrical systems are specified in other Sections of Division 26.

B. This Section covers overcurrent protective devices for systems operating at 600 V AC or less in equipment furnished under Division 26.

C. This Section includes responsibilities and obligations in support of the performance verification specified in Section 26 00 90, Electrical Performance Verification.

1.2 1.02 QUALITY ASSURANCE:

A. Conform to the following:

1. National Electrical Code-2014 with South Carolina Modifications-2016.
2. UL 489-2016.
3. UL 1066-2012.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES:

A. Quick-make quick-break fusible type. Fusible switches with frames 30 A through 600 A shall be furnished with fuses and matching fuse clips specified herein.

B. Switches shall incorporate safety cover interlocks to prevent opening the cover with the switch in the on position or prevent placing the switch in on position with the cover open, and a defeater.

C. Handles shall have provisions for padlocking and shall clearly indicate the on or off position. Front cover doors shall be capable of being padlocked in the closed position.

D. Manufacturer: Eaton, GE, Siemens, or Square D.

2.2 MOLDED CASE CIRCUIT BREAKERS:

A. Molded case circuit breakers shall provide complete circuit overcurrent protection by having inverse time and instantaneous tripping characteristics, and where indicated on the Drawings or specified herein shall be current limiting.

B. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip free. Automatic tripping of the breaker shall be indicated by handle position. Contacts shall be nonwelding silver alloy and arc extinction shall be accomplished by means of arc chutes.

C. Minimum circuit breaker interrupting capacities shall be as indicated on the Drawings with the minimum rating level as specified herein.

1. Lighting and branch circuit panelboard circuit breakers shall be rated a minimum of 14000 RMS symmetrical AIC for 277 V and 480 V, and 10000 RMS symmetrical AIC for 120 V and 208 V.
2. Circuit breakers used in combination starters shall have a minimum interrupting capacity equal to or greater than the short circuit capacity shown for the panelboard or switchboard immediately upstream between the device and the source.
3. Individually mounted circuit breakers shall have a minimum interrupting capacity equal to or greater than the short circuit capacity shown for the panelboard, switchboard, or switchgear immediately upstream between the device and the source.
4. Protective devices in panelboards shall be fully rated for the fault current available at the point of application. Series rated devices shall not be provided.

D. Individually mounted circuit breakers shall incorporate hinged covers with external operating handles. Devices shall be removable from the front.

E. Breakers with frames 600 A and larger shall include solid state trip complete with built-in current transformers, solid state trip unit and shunt trip. Breakers shall have trip ratings as indicated on the Drawings. Trip units shall have adjustable short time setting with a fixed instantaneous override for circuit protection. Main breakers shall be provided with additional short delay trip time adjustment for increased system coordination. Where indicated on the Drawings, or specified herein, breakers shall have built-in ground fault protection with adjustable pick-up rating not exceeding 1200 A. Ground fault time delay shall be adjustable 0.1 s to 0.5 s. Breakers shall have a neutral ground fault current transformer for 4-wire systems.

F. Insulated Case Circuit Breakers:

1. Breakers shall be UL listed, insulated case type, minimum AIC as indicated on the Drawings. Breakers shall be stationary, 100% equipment rated units, with pad-lock function. Breakers shall be listed for series rating of 150000 RMS symmetrical AIC minimum with Class L fuses applied on the line side.
2. Breakers shall be equipped with integral solid state programmer with adjustable current, adjustable long-time delay, adjustable short-time delay, adjustable instantaneous pick-up, adjustable ground fault pick-up, adjustable ground fault delay, and overload, short circuit, and ground fault trip indication targets. Ground fault trip range shall be approximately 25% to 100% of nominal breaker rating, up to a maximum of 1200 A.

G. Manufacturer: Eaton, GE, Siemens, or Square D.

2.3 FUSES:

A. Fuses in devices through 600 A capacity: UL Class RK1 current limiting, dual element, time-delay type with Class R fuse clips for motor branch circuits and transformer feeders, and UL Class J current limiting, quick acting type for other applications.

B. Fuses shall be voltage rated for the system in which they are installed.

C. Manufacturer: Bussmann, Edison Fusegear, Ferraz Shawmut, GE, or Littelfuse.

2.4 SPECIAL FUSES:

A. Fuses in control circuits and special applications shall be of type and size for duty for the specific application.

2.5 ENERGY-REDUCING MAINTENANCE SWITCHING

A. Circuit breakers identified in this Section and other Sections with Energy-Reducing Maintenance Switching shall reduce the instantaneous pickup value to no intentional delay, via circuit breaker trip unit or remote settings via a remote switch.

B. A local status indicator shall be provided to indicate status.

C. The Energy-Reducing Maintenance Switching setting shall be activated and deactivated without opening the equipment. When activated, the setting shall not compromise circuit breaker phase protection and when disabled, recalibration of the circuit breaker settings shall not be required.

PART 3: EXECUTION

3.1 INSTALLATION:

A. Install overcurrent protective devices as indicated on the Drawings or specified herein, in accordance with manufacturer's written instructions.

3.2 FUSIBLE SWITCHES:

A. Install fuses in fusible switches.

B. Provide fuses in fusible switches serving packaged air conditioning units, elevators, and escalators, in accordance with manufacturers' recommendations and nameplate requirements.

3.3 CIRCUIT BREAKERS:

A. Fasten circuit breakers without causing mechanical stresses, twisting or misalignment being exerted by clamps, supports, or cabling.

B. Install fuses in circuit breakers with fuse protection.

3.4 SPARE FUSES:

A. Provide 3 spare fuses of each size, UL class, and voltage rating and turn over to the Owner. Obtain a receipt for same.

3.5 FUSE STORAGE:

A. Furnish a galvanized sheet metal cabinet with hinged door and latch in the main electrical service room to contain spare fuses. To the back side of the door attach a type written list of spare fuses itemized to show quantity, amperage, class and catalogue order number.

END OF SECTION 264750

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SECTION 264760 - INDIVIDUAL CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 DESCRIPTION:

A. General provisions and other electrical systems are specified in other Sections of Division 26.

B. This Section covers individual circuit breakers.

C. This Section includes responsibilities and obligations in support of the performance verification specified in Section 26 00 90, Electrical Performance Verification.

PART 2: PRODUCTS

2.1 GENERAL:

A. Circuit breakers shall be the molded case frame type, with number of poles and trip rating as indicated on the Drawings. Enclosures shall be NEMA 1 in dry spaces, and NEMA 3R in wet or exposed locations.

B. Breakers: as specified in Section 26 47 50, Overcurrent Protective Devices.

2.2 MANUFACTURER:

A. Circuit breakers shall be by the same manufacturer as panelboards.

PART 3: EXECUTION

3.1 INSTALLATION:

A. Circuit breakers shall be supported and located in same manner as specified herein for disconnect switches.

END OF SECTION 264760

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SECTION 265100 - LUMINAIRES

PART 1 - GENERAL

1.1 DESCRIPTION:

A. General provisions and other electrical systems are specified in other Sections of Division 26.

B. This Section covers luminaires, both interior and exterior.

C. Modular flexible wiring systems are specified in Section 26 12 60, Modular Flexible Wiring Systems.

D. Seismic restraints are specified in Section 26 00 10, Electrical General.

E. This Section includes responsibilities and obligations in support of the performance verification specified in Section 26 00 90, Electrical Performance Verification.

1.2 SPACE CONDITIONS:

A. Exact locations of luminaires shall be as indicated on the architectural reflected ceiling plans and wall elevations. Where variance exists between the Electrical and Architectural Drawings, the Architectural Drawings shall govern.

1.3 QUALITY ASSURANCE:

A. Conform to the following:

1. National Electric Code-2014 with South Carolina Modifications-2016.

PART 2 - PRODUCTS

2.1 GENERAL:

A. Luminaires shall be UL listed, and factory wired.

B. Molded-plastic materials used as lenses or louvers for the transmission or diffusion of light shall comply with requirements for approved light transmitting plastics in the International Building Code-2015 with South Carolina Ammendments. The manufacturer of each luminaire shall provide notarized certification including reference to the UL listing. Each sheet, panel, grid or unit shall be labeled for identification.

C. Painted metal components shall be painted after fabrication.

D. Disconnects: luminaires shall have factory installed integral disconnection means that simultaneously open circuit conductors between branch circuits and drivers including grounded conductors.

2.2 SUSPENDED LUMINAIRES:

A. Suspended fluorescent luminaires shall be chain hung using SJT cord.

B. Suspended direct/indirect luminaires shall have field adjustable aircraft cable suspension. Luminaires shall be provided with straight power cords. Suspension points shall be symmetrically located from the center of the luminaire. Sloped ceiling adaptors shall be provided where applicable.

2.3 RECESSED LUMINAIRES:

A. Recessed luminaires shall have trim and supports provided by the fixture manufacturer and designed for the type of ceiling in which they will be installed.

B. Recessed luminaires in lay-in ceilings shall be the lay-in type unless indicated otherwise on the Drawings, and shall be designed for the type of ceiling and grid in which they will be installed.

2.4 EXTERIOR LUMINAIRES:

A. Exterior luminaires shall be UL classified for damp or wet locations as applicable, and shall be complete with gaskets, cast aluminum weatherproof outlet boxes, and grounding.

2.5 LED LUMINAIRES:

A. Electrical and photometric testing methodology for LED luminaires shall comply with IES LM-79-2008.

B. Projected long term lumen maintenance of LED light sources shall be determined in accordance with IES TM-21-2011 (Addendum B). Lumen maintenance for LED luminaires shall meet or exceed L70 at 50,000 hours of operation. Lumen maintenance testing shall comply with IES LM-80-2015 Errata 1.

C. LED drivers shall operate from an input source of 47 Hz to 63 Hz and 90 V to 305 V.

D. LED modules and drivers shall be field replaceable.

E. LED luminaires shall have a 5 year written warranty from date of shipment to the site against mechanical or electrical defects under normal conditions of use, including a replacement labor allowance.

PART 3 - EXECUTION

3.1 LUMINAIRES:

A. Provide drivers for LED luminaires.

3.2 INSTALLATION:

A. Exterior luminaires shall not be installed until after the building exterior has been rinsed of any corrosive cleaning materials.

B. Install pendant luminaires so that the luminaire housing does not rotate when changing a lamp by pole or other means.

C. Aircraft cable for suspended direct/indirect luminaires shall be attached to the structure above the ceiling.

D. Luminaires shall be adjusted and installed to provide the lighting pattern for which the fixture is designed.

3.3 SUPPORT:

A. Recessed luminaires shall be supported from the structure independent of the ceiling support system. Provide at least two supports on diagonals where any horizontal dimension of the luminaire is 18" or larger.

B. Surface- and pendant-mounted and chain hung luminaires shall be supported from the structure above.

3.4 LUMINAIRE ADJUSTMENTS:

A. Provide final luminaire adjustments of adjustable luminaires under supervision of the Architect. Adjustments shall be carried out before the final site visit, unless indicated by the Architect. Provide personnel and equipment for this task. Adjustments shall be as directed by the Architect. When aiming and adjusting is completed, locking set screws and nuts and bolts shall be tightened securely.

B. Luminaires shall be focused during the normal working day; however, where daylight interferes with illumination levels, aiming shall be accomplished at night, at no additional cost to the Owner.

C. Luminaire adjustments shall be reviewed and approved by the Architect prior to occupancy by the Owner.

END OF SECTION 265100

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SECTION 265910 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION:

A. General provisions and other electrical systems are specified in other Sections of Division 26.

B. This Section covers wall switch digital timers, wall box dimmers, occupancy sensors, photosensors, time switches, photocells, and lighting contactors.

C. This Section includes responsibilities and obligations in support of the performance verification specified in Section 26 00 90, Electrical Performance Verification.

1.2 QUALITY ASSURANCE:

A. Conform to the following:

1. National Electric Code-2014 with South Carolina Modifications-2016.

B. Codes, standards and regulations specified herein refer to the edition date. Revisions and addenda to these codes, standards and regulations shall be part of these specifications. Provisions of referenced codes, standards and regulations do not create duty or responsibility by the Architect or the Owner, unless otherwise specified herein.

C. Codes, standards and regulations referred to are minimum standards. Where the requirements of these specifications or drawings exceed those of the codes, standards and regulations, the drawings or specifications govern.

PART 2 - PRODUCTS

2.1 GENERAL:

A. Like products shall be by the same manufacturer.

2.2 WALL SWITCH DIGITAL TIMERS:

A. Wall-mounted digital timer switches shall be programmable to shut off lighting automatically after a preset time. Timer switches shall be single-pole, single-throw, rated 800 W at 120 V, 1200 W at 277 V, and 1/6 hp at 120 V. Switches shall have an adjustable time out setting of 5 minutes to 12 hours. Switches shall be capable of providing audible or visual alerts before lighting shut off. Switches shall have on/off lighting control override pushbutton switch. Switches shall be compatible with LED, or motor loads. Color shall be gray.

1. Manufacturer: Greengate TSW-MV, Hubbell Building Automation TD200, Sensor Switch TS2, or WattStopper TS-400.

2.3 WALL BOX DIMMERS:

A. Solid state, combination dimmer/switch type, designed for flush wall mounting. Dimmers shall be LED or 3-way type as indicated on the Drawings.

1. Three-way wall switches used in conjunction with 3-way dimming systems or mounted adjacent to wall box dimmers shall be 20 A rated and shall be of the same style and manufacturer as wall box dimmers.

B. Wattage ratings indicated on the Drawings are for individual mounting. Wattage shall be derated in accordance with the manufacturer's recommendations when dimmers are ganged together.

C. Dimmers shall have positive air gap on-off position, and shall have slide type operation.

D. Dimmers and faceplates color shall be selected by the Architect.

E. Manufacturer: Leviton Renior II, Cooper Skye, or Lutron Nova T✯.

2.4 OCCUPANCY SENSORS:

A. General:

1. Occupancy sensors shall not emit audible noise or signals that interfere with electronic devices.
2. Occupancy sensors shall be designed to be compatible with LED drivers.
3. Occupancy sensors shall have field selectable automatic or manual on operation modes.
4. Occupancy sensors shall be designed to have RFI and EMF immunity, zero crossing relay control, and voltage drop protection.

B. Wall Switch Occupancy Sensors:

1. Sensors shall be 60 Hz, with adjustable ambient light levels, adjustable sensitivity and time delay, and manual push button on/off control with LED indicator light. Sensitivity and time delay settings shall have field selectable self-adjusting and manual modes.
2. Occupancy sensors shall accommodate loads from 0 W to 800 W at 120 V, 0 W to 1200 W at 277 V, and shall have 180° coverage capability.
3. Sensors shall be provided with a manual override feature to bypass the occupancy sensor function and override lights to on when a sensor is malfunctioning. The pushbutton on/off control shall manually turn lights on and off when the sensor is in bypass mode.
4. Dual relay occupancy sensors shall be provided with two fully rated relays for controlling two independent lighting loads or circuits.
5. Dual technology sensors shall be factory preset to require sensing of both technologies to initially trigger the device. Once the device has been triggered, the detection of either technology shall maintain the triggered state. This operating logic shall be field selectable.
6. Sensors color shall be selected by the Architect.
7. Occupancy sensors shall have a 5 year written warranty. The warranty period shall begin at date of substantial completion.
8. Passive Infrared:

a. Manufacturer: Greengate ONW-P-MV, Hubbell LHIRS1, Leviton ODSXX-ID, or WattStopper PW-100.

9. Passive Infrared, Dual Relay:

    a. Manufacturer: Greengate ONW-P-DMV, Hubbell LHIRD2, Leviton ODS0D-ID, or WattStopper PW-200.

10. Ultrasonic:

    a. Manufacturer: Greengate ONW-U-MV, Hubbell LHUSS1, Leviton ODSXX-UD, or WattStopper UW-100.

11. Ultrasonic, Dual Relay:

    a. Manufacturer: Greengate ONW-U-DMV, Hubbell LHUSD2, Leviton ODS0D-UD, or WattStopper UW-200.

12. Dual Technology, Passive Infrared and Ultrasonic:

    a. Manufacturer: Greengate ONW-DT-MV, Hubbell LHMTS1, Leviton ODSMT-MD, or WattStopper DW-100.

13. Dual Technology, Passive Infrared and Ultrasonic, Dual Relay:

    a. Manufacturer: Greengate ONW-DT-DMV, Hubbell LHMTD2, Leviton ODSMD-MD, or WattStopper DW-200.

C. Ceiling-, Wall-, and Corner-Mounted Occupancy Sensors:

1. Ceiling-Mounted Occupancy Sensors Ultrasonic and Passive Infrared:

    a. Ultrasonic type with 32 kHz to 40 kHz operating frequency, 360° field of view with 2000 ft² coverage area, adjustable ambient light levels, adjustable time delay, isolated relay, and LED indicator light. Sensitivity and time delay settings shall have field selectable self-adjusting and manual modes. Low voltage power supplies and relays required for control of lighting loads shall be by same manufacturer as occupancy sensors and provided with sensors at voltage as indicated on the Drawings.
    b. Passive infrared type with 360° field of view with 450 ft² coverage area, adjustable ambient light levels, adjustable time delay, isolated relay, and LED indicator light. Sensitivity and time delay settings shall have field selectable self-adjusting and manual modes. Low voltage power supplies and relays required for control of lighting loads shall be by same manufacturer as occupancy sensors and provided with sensors at voltage indicated on the Drawings.
    c. Dual technology type, with passive infrared and ultrasonic technologies, with 360° field of view with 2000 ft² coverage area, adjustable ambient light levels, adjustable time delay, isolated relay, and LED indicator light. Sensitivity and time delay settings shall have field selectable self-adjusting and manual modes. Low voltage power supplies and relays required for control of lighting loads shall be by same manufacturer as occupancy sensors and provided with sensors at voltage indicated on the Drawings.

2. Ceiling/Wall/Corner-Mounted Occupancy Sensors, Ultrasonic and Passive Infrared:

a. Passive infrared type with 115° field of view with 1000 ft² to 2000 ft² coverage area, adjustable ambient light levels, adjustable time delay, isolated relay, and LED indicator light. Sensitivity and time delay settings shall have field selectable self-adjusting and manual modes. Low voltage power supplies and relays required for control of lighting loads shall be by same manufacturer as occupancy sensors and provided with sensors at voltage indicated on the Drawings.

b. Dual technology type, with passive infrared and ultrasonic technologies, with 115° to 180° field of view with 1000 ft² to 2000 ft² coverage area, adjustable ambient light levels, adjustable time delay, isolated relay, and LED indicator light. Sensitivity and time delay settings shall have field selectable self-adjusting and manual modes. Low voltage power supplies and relays required for control of lighting loads shall be by same manufacturer as occupancy sensors and provided with sensors at voltage indicated on the Drawings.

3. Manufacturer: Greengate, Hubbell, Leviton, or WattStopper.

2.5 PHOTOSENSORS:

A. Class 2 low voltage type designed for interior applications. Units shall be designed for recessed ceiling mounting or on luminaires. Sensors shall be partially shielded to prevent luminaire or horizontal lighting components from effecting accurate detection of available daylight. Response to daylight shall be linear.

1. Manufacturer: Greengate, Hubbell, Leviton, Sensor Switch, or WattStopper.

2.6 PHOTOCELLS:

A. Heavy duty die cast enclosure, weatherproof, gasketed, containing cadmium sulphide hermetically sealed cell. Contacts shall be single-pole, single-throw normally closed. On-off adjustment shall be by movable light level selector. Units shall be designed for mounting on threaded conduit nipple.

B. Manufacturer: Intermatic K4100 series, or Tork 2100 series.

2.7 LIGHTING CONTACTORS:

A. Mechanically held type, 20 A, 277 V, 60 Hz maximum rating, number of poles indicated on the Drawings, normally open, NEMA 1 enclosure with hand-off-automatic switch mounted on enclosure. Mechanically held contactors shall have solid state control modules for 2-wire operation.

B. Manufacturer: Asco, GE, Siemens, or Square D.

2.8 EMERGENCY LIGHTING CONTROL RELAY DEVICES:

A. Emergency lighting control relay devices shall consist of relay switching circuitry contained in a NEMA Type 1 wall mountable enclosure to control any type of lighting and to bypass any lighting control device during a normal power failure and transfer to the alternate power source regardless of the control device state. Device features shall include:

1. UL 924-2016 and UL 1008-2014 listed for field installation and suitable for use in indoor and damp locations.
2. Test switch to test unit under load conditions.
3. LED indicator lights for normal and emergency power sources.
4. Operate at 120 or 277 V AC, 60 Hz, and a temperature between -4°F to 131°F.
5. Lighting load rating of 20 A maximum.
6. Five-year full warranty from date of installation.

B. Manufacturer: Bodine GTD20A, Chloride MTD20D, or Dual-Lite ATSD20.

2.10 TIME SWITCHES:

A. Electronic 4-channel time switch with 7 day programming, automatic daylight savings and leap year adjustments, holiday scheduling, astronomic capability on all channels, LED display, battery powered memory, and manual permanent override switches. Input voltage shall be 120 V AC. Outputs shall be single-pole, double-throw relays with 10 A, 120 V AC maintained contacts. Enclosure shall be lockable NEMA 1 surface-mounted.

1. Manufacturer: Intermatic, or Tork.

PART 3 - EXECUTION

3.1 GENERAL:

A. Wall-mounted devices shall be installed flush in the wall on which they are located when served by concealed conduit. Where necessary to conceal the conduit or flush mount the device box, masonry or plaster shall be channeled and patched.

B. Wall-mounted devices shall be surface mounted where their connecting raceways are indicated on the Drawings exposed.

C. Where 2 or more wall box type lighting control devices are indicated on the Drawings at the same location, they shall be ganged and covered with 1 faceplate.

D. Install device faceplates and adjust devices to achieve a flush fit with no gaps.

E. For occupancy sensors, photosensors, and time switches, the manufacturer shall provide factory start-up and training of the installation. Every device in the system shall be tested and adjusted as needed to provide optimum performance of the system. The factory-trained representative shall provide a minimum of 4 hours of training to the Owner's operating personnel. Provide the Owner with certificates of system start-up, and instruction of operating personnel.

3.2 WALL SWITCH DIGITAL TIMERS:

A. Install per manufacturer's installation instructions. Time out adjustment shall be set at 15 minutes.

3.3 PHOTOSENSORS:

A. The exact locations and quantities of photosensors shall be determined at the building; refer to manufacturer's installation instructions prior to installation for manufacturer's recommended placement. Locate sensors in the correct location required for the proper coverage of controlled areas and to minimize interference from other light sources.

B. The sensors shall be adjusted for a target illuminance of as directed by the Owner.

3.4 PHOTOCELLS:

A. Mount photocells on threaded conduit nipples, north facing at locations indicated on the Drawings. coordinated with the Architect.

3.5 OCCUPANCY SENSORS:

A. Install per manufacturer's installation instructions. Ambient light level setting shall be adjusted to maximum.

B. For sensors set to a manual mode, set the time delay to 15 minutes and sensitivity to maximum.

C. Sensors in corridors shall be set to self-adjusting mode. Other sensors shall be set to manual mode.

D. Sensors in private offices, break rooms, conference rooms, mail rooms, and storage rooms, shall be set to "manual on" mode. Other sensors shall be set to automatic on mode.

E. Install ultrasonic, infrared, or dual technology type occupancy sensors per manufacturer's recommendations based on the room type, height, usage, partitions, and other factors that directly affect the sensors' operation.

F. The locations and quantities of occupancy sensors indicated on the Drawings are diagrammatic and indicate only that the rooms are to be provided with occupancy sensors. The exact locations and quantities shall be determined at the building; refer to manufacturer's installation instructions prior to installation for manufacturer's recommended placement. Locate and aim occupancy sensors in the correct location required for the complete and proper volumetric coverage within the range of coverages of controlled areas per the manufacturer's recommendations. Rooms shall have 90% to 100% coverage of the controlled area to accommodate occupancy habits of single or multiple occupants at any location within the rooms. Provide additional occupancy sensors if required to properly and completely cover the respective room at no additional cost to the Owner.

G. The right is reserved to change the location of any sensor in any room before it is permanently installed, without additional cost to the Owner.

H. Provide control wiring between occupancy sensors, low voltage power supplies, and relays per manufacturer's requirements. Provide additional low voltage power supplies and relays as required at no additional cost to the Owner.

I. Control wiring shall be installed in raceways in spaces where ceilings are exposed to structure.

J. Verify adjustment and occupancy sensor placement to ensure a trouble-free occupancy-based lighting control system.

3.6 EMERGENCY LIGHTING CONTROL RELAY DEVICES:

A. Locate emergency lighting control relay devices as indicated on the Drawings.

B. Permanently identify the box or enclosure as a component of the emergency system. Include the normal and emergency circuit numbers.

C. Mark each designated standby luminaire with red dot labels.

3.07 TIME SWITCHES:

A. Install per manufacturer's installation instructions. Set time switches as directed by the Owner.

END OF SECTION 265910

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SECTION 266710 - SURGE PROTECTIVE DEVICES

PART 1: GENERAL

1.1 DESCRIPTION:

A. General provisions and other electrical systems are specified in other Sections of Division 26.

B. This Section covers surge protective devices (SPDs) for low-voltage, 600 V or less, electrical distribution equipment.

C. This Section includes responsibilities and obligations in support of the performance verification specified in Section 26 00 90, Electrical Performance Verification.

1.2 QUALITY ASSURANCE:

A. Conform to the following:

1. IEEE C62.41.1-2002 (R2008).
2. IEEE C62.41.2-2002 (COR 1-2012).
3. National Electric Code-2014 with South Carolina Modifications-2016.
4. UL 1283-2017.
5. UL 1449-2014.

B. SPDs shall have a 5 year warranty.

PART 2 - PRODUCTS

2.1 SURGE PROTECTIVE DEVICES:

A. General:

1. UL 1449-2014 voltage protection rating (VPR) label shall be permanently affixed to the units.
2. Maximum continuous operating voltage (MCOV) shall be greater than 115% of the nominal system operating voltage.
3. Protection modes: for a wye-configured system, devices shall have directly connected suppression elements between line-neutral (L-N), line-ground (L-G), and neutral-ground (N-G). For a delta-configured system, devices shall have suppression elements between line-line (L-L) and line-ground (L-G).
4. Nominal discharge current (in): SPDs applied to the distribution system shall have a 20 kA in rating regardless of their SPD type (including Types 1 and 2) or operating voltage.
5. UL 1449-2014 component voltage protection rating shall not exceed the following:

System Voltage	208Y/120	480Y/277
L-N; L-G; N-G	700 V	1200 V
L-L	1200 V	2000 V

6. Electrical noise filter: each unit shall include a high performance EMI/RFI noise rejection filter.

7. Internal connections: internal components shall be hardwired with connections utilizing low impedance conductors and compression fittings.
8. Overcurrent protection: each unit shall be provided with overcurrent protection to provide both thermal overload protection for small magnitude fault current conditions or temporary over voltage conditions as well as short circuit current protection for high magnitude fault conditions. Each MOV module or element shall be individually fused with 200000 RMS symmetrical AIC internal fuses.
9. Monitoring and Diagnostics:

    a. SPDs shall be equipped with visible indication of proper connection and operation. Indicator lights shall indicate which phase as well as which module is fully operable.
    b. SPDs shall be equipped with an audible alarm which shall activate when any one of the surge current modules has reached an end-of-life condition. An alarm on/off switch shall be provided to silence the alarm. The switches and alarm shall be located on the front cover of each enclosure.
    c. SPDs shall be equipped with contacts for remote annunciation of alarm or trouble.
    d. SPDs installed at service entrance locations or within switchboards shall be equipped with a transient event counter.

10. Each unit shall incorporate an integral test feature to verify the operational integrity of the unit's monitoring system.

2.2 SYSTEM APPLICATIONS:

A. SPD applications covered under this Section include distribution and branch circuit panelboard locations and switchboard assemblies.

B. SPDs shall be designed and tested for application within IEEE C62.41.1-2002 (R2008) Category C, B, and A environments.

C. Surge current capacity: the minimum surge current capacity that each unit is capable of withstanding shall be as shown in the following table:

IEEE 62.41-2002 (R2008) Location Category	Application	Minimum Surge Current Per Phase	Minimum Surge Current Per Mode*
C	Service entrance (switchboards, main entrance)	250 kA	100 kA
B	Distribution and power panelboards	150 kA	50 kA
A	Branch circuit panelboards	100 kA	50 kA

*L-G, L-N and N-G (wye system); L-L, L-G (delta system).

D. SPD type: SPDs installed on the line side of the service entrance disconnect shall be Type 1. SPDs installed on the load side of the service entrance disconnect shall be Type 2.

E. Panelboard Requirements:

1. Units shall be designed for IEEE C62.41.1-2002 (R2008) and IEEE C62.41.2-2002 (COR 1-2012) Category B environments.

F. Switchboard Requirements:

1. Service entrance and other switchboard SPD units shall be designed for IEEE C62.41.1-2002 (R2008) and IEEE C62.41.2-2002 (COR 1-2012) Category C environments.
2. Provide a disconnect switch directly ahead of or integral to the suppressor assembly.
3. Monitoring diagnostic features such as indicator lights, trouble alarms, and surge counter shall be mounted on the front of the switchboard.

2.3 MANUFACTURER:

A. Square D Surgelogic.

PART 3: EXECUTION

3.1 INSTALLATION:

A. Install SPDs in accordance with manufacturer's written instructions.

B. Install SPDs in service entrance equipment.

C. Provide SPDs for switchboards, distribution panelboards, and branch-circuit panelboards where indicated in the Drawings. SPDs shall be installed integral to electrical distribution equipment by the electrical distribution equipment manufacturer.

1. Locate SPDs on the load side of the main disconnect device, as close as possible to the phase conductors and ground and neutral bar.
2. SPDs and integral disconnects shall be installed in switchboard using a direct bus bar connection or cable connection between each bus bar and SPD. Maximum cable lead length between suppressor and bus bar shall not exceed 14".
3. SPDs shall be integrated within panelboards and shall be direct bus bar mounted.

END OF SECTION 266710

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SECTION 270526 - GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1: GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.

1.02 SUMMARY

A. Section Includes:

1. Grounding conductors.
2. Grounding connectors.
3. Grounding busbars.
4. Grounding labeling.

1.03 DEFINITIONS

A. BCT: Bonding conductor for telecommunications.

B. EMT: Electrical metallic tubing.

C. TBB: Telecommunications bonding backbone

D. TGB: Telecommunications grounding busbar.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.05 INFORMATIONAL SUBMITTALS

A. As-Built Data: Plans showing as-built locations of grounding and bonding infrastructure, including the following:

1. BCT, TGBs, TBBs and routing of their bonding conductors.

B. Field quality-control reports.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding to include in operation, and maintenance manuals.

1.07 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Installation Supervision: Installation shall be under the direct supervision of ITS Technician, who shall always be present when Work of this Section is performed at Project site.
2. Field Inspector: Currently registered by BICSI as a registered communications distribution designer to perform the on-site inspection.

PART 2: PRODUCTS

2.01 SYSTEM COMPONENTS

A. Comply with J-STD-607-A.

2.02 CONDUCTORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Harger Lightning & Grounding.
2. TE Connectivity, LTD
3. Engineer Approved Equal

B. Comply with UL 486A.

C. Insulated Conductors: Stranded copper wire, green or green with yellow stripe insulation, insulated for 600 V, and complying with UL 83.

1. Ground wire for custom-length equipment ground jumpers shall be No. 6 AWG, 19-strand, UL-listed, Type THHN wire.
2. Cable Tray Equipment Grounding Wire: No. 6 AWG.

D. Cable Tray Grounding Jumper:

1. Not smaller than No. 6 AWG and not longer than 12 inches. If jumper is a wire, it shall have a crimped grounding lug with two holes and long barrel for two crimps. If jumper is a flexible braid, it shall have a one-hole ferrule. Attach with grounding screw or connector provided by cable tray manufacturer.

E. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.
4. Bonding Cable: 28 kcmils, 14 strands of No. 17 AWG conductor, and 1/4 inch in diameter.

5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Tinned-copper tape, braided conductors terminated with two-hole copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

2.03 CONNECTORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Burndy; Part of Hubbell Electrical Systems.
2. Chatsworth Products, Inc.
3. Harger Lightning & Grounding.
4. TE Connectivity, LTD
5. Engineer Approved Equal

B. Irreversible connectors listed for the purpose. Listed by an NRTL as complying with NFPA 70 for specific types, sizes, and combinations of conductors and other items connected. Comply with UL 486A-486B.

C. Compression Wire Connectors: Crimp-and-compress connectors that bond to the conductor when the connector is compressed around the conductor. Comply with UL 467.

1. Electroplated tinned copper, C and H shaped.

D. Busbar Connectors: Cast silicon bronze, solderless compression-type, mechanical connector; with a long barrel and two holes spaced on 5/8 inch centers for a two-bolt connection to the busbar.

E. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.04 GROUNDING BUSBARS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Chatsworth Products, Inc.
2. Harger Lightning & Grounding.
3. TE Connectivity, LTD

B. TGB: Predrilled, wall-mounted, rectangular bars of hard-drawn solid copper, 1/4 by 4 inches in cross section, length as indicated on Drawings. The busbar shall be NRTL listed for use as TGB and shall comply with J-STD-607-A.

1. Predrilling shall be with holes for use with lugs specified in this Section.
2. Mounting Hardware: Stand-off brackets that provide a 4-inch clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.

C. Rack and Cabinet Grounding Busbars: Rectangular bars of hard-drawn solid copper, accepting conductors ranging from No. 14 to No. 2/0 AWG, NRTL listed as complying with UL 467, and complying with J-STD-607-A. Predrilling shall be with holes for use with lugs specified in this Section.

1. Cabinet-Mounted Busbar: Terminal block, with stainless-steel or copper-plated hardware for attachment to the cabinet.
2. Rack-Mounted Horizontal Busbar: Designed for mounting in 19 in. equipment racks. Include a copper splice bar for transitioning to an adjoining rack, and stainless-steel or copper-plated hardware for attachment to the rack. See drawings for detailed information concerning rack-mounted horizontal busbars.

2.05 LABELING

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Brother International Corporation.
2. HellermannTyton.
3. Engineer Approved Equal

B. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

PART 3: EXECUTION

3.01 EXAMINATION

A. Examine the ac grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of the electrical system.

B. Inspect the test results of the ac grounding system measured at the point of BCT connection.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

D. Proceed with connection of the BCT only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Bonding shall include the ac utility power service entrance, the communications cable entrance, and the grounding electrode system. The bonding of these elements shall form a loop so that each element is connected to at least two others.

B. Comply with NECA 1.

C. Comply with J-STD-607-A.

3.03 APPLICATION

A. Conductors: Install solid conductor for No. 8 AWG and smaller and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

1. The bonding conductors between the TGB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.

B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2 AWG minimum.

C. 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.

D. Conductor Support:

1. Secure grounding and bonding conductors at intervals of not less than 36 inches.

E. Grounding and Bonding Conductors:

1. Install in the straightest and shortest route between the origination and termination point, and no longer than required. The bend radius shall not be smaller than eight times the diameter of the conductor. No one bend may exceed 90 degrees.
2. Install without splices.
3. Install in telecom cable tray or support at not more than 36-inch intervals where cable tray is not available.
4. If a grounding and bonding conductor is installed in ferrous metallic conduit, bond the conductor to the conduit using a grounding bushing that complies with requirements in Section 270528 "Pathways for Communications Systems," and bond both ends of the conduit to a TGB

3.04 GROUNDING ELECTRODE SYSTEM

A. The BCT between the TGB and the ac service equipment ground shall not be smaller than No. 3/0 AWG.

3.05 CONNECTIONS

A. Bond metallic equipment in a telecommunications equipment room to the grounding busbar in that room, using equipment grounding conductors not smaller than No. 6 AWG.

B. Stacking of conductors under a single bolt is not permitted when connecting to busbars.

C. Assemble the wire connector to the conductor, complying with manufacturer's written instructions and as follows:

1. Use crimping tool and the die specific to the connector.
2. Pre-twist the conductor.
3. Apply an antioxidant compound to all bolted and compression connections.

D. Primary Protector: Bond to the TGB with insulated bonding conductor.

E. Telecommunications Enclosures and Equipment Racks: Bond metallic components of enclosures to the telecommunications bonding and grounding system. Install top-mounted rack grounding busbar unless the enclosure and rack are manufactured with the busbar. Bond the equipment grounding busbar to the TGB with a No. 6 AWG bonding conductors.

F. Structural Steel: Where the structural steel of a steel frame building is readily accessible within the room or space, bond each TGB to the vertical steel of the building frame.

G. Electrical Power Panelboards: Bond each TGB to the ground bar of each panelboard serving each communication room.

H. Shielded Cable: Bond the shield of shielded cable to the TGB in communications rooms and spaces. Comply with TIA/EIA-568-B.1 and TIA/EIA-568-B.2 when grounding screened, balanced, twisted-pair cables.

I. Rack- and Cabinet-Mounted Equipment: Bond powered equipment chassis to the cabinet or rack grounding bar. Power connection shall comply with NFPA 70; the equipment grounding conductor in the power cord of cord- and plug-connected equipment shall be considered as a supplement to bonding requirements in this Section.

3.06 IDENTIFICATION

A. Labels shall be preprinted or computer-printed type.
1. Label TGB(s) with "fs-TGB," where "fs" is the telecommunications space identifier for the space containing the TGB.
2. Label the BCT and each telecommunications backbone conductor at its attachment point: "WARNING! TELECOMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!"

3.07 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
2. Test the bonding connections of the system using an AC earth ground-resistance tester, taking two-point bonding measurements in each telecommunications equipment room containing a TGB and using the process recommended by BICSI TDMM. Conduct tests with the facility in operation.

    a. Measure the resistance between the busbar and the nearest available grounding electrode. The maximum acceptable value of this bonding resistance is 100 milliohms.

3. Test for ground loop currents using a digital clamp-on ammeter, with a full-scale of not more than 10 A, displaying current in increments of 0.01 A at an accuracy of plus/minus 2.0 percent.

    a. With the grounding infrastructure completed and the communications system electronics operating, measure the current in every conductor connected to the TGB. Maximum acceptable ac current level is 1 A.

C. Excessive Ground Resistance: If resistance to ground at the BCT exceeds 5 ohms, notify Design Consultant promptly and include recommendations to reduce ground resistance.

D. Grounding system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 270526

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SECTION 270528 - PATHWAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.

1.2 SUMMARY

A. Section Includes:

1. Metal conduits and fittings.
2. Nonmetallic conduits and fittings.
3. Optical-fiber-cable pathways and fittings.
4. Fire Rated Cable Pathways
5. J-Hooks.
6. Boxes, enclosures, and cabinets.
7. Buried communication line marking tape

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. GRC: Galvanized rigid conduit.

C. IMC: Intermediate metal conduit.

D. RNC: Rigid non-metallic conduit.

1.4 ACTION SUBMITTALS

A. Product data: For each type of product.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Pathway routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

1. Structural members in paths of pathway groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. Description: Metal raceway of circular cross section with manufacturer-fabricated fittings.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. AFC Cable Systems; a part of Atkore International.
2. Allied Tube & Conduit; a part of Atkore International.
3. Alpha Wire.
4. Anamet Electrical, Inc.
5. Electri-Flex Company.
6. O-Z/Gedney; a brand of Emerson Industrial Automation.
7. Picoma Industries, Inc.
8. Plasti-Bond.
9. Republic Conduit.
10. Southwire Company.
11. Thomas & Betts Corporation; A Member of the ABB Group.
12. Western Tube and Conduit Corporation.
13. Engineer Approved Equal.

C. General Requirements for Metal Conduits and Fittings:

1. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.
2. Comply with TIA-569-D.

D. GRC: Comply with ANSI C80.1 and UL 6.

E. IMC: Comply with ANSI C80.6 and UL 1242.

F. EMT: Comply with ANSI C80.3 and UL 797.

G. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.

1. Fittings for EMT:

a. Material: Steel.
b. Type: Compression.

2. Expansion Fittings: PVC or steel to match conduit type, complying with UL-467, rated for environmental conditions where installed, and including flexible external bonding jumper.

H. Joint Compound for IMC or GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS AND FITTINGS

A. Description: Nonmetallic raceway of circular section with manufacturer-fabricated fittings.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. AFC Cable Systems; a part of Atkore International.
2. Allied Tube & Conduit; a part of Atkore International.
3. Anamet Electrical, Inc.
4. Arnco Corporation.
5. CANTEX INC.
6. Carlon; a brand of Thomas & Betts Corporation.
7. CertainTeed Corporation.
8. Condux International, Inc.
9. Dura-Line.
10. Electri-Flex Company.
11. Kraloy.
12. Lamson & Sessions.
13. Niedax Inc.
14. RACO; Hubbell.
15. Engineer Approved Equal.

C. General Requirements for Nonmetallic Conduits and Fittings:

1. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
2. Comply with TIA-569-D.

D. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.

E. Fittings: Comply with NEMA TC 3; match to conduit or tubing type and material.

F. Solvents and Adhesives: As recommended by conduit manufacturer.

2.3 OPTICAL-FIBER-CABLE PATHWAYS AND FITTINGS

A. Description: Comply with UL 2024; flexible-type pathway with a circular cross section, approved for plenum installation unless otherwise indicated.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Maxcell Innerduct.
2. Engineer Approved Equal.

C. General Requirements for Optical-Fiber-Cable Pathways and Fittings:

1. White Polyester and Nylon resin polymer
2. Standard Outdoor Textile Innerduct: 3-inch, 3-cell polyester/nylon textile innerduct containing 1250lb polyester flat woven pull tape.

3. Conduit Plugs: Compression-type conduit plugs with locking nuts for sealing and securing one or more textile innerducts within a 4-inch inside diameter conduit, e.g. 4-inch plug with nine holes for cables in a 3 pack (9-cell) configuration.
4. Termination Bags: Inflation-type bags for sealing and securing around one or more textile innerducts and cables within 2-inch outside diameter or larger conduit.
5. Duct Water Seal: products suitable for closing underground and entrance conduit openings where innerduct or cable is installed, to prevent entry of gases, liquids, or rodents into the structure.
6. Integral Tracer Wire: solid copper, polyvinyl color coated conductor (18AWG minimum) for tracing and rated for a minimum of 6 amps and 600 volts. Conductor shall be placed in the sidewall edge fold of the textile sleeve.

D. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

E. Comply with TIA-569-D.

2.4 FIRE RATED CABLE PATHWAYS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Hilti North America - Firestop Speed Sleeve
2. Wiremold/Legrand Flamestopper
3. Specified Technologies Inc. (STI) - EZ Path
4. Engineer Approved Equal

B. General Requirements for fire rated cable pathways:

1. Fire rated cable pathway devices shall be used in fire-rated construction for low-voltage, video, data and voice cabling and optical fiber cabling at locations shown on the drawings.
2. Fire rated cable pathways shall contain a built-in fire sealing system sufficient to maintain the hourly fire-rating of fire rated wall and or floor penetrated.
3. The self-contained sealing system shall adjust to the installed cable loading and shall permit cables to be installed or removed without the need to remove or reinstall firestop materials.
4. Fire rated cable pathways shall be engineered such that two or more devices may be ganged together for larger cable capacities.
5. Affix adhesive wall label immediately adjacent to devices to communicate to future cable technicians, authorities having jurisdiction and others the manufacturer of the device and the corresponding UL System number installed.
6. Fire rated cable pathway shall replace conduit sleeves with firestop sealant/putty in walls and floors, and;

    a. When installed individually in walls/floors, devices shall pass through core-drilled opening utilizing tested wall/floor plates.
    b. When multiple units are ganged in walls/floors, devices shall be anchored by means of a tested grid.

7. Cable tray/cabled runway shall terminate at each wall/floor and resume on the other side such that cables pass independently through fire rated pathway devices. Cable tray/cable runway shall be properly supported on each side of the wall/floor.
8. Fire rated cable pathways shall be UL Classified and/or FM Systems Approved and tested to the requirements of ASTM E814 (UL1479).

2.5 J-HOOKS

A. Description: Prefabricated sheet metal cable supports for telecommunications cable.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Erico, Inc.
2. Panduit Corp.
3. Engineer Approved Equal.

C. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

D. Comply with TIA-569-D.

E. Rated for use with Category 6 cable.

F. Galvanized steel.

G. J shape.

2.6 BOXES, ENCLOSURES, AND CABINETS

A. Description: Enclosures for communications.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Adalet.
2. Carlon; a brand of Thomas & Betts Corporation.
3. Crouse-Hinds, an Eaton business.
4. EGS/Appleton Electric.
5. Erickson Electrical Equipment Company.
6. FSR Inc.
7. Hoffman; a brand of Pentair Equipment Protection.
8. Milbank Manufacturing Co.
9. Molex Industrial Products Group; Woodhead Brand.
10. MonoSystems, Inc.
11. Oldcastle Enclosure Solutions.
12. O-Z/Gedney; a brand of Emerson Industrial Automation.
13. Plasti-Bond.
14. Quazite: Hubbell Power Systems, Inc.
15. Engineer Approved Equal.

C. General Requirements for Boxes, Enclosures, and Cabinets:

1. Comply with TIA-569-D.
2. Boxes, enclosures, and cabinets installed in wet locations shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for use in wet locations.
3. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
4. Device Box Dimensions: 4 11/16 inches square by 3 inches deep.

D. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

E. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

F. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

G. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover.

H. Hinged-Cover Enclosures and Cabinets: Comply with UL 50 and NEMA 250, with continuous-hinge cover, screw down clamps, padlock hasp and mounting panel unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Nonmetallic Enclosures:

a. Material: Fiberglass.
b. Finished inside with radio-frequency-resistant paint.

3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
4. Accessory feet where required for freestanding equipment.
5. Refer to drawings for required NEMA ratings.

2.7 BURIED COMMUNICATION LINE MARKING TAPE

A. Underground Communication Line Marking Tape: Permanent, bright-colored, continuous-printed, plastic, tape compounded for direct-burial service not less than 6 inches wide by 4 mils thick. Printed legend shall be indicative of general type of underground line below, such as "CAUTION - BURIED COMMUNICATION LINE BELOW". Tape shall have integral metallic facing or metallic core to allow locating buried tape with electronic detection equipment.

PART 3 - EXECUTION

3.1 PATHWAY APPLICATION

A. Outdoors: Apply pathway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC.
2. Concealed Conduit, Aboveground: GRC.
3. Underground Conduit: RNC, Type EPC-40-PVC.

4. Boxes and Enclosures, Aboveground: NEMA 250, Type 4X.

B. Indoors: Apply pathway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: GRC.
4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Damp or Wet Locations: IMC.
6. Pathways for Non-Armored-Optical-Fiber Cable in Spaces Used for Environmental Air: Plenum-type, optical-fiber-cable pathway.
7. Pathways for Non-Armored-Optical-Fiber Cable Risers in Vertical Shafts: Riser-type, optical-fiber-cable pathway.
8. Pathways for Concealed General-Purpose Distribution of Non-Armored-Optical-Fiber Cable: Plenum-type, optical-fiber-cable pathway.
9. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4X stainless steel units in outdoor locations or garage locations.
10. Optical-fiber-cable pathway not required for armored optical fiber.

C. Minimum Pathway Size: 1-inch (21-mm) trade size for copper cables, and 1 1/2 inch (25 mm) for optical-fiber cables.

D. Pathway Fittings: Compatible with pathways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. EMT: Use compression, steel fittings. Comply with NEMA FB 2.10.

E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

F. Install surface pathways only where indicated on Drawings.

3.2 INSTALLATION

A. Comply with the following standards for installation requirements except where requirements on Drawings or in this Section are stricter:

1. NECA 1.
2. NECA/BICSI 568.
3. TIA-569-D.
4. NECA 101
5. NECA 102.
6. NECA 105.
7. NECA 111.

B. Cabling shall be concealed where possible and shall be installed as follows

1. Cables concealed inside hollow wall construction shall be installed in conduits stubbed into accessible ceiling cavities.
2. Cables installed in accessible ceiling cavities shall be supported with cable tray or J-Hook supports.

3. Cables located in rooms with an exposed ceiling structure shall be installed in conduit.
4. Cables installed above inaccessible ceilings shall be installed in conduit.
5. It is acceptable to fish flexible metal conduit inside existing hollow walls and above existing inaccessible ceilings.
6. Cables installed outdoors shall be installed in conduit.
7. Cables installed in casework shall be installed in conduit.
8. Route conduit and cables to suit field conditions.

C. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.

D. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

E. Comply with requirements in Section 270529 "Hangers and Supports for Communications Systems" for hangers and supports.

F. Keep pathways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.

G. Complete pathway installation before starting conductor installation.

H. Arrange stub-ups so curved portions of bends are not visible above finished slab.

I. Install no more than the equivalent of two 90-degree bends in any pathway run. Support within 12 inches (300 mm) of changes in direction. Utilize long radius ells for all optical-fiber cables.

J. Conceal rigid conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

K. Support conduit within 12 inches (300 mm) of enclosures to which attached.

L. Stub-ups to Above Recessed Ceilings:

1. Use EMT or IMC for pathways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

M. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of pathway and fittings before making up joints. Follow compound manufacturer's written instructions.

N. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install insulated bushings on conduits terminated with locknuts.

O. Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus one additional quarter-turn.

P. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure, to assure a continuous ground path.

Q. Cut conduit perpendicular to the length. For conduits of 2-inch (50-mm) trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.

R. Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Secure pull wire, so it cannot fall into conduit. Cap pathways designated as spare alongside pathways in use.

S. Pathways for Optical-Fiber and Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:

1. 1-Inch (25-mm) Trade Size and Larger: Install pathways in maximum lengths of 75 feet (23 m).
2. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.

T. Install pathway-sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed pathways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install pathway-sealing fittings according to NFPA 70.

U. Install suitable pliable compound to seal pathway interiors at accessible locations. Locate seals, so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all pathways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service pathway enters a building or structure.
3. Where an above grade pathway enters or exits a building structure.
4. Where otherwise required by NFPA 70, Article 300.7 (A).

V. Comply with manufacturer's written instructions for solvent welding PVC conduit and fittings.

W. Expansion-Joint Fittings:

1. Install in each run of aboveground PVC that is located where environmental temperature change may exceed 30 deg F (17 deg C), and that has straight-run length that exceeds 25 feet (7.6 m). Install in each run of aboveground metal that is located where environmental temperature change may exceed 100 deg F (55 deg C), and that has straight-run length that exceeds 100 feet (30 m).
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:

    a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
    b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
    c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.

d. Attics: 135 deg F (75 deg C) temperature change.

3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F (0.0115 mm per meter of length of straight run per deg C) of temperature change for metal conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion and seismic joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

X. Optical-Fiber-Cable Pathways and Fittings

1. Protect products from the effects of moisture, UV exposure, corrosion and physical damage during construction.
2. When installed in 4” conduit, use two 3” 3-Cell packs with an additional pull tape on the outside for future pulls in each conduit.
3. Provide textile innerduct in conduit and wire ways, and place textile innerduct within and under cable trays using continuous unspliced lengths of textile innerduct between maintenance holes, pull boxes, and/or termination points as indicated on the drawings.
4. At locations where textile innerduct will be continuous through a manhole or hand hole, allow sufficient slack so that the innerduct may be secured to the side of the vault maintaining the minimum bend radius.
5. At manhole or handholes serving as the junction location, pull the exposed end of the innerduct to the far end of the vault, install termination bag, and secure to the vault.

Y. Fire Rated Pathways

1. Before beginning installation, verify that substrate conditions previously installed under other sections are acceptable for installation of firestopping in accordance with manufacturer’s installation instructions and technical information.
2. Install systems in accordance with Performance Criteria and in accordance with the conditions of testing and classification as specified in the published design.
3. Comply with manufacturer’s instructions for installation of products.
4. Place system stickers on each side of wall penetrations.

Z. J-Hooks:

1. Size to allow a minimum of 25 percent future capacity without exceeding design capacity limits.
2. Shall be supported by dedicated support wires. Do not use ceiling grid support wire or support rods.
3. Hook spacing shall allow no more than 6 inches (150 mm) of slack. The lowest point of the cables shall be no less than 6 inches (150 mm) adjacent to ceilings,

mechanical ductwork and fittings, luminaires, power conduits, power and telecommunications outlets, and other electrical and communications equipment.

4. Space hooks no more than 4 feet o.c.
5. Provide a hook at each change in direction.
6. Category 6A and fiber optic cable shall not be hung on the same J-Hook, use multiple J-Hooks to separate Category 6A cable from fiber optic cable.

AA. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

BB. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surface to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

CC. Horizontally separate boxes mounted on opposite sides of walls, so they are not in the same vertical channel.

DD. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

EE. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe of less than 6 inches (150 mm) in nominal diameter.
2. Install backfill as specified in Section 312000 "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."
4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.

    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete around conduit for a minimum of 12 inches (300 mm) on each side of the coupling.
    b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.

5. Buried Communication Line Warning Tape: Bury warning tape approximately 12 inches above all underground communication conduits.

3.4 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 PROTECTION

A. Protect coatings, finishes, and cabinets from damage or deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 270528

SECTION 270529 - HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.

1.2 SUMMARY

A. Section Includes:
1. Steel slotted support systems for communication raceways.
2. Conduit and cable support devices.
3. Support for conductors in vertical conduit.
4. Structural steel for fabricated supports and restraints.
5. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
6. Fabricated metal equipment support assemblies.

B. Special Application in Parking Garage
1. Contractor shall coordinate installation of any anchors, through-bolts and core drilling of any T-flange, T-stem or structural member inside the parking garage prior to installation of anchors or core drilling.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
a. Slotted support systems, hardware, and accessories.
b. Clamps.
c. Hangers.
d. Brackets.
2. Include rated capacities and furnished specialties and accessories.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch- (10-mm-) diameter holes at a maximum of 8 inches (200 mm) o.c. in at least one surface. Provide fittings and accessories that mate and match with steel slotted support systems and are of the same manufacturer.

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. B-line, an Eaton business.
   b. Unistrut; Part of Atkore International.
   c. Equal.
2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Material for Channel, Fittings, and Accessories: Galvanized steel.
4. Channel Width: Selected for applicable load criteria.
5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
6. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
7. Channel Dimensions: Selected for applicable load criteria.
8. Provide steel channels with hot-dip galvanized finish for all outdoor locations.

B. Conduit and Cable Support Devices: Steel clamps, hangers, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored communications 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 made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
1. Powder-Actuated Fasteners: Threaded-steel stud for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
   a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      1) Hilti, Inc.
      2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
      3) MKT Fastening, LLC.
2. 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 where used.
   a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      1) B-line, an Eaton business.
      2) Empire Tool and Manufacturing Co., Inc.
      3) Hilti, Inc.
      4) ITW Ramset/Red Head; Illinois Tool Works, Inc.
      5) Equal.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 05 50 00 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:
1. NECA 1.
2. NECA/BICSI 568.
3. TIA-569-D.
4. NECA 101
5. NECA 102.
6. NECA 105.
7. NECA 111.

B. Comply with requirements for pathways specified in Section 27 05 28 "Pathways for Communications Systems."

C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMTs, IMCs, and RMCs as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.

D. 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 percent in future without exceeding specified design load limits.
1. Secure raceways and cables to these supports with two-bolt conduit clamps

E. Special Application in Parking Garage
1. Contractor shall coordinate installation of any anchors, through-bolts and core drilling of any T-flange, T-stem or structural member inside the parking garage prior to installation of anchors or core drilling.

3.2 SUPPORT INSTALLATION

A. 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 (90 kg).

B. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten communications 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: Use approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
   4. To Existing Concrete: Use expansion anchor fasteners.
   5. Instead of expansion anchors, powder-actuated-driven threaded studs, provided with lock washers and nuts, may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
   6. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
   7. To Light Steel: Sheet metal screws.
   8. 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 comply with seismic-restraint strength and anchorage requirements.

C. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 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 (0.05 mm).

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 270529

SECTION 271100 - COMMUNICATIONS EQUIPMENT ROOM FITTINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cable runways
2. Backboards.

B. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.

1.2 DEFINITIONS

A. BICSI: Building Industry Consulting Service International.

B. LAN: Local area network.

C. OWNER: GSP IT Department Representative

D. RCDD: Registered Communications Distribution Designer.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for equipment specified herein. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For communications equipment room fittings and cable trays. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Grounding: Indicate location of grounding bus bar and its mounting detail showing standoff insulators and wall mounting brackets.

C. Qualification Data: For Installer qualified layout technician, installation supervisor, and field inspector.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings shall be under the direct supervision of RCDD.

2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall always be present when Work of this Section is performed at Project site.
3. Field Inspector: Currently registered by BICSI as RCDD to perform the on-site inspection.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.

1.5 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install equipment and cable trays until spaces are enclosed and weathertight, wet work in spaces is complete and dry, and work above ceilings is complete.

1.6 COORDINATION

A. Coordinate layout and installation of communications equipment with GSP IT Department Representative (Owner).

1. Meet jointly with Owner to exchange information and agree on details of equipment arrangements and installation interfaces.
2. Record agreements reached in meetings and distribute them to other participants.
3. Adjust arrangements and locations of cabinets/racks, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of telecommunication and LAN equipment.
4. Adjust arrangements and locations of equipment with cabinets/racks, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in the equipment room.

B. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

PART 2 - PRODUCTS

2.1 CABLE RUNWAY

A. General Requirements: Comply with TIA/EIA-569-A.

B. Cable Support: NRTL labeled. Cable support brackets shall be designed to prevent degradation of cable performance and pinch points that could damage cable. Cable tie slots fasten cable ties to brackets.

1. Comply with NFPA 70 and UL 2043 for fire-resistant and low-smoke-producing characteristics.
2. Support brackets with cable tie slots for fastening cable ties to brackets.
3. Lacing bars, spools, J-hooks, and D-rings: rated to support Category 6 and fiber optic cable.

4. Straps: all straps shall be Velcro-type. Plastic zip ties shall not be allowed to secure cable.

C. Cable Runway

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. Chatsworth Products, Inc. – Universal Cable Runway
   b. Cooper B-Line – Cable Runway
   c. Engineer Approved Equal

2. Construction: Cable runway shall be manufactured from 3/8" (9.5 mm) wide by 1-1/2" (38 mm) high tubular steel with .065" (1.65 mm) wall thickness. Cable runway (side stringers) will be 9'-8½ "(2959mm) long. Cross members will be welded in between stringers on 9" (230 mm) intervals/centers beginning 4-1/4" (108mm) from one end.
3. UL Listed: Cable runway will be UL Classified for suitability as an equipment grounding conductor only (Contractor shall remove paint or use ground straps at splices and intersections).
4. Sizes: Provide cable runway sizes as defined on drawings.
5. Finish shall be epoxy-polyester hybrid powder coat (paint) in black, unless noted otherwise.
6. Connector Assemblies: Turns, transitions, corners and brackets shall meet the same specification as the cable runway section.
7. Connector Assembly Capacity: Splices located within support span shall not diminish rated loading capacity of cable runway.
8. Hardware and Fasteners: Steel, zinc plated matching same color as cable runway section.
9. Support: Provide a combination of wall mount, data cabinet to cable runway mount, relay rack to cable runway mount and ceiling trapeze cable runway support. The use of a single center hung support rod shall not be allowed.
10. Grounding: Grounding kits are required to provide a method of bonding cable runway sections and turns together that is independent of the pathway splices. The grounding kit shall be constructed of UL Listed components. The preferred solution is a #6 AWG green insulated stranded copper conductor connected on both ends to ladder rack using two-hole compression lugs and stainless-steel hardware.
11. Accessories: All accessories shall be manufactured from same material as cable runway section. Provide following accessories:

    a. Cable straps used for attaching cable bundles to the cable runway cross members must be reusable with a hook and loop-style closure.
    b. End caps used to cover the ends of cable runway shall be manufactured from a black fire-retardant rubberized material.
    c. End closing kits used to cover the end of cable runway. Kits shall consist of a bar cut to match the width of the cable runway and the hardware required to attach the bar to the end of a length of cable runway.

12. Radius drops used to create a radius to form cables over as the cables exit or enter the cable runway. The extrusion will be formed in a 90° arc with a minimum bend

radius of 3” (75 mm). Radius drops will attach to either the side stringer or the cross member of the cable runway using a clevis pin. Provide radius drops at all sections where cable exits runway

2.2 BACKBOARDS

A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches. Comply with requirements for plywood backing panels specified in Division 06 Section "Miscellaneous Rough Carpentry."
   1. Backboards shall be installed in all IDF Rooms. Install backboard on all walls of the room starting at 12” AFF with 96” dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joint, unless noted otherwise on drawings.
   2. Backboards installed in IDF Rooms shall be painted with white, fire retardant paint (leaving the certification label exposed and unpainted) on all six (6) sides. Backboards shall be painted prior to installation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Comply with BICSI TDMM for layout and installation of communications equipment rooms.

C. Cable Runways: Comply with NEMA VE 2 and TIA/EIA-569-A-7.

D. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.2 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements in Division 27 Section "Premise Distribution System.

B. See Division 27 Section “Premise Distribution System" for additional identification requirements. Coordinate exact labeling standard with Owner prior to generation of labeling and/or documentation.

C. Labels shall be preprinted or computer-printed type.

END OF SECTION 271100

SECTION 271300 - PREMISE DISTRIBUTION SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Category 6 horizontal cables, terminations and testing
2. Fiber optic backbone cables, terminations and testing
3. Copper backbone cables, terminations and testing
4. Coaxial cables, terminations and testing
5. Equipment racks and cabinets
6. Uninterruptable Power Supplies and Power Distribution Units
7. Innerduct

B. Specific reference in Specifications to codes, rules, regulations, standards, manufacturer's instructions or requirements of regulatory agencies shall mean the latest printed edition of each in effect at date of contract unless the Document is shown dated.

C. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.

D. Conflicts:
1. Between referenced requirements: Comply with the one establishing the more stringent requirements.
2. Between referenced requirements and contract documents: Comply with the one establishing the more stringent requirements.

E. References: Cabling, connectors, installation and testing shall comply with the following codes, standards, and design guidelines:
1. ANSI/TIA/EIA-568-B.2-1, Transmission Performance Specifications for 4-Pair 100 Ohm Category 6
2. ANSI/TIA/EIA-568-B.3 Optical Fiber Cabling Components Standard
3. ANSI/TIA/EIA – 569-A Pathway and Spaces
4. ANSI/TIA/EIA - 606
5. ISO/IEC – 11801
6. FCC 47 CFR 68
7. Building Industry Consulting Services International (BICSI) Telecommunications Distribution Methods Manual (TDMM)
8. NFPA 70 (Current Version); National Electrical Code.
9. Local codes and ordinances, as applicable.

1.2 SYSTEM DESCRIPTION

A. The premise distribution system provides a consolidated communications infrastructure to be used by network systems and is comprised of copper and fiber optic cables. This system shall provide transmission media for all voice, data, and video signals. The contractor shall provide premise distribution transmission media, components, and testing as specified herein or shown on the plans and in conformance with manufacturers' requirements and

recommendations. The premise distribution system shall consist of riser (backbone) and horizontal (station) cabling. Riser cabling shall include singlemode fiber optic and multipair telephone riser cables installed in a star topology from the MDF Room to IDF Rooms. Horizontal cabling shall include Category 6 UTP installed in a star topology from the IDF Rooms and Network Equipment Cabinets to voice and data outlets.

1.3 COORDINATION

A. Contractor is responsible for coordination with the GSP IT Department Representative (Owner) for rack and cabinet space and the installation of network equipment furnished and installed by the Contractor as defined in 272100 Local Area Network. Contractor shall provide cross-connects and cabling as required to connect the premise distribution system to Owner's equipment.

B. Contractor shall coordinate installation of network data connections for parking revenue control system (PARCS) and parking guidance systems (PGS) equipment to be furnished and installed by others. Contractor shall meet with the parking systems vendors to define exact location and installation of all cables and connections to support parking equipment.

1.4 SUBMITTALS

A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product Data: For each type of premise distribution system component include manufacturer's name, model numbers, data sheets and ratings.

C. Shop Drawings:
1. Provide raceway layout plans detailing penetrations of fire rated walls.
2. Provide pulling plan prior to cable installation.
3. Provide rack elevations detailing all patch panels, punchdown blocks, wire management and other equipment located within the racks.

D. Identification Scheme: Contractor shall conform to owner identification standards specified under Part 3 of this specification.

E. Test and Acceptance Plan: Indicate testing methods, testing device calibration, and interpretations of test results for Field Acceptance Tests. Submit to the engineer for review and approval the testing plan. Deliver the test plan at least 14 days prior to the scheduled start of the first test. The test plan shall detail the objectives of all tests. The tests shall clearly demonstrate that the system and its components fully comply with the requirements specified herein. Test plan shall identify printed and electronic format of test results report. The test procedures shall contain at a minimum the following elements:
1. Statements of purpose identifying the goals of the test.
2. The methods used for testing.
3. Duration and schedule of tests.
4. Examples of all graphs, tables and charts necessary for display of testing results.
5. Certifications and qualifications of all persons conducting the testing.
6. Calibration certificate of test equipment.

F. Operation and maintenance manuals: It is the intent to require complete documentation of the premise distribution system for the purpose of system operation and maintenance during and after the warranty period. The Contractor shall provide the Owner with complete operation and maintenance manuals and drawings of the completed system. Manuals shall be compiled after system fabrication and testing and shall incorporate all changes made after shop drawing submittal. Manuals shall be permanently bound in hard plastic covers. Manuals shall contain the following:

1. Manufacturer's standard literature, covering all equipment included in the system. Literature shall contain specifications, adjustment procedures, circuit schematics, component location diagrams, and replacement parts identification. All references to equipment not supplied on this project shall be crossed out.
2. Spare parts list covering the manufacturer's recommended spare parts to maintain the system. List shall include part names, part numbers, and source for additional purchase and shall be cross-referenced to the block diagrams and the product data.
3. Special tools and test equipment list covering the tools and equipment required to maintain and test the system. List shall include the part name, number and source for all special tools and test equipment.
4. Block Diagram: Provide an overall block diagram showing the interconnections of major system components.
5. Wiring diagrams: Provide wiring diagrams showing all field installed interconnecting wiring. Wiring identification on the diagrams shall agree with the wire markers installed on the equipment.

G. Manufacturer Certification: Provide certificates signed by the manufacturer, which states that the installer is a manufacturer certified Category 6 system installer. Provide certificates signed by the manufacturer for each type fiber optic product, which state that the installer is a certified installer of the product.

H. Field quality-control test reports and documentation as described in Part 3.

I. Certificate of completion and manufacturer's extended warranty.

J. Quality Assurance Submittals: Submit with the bid documents, the names of at least three premise distribution system installation projects completed within the last five years of similar size in quantity of data and fiber optic drops.

K. As-Built Drawings: Provide as-built drawings showing the location and identification number of all voice and data outlets. In addition, as-built drawings must detail the copper patch panels and fiber optic patch panels in each rack/cabinet. Documentation must show a cable or fiber identifier on each workstation area outlet and each patch panel port.

1.5 QUALITY ASSURANCE

A. Certification: Engage an experience Installer with a minimum RCDD "Technician Level" certification to manage installation of Structure Cabling System. All Installers of cabling under this specification shall have a minimum Level 1 RCDD Certification.

B. Fiber Optic Cable Installer Qualifications: Engage an experienced Installer to install fiber optic cables. The manufacturer of each type of fiber optic product shall certify all personnel performing installation, splices and fiber optic connector terminations.

C. Category 6 UTP Installer Qualifications: Engage an experienced Installer to install Category 6 cables. The manufacturer of each type Category 6 product shall certify all personnel performing installation and connector terminations.

D. Testing Firm Qualifications: The testing firm shall meet OSHA criteria for accreditation of testing laboratories, Title 29, Part 1910.7, or shall be a full member company of the InterNational Electrical Testing Association (NETA).

E. Testing Firm's Field Supervisor Qualifications: A person currently certified by the InterNational Electrical Testing Association (NETA) or National Institute for Certification in Engineering Technologies to supervise on site testing specified in Part 3.

F. Compliance Requirements: Comply with applicable building code, local ordinances and regulations, and requirements of authorities having jurisdiction. Electrical components, devices, and accessories shall be listed and labeled as defined in NFPA 70, Article 100, by a "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7, acceptable to authorities having jurisdiction, and marked for intended use.
1. Comply with the latest edition of NFPA 70.
2. Comply with the latest edition of Telecommunications Industry Association and Electronic Industry Alliance (TIA/EIA) unless directed otherwise.
3. Comply with the latest edition of Building Industry Consulting Services International (BICSI) unless directed otherwise.

1.6 WARRANTY

A. Period: The Contractor shall warranty all labor, workmanship, and materials for a period of one (1) year from the date of final acceptance. Should a failure occur within the first year to the system, the Contractor shall provide all labor and materials necessary to restore the system to the condition required for the final test and acceptance for this contract, at no cost to the Owner.

B. Extended Warranty: The manufacturer shall guarantee in writing that the premise distribution system channels as installed by this contract are free from defects in materials and workmanship and will meet the applicable ANSI/TIA/EIA and ISO/IEC channel transmission requirements in effect at the time of installation and will support any current or future application ratified by IEEE, ANSI, or ISO designed to operate over the applicable ANSI/TIA/EIA-568-B, ISO/IEC 11801, CAT 6 draft or standard in effect at the time of installation. The duration of this warranty shall be for a period of twenty (20) years from date of the installation. Defective products shall be repaired or replaced by the manufacturer, at no cost to the Owner.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Copper and Fiber Optic Cable (Including Patch Cords):
1. UTP Category 6 Indoor Rated:
   a. Commscope: CS37P (UN874043014/10)
   b. No Equal
2. UTP Category 6 Outdoor Rated:

a. Commscope: 1571A (760090043)
b. No Equal

3. Fiber Optic Cable:

a. Commscope TeraSPEED
b. No Equal

4. Category 3 Multipair Cable

a. Superior-Essex
b. Belden
c. No Equal

5. Coaxial Cable:

a. Superior-Essex
b. Belden
c. No Equal

B. Terminating Equipment: (Jacks, Patch Panels, Punchdown Blocks etc.)

1. UTP Category 6 and Cat 3:

a. Commscope USL600 Series
b. No Equal

2. Fiber Optic:

a. Commscope SFC-LCF Series
b. No Equal

C. Racks and Cabinets:

1. Ortronics/Legrand
2. DSI (Co-Location Cabinets only)
3. Multilink (Network Equipment Cabinets only)
4. No Equal

2.2 COPPER AND FIBER OPTIC CABLE

A. Category 6 Cable
1. General: Unshielded Twisted-Pair Cat 6 cable shall exceed all requirements for ANSI/TIA/EIA-568-B.2-1, Transmission Performance Specifications for 4-Pair 100 Ohm Category 6 and support the following high-speed communication network applications:

a. 100MB Faster Ethernet IEEE 802.3
b. 1GB Ethernet IEEE 802.3ab
c. ATM: 155MB, 622MB and 1.2GB, 2.4GB and 4.8 GB
d. T1/E1, XDSL, ISDN
e. 550 MHz Broadband Video

2. Rating: Provide UL-listed Communications Cable Type CMP for plenum applications where cable is run exposed on j-hooks or in cable tray located in ceiling cavities.
3. Construction: PVC jacket. FEP/Polyolefin insulation with FEP separator. Jacket color shall be blue.
4. Conductor shall be 23 AWG (minimum) solid, bare, annealed copper in a core of four balanced twisted pairs held in place by a full cross-web separator.
5. Manufacturer Testing: Furnish a copy of the factory certified test report verifying that final production reels are tested to at least 350 MHz and conform to all ANSI/TIA/EIA Category 6 requirements.
6. Field Testing: All cabling and connectors shall comply with and be tested to ANSI/TIA/EIA-568-A-2 (includes TSB-67) and as specified in Part 3. Cable shall meet or exceed ANSI/TIA/EIA requirements for NEXT, ELFEXT, Attenuation and Return Loss as defined in the respective Standard.
7. Outdoor Rated Category 6 Cable: outdoor rated Category 6 cable shall meet all performance requirements as specified for indoor/interior Category 6 cable. In addition, the inner construction of the cable shall be surrounded by a filling compound to prevent water ingress. The outer core shall be a sunlight and abrasion resistant black polyethylene outer jacket. Provide outdoor rated cable at all locations identified on the drawings.

B. 9/125 Micrometer Single-Mode, Outdoor Optical Fiber Cable (OS2)
1. General: The fiber optic cable construction shall consist of 8.3 µm single mode optical fibers or a combination, typically formed into groups of six (6) or twelve (12) fibers each. Size, strand count and routing of fiber optic cables shall be as indicated on the drawings. These groups and individual fibers shall exceed all requirements for ANSI/TIA/EIA-568-B.3 and support high-speed communication network applications. These groups are assembled to form a single compact core, which is covered by a protective sheath.
2. Single-mode (Dispersion Un-shifted): All single-mode fiber shall support 10 Gigabit Ethernet (10 Gbps) to distances of up to 10,000 meters @ 1310 nm and 40,000 meters @ 1550 nm per IEEE 802.3 performance. The single-mode fiber utilized in the optical fiber cable shall meet TIA-492CAAB, "Detail Specification for Class Iva Dispersion-Unshifted Single-Mode Optical Fibers with Low Water Peak," and ITU recommendation G.652.C "Characteristics of a single-mode optical fiber cable." Provide yellow colored jacket.
3. Identification: The individual fibers shall be color coded for identification. The optical fiber color coding shall be in accordance with EIA/TIA-598, "Optical Fiber Cable Color Coding." When buffered fibers are grouped into individual subunits, each subunit jacket shall be numbered for identification, with the exception of filler subunits where used. The outer jacket shall be marked with the manufacturer's name or ETL file number, date of manufacture, fiber count, fiber type, flame rating, listing symbol, and sequential length markings every two feet.
4. Design Specifications: Provide cable suitable for installation in outdoor, underground environments with loose tube, gel-free waterproof cables. Cable jacket shall meet the following specification:
    a. Jacket Color: Black.
    b. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.

c. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).
d. Applications: Suitable for underground duct installation, polyethylene jacket.
e. Waterblock: Fully waterblocked, gel-free water-swellable tape requiring no clean up

5. Physical Characteristics: 600 lb. maximum installation tension (short term), 200 lb. maximum operating tension (long term). The minimum installation bend radius shall be a minimum of 15 times the cable outer diameter, and the minimum operating bend radius shall be a minimum of 10 times the cable outer diameter.
6. Manufacturer Testing: Furnish a copy of the factory certified optical test report verifying that final production reels comply with the attenuation requirement listed within this specification.

a. All cabled optical fibers > 1000 meters in length shall be 100% attenuation tested. The attenuation of each fiber shall be provided with each cable reel.
b. The cable manufacturer shall be TL 9000 registered.

7. Field Testing: All cabling and connectors shall comply with and be tested to ANSI/TIA/EIA-568-A and as specified in Part 3.

C. Category 3 Backbone Cable
1. General: Unshielded Twisted-Pair Cat 3 Riser Cable shall be distributed in a star configuration from the MDF to the IDF. Size and routing of riser cables shall be as indicated on drawings.
2. Rating: UL-listed suitable for installation in underground conduit/
3. Cable Construction:

a. 24 AWG solid, copper conductors.
b. PVC insulation with standard telephony color code.
c. Flame retardant PVC jacket.
d. Outside plant cable shall be PE-89 rated.

D. Coaxial Cable and Connectors
1. Single Conductor Coaxial Video Cable: 75-ohm characteristic impedance, Foam FEP core, 18-gauge solid center conductor, copper braid shield, FEP jacket, Type RG 6/U.
2. Coaxial Connectors: Provide the connector type as required for the application, design documents or as directed by the Engineer.

a. F-Series crimp-type connector, brass body-copper ferrule, 75ohm impedance, 0-1GHz frequency range, -100 dB min @ 1GHz RF leakage.

3. Coaxial cable shall meet requirements of ANSI/TIA/EIA-568-B.1 Annex C for the application to be supported.
4. Provide UL-listed Communications Cable Type CMP for plenum applications where cable is run exposed on j-hooks or in cable tray located in ceiling cavities..

2.3 CONNECTORS

A. Category 6 Jacks:
1. Female; eight position; modular; fixed telecommunications connector designed for termination of a single four-pair, 100-ohm, Category 6 unshielded twisted pair cable.

2. Designed to snap-in to a patch panel or faceplate.
3. Standard: Comply with TIA-568-C.2.
4. Marked to indicate transmission performance.
5. Jacks shall be modular and identified by color as follows (Coordinate color types with Owner prior to ordering):
    a. Data Jacks – Blue
    b. Voice Jacks - White
6. Coordination with the modular furniture provider shall be necessary to determine type and design of outlet configurations to be incorporated into the furniture.

B. Surface Mount (Biscuit) Outlets
1. Surface mount outlets shall accept connector modules and shall be used to support data applications in open office, retrofit, and other surface-mount environments.
2. Surface mount outlets shall be compatible with the Category 6 connector module specified in this document.
3. Surface mount outlets shall be mounted with a screw. The use of adhesive tape is not allowed.
4. Surface mount outlet shall be UL listed and shall be constructed of fire-retardant ABS plastic rated UL 1863 and UL 2043.
5. Connector modules for use in surface mount outlets shall follow the same color schemes for work area outlets.
6. Provide plenum rated surface mount outlets where noted on drawings.

C. Fiber Optic Connectors
1. LC, Single-mode (OS2), UPC, ceramic ferrule, field installable, blue housing, blue boot, pre-polished connector.
2. Comply with Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA-604-2-B for Type LC connectors and TIA-604-5-D for Type MPO connectors. Comply with TIA-568-C.3.
3. Quick-connect, duplex, Type LC connectors. Insertion loss not more than 0.25 dB.
4. Contractor shall coordinate with Owner to provide the correct fiber optic connector style/type for both the patch panels and patch cords. Selected fiber connector style/types shall be submitted as part of shop drawings to Engineer for final approval.

D. Faceplates
1. Two to Six port, vertical single gang faceplates designed to mount to single gang wall boxes or adapter.
2. Plastic Faceplate: High-impact plastic. Coordinate color with Architect prior to ordering.
3. For use with snap-in jacks accommodating any combination of twisted pair, optical fiber, and coaxial work area cords.
4. Flush mounting jacks.
5. Integral, reusable clear plastic label field above and below ports.

2.4 COPPER PATCH PANELS AND PUNCHDOWN BLOCKS

A. Patch Panel: Blank modular patch panels housing numbered jack units with ability to accept an IDC-type keystone jack at each port location. Patch panels containing fixed, irreplaceable jacks are not acceptable.

1. High density supporting 48 open modular ports
2. 2U mounting height
3. Labeling areas adjacent to ports.
4. Construction: 16-gauge steel and mountable on 19-inch (483 mm) equipment racks.
5. Number of Jacks per Field: One for each four-pair cable indicated.

B. Riser & Voice Punchdown Blocks: Punchdown blocks for riser terminations and horizontal voice circuits (telephone and/or intercom) shall be rack mountable standard Category 6, 110-type connecting blocks providing terminations for 22-26 AWG solid cable. 110 wiring bases shall feature sturdy single-piece construction of fire-retardant plastic rate UL 94V-O. Each panel shall be provided with designation strips or labels for labeling each circuit. Blocks shall be rack-mounted and sized as per the drawings.

2.5 FIBER OPTIC PATCH PANELS

A. Patch Panel Housings
1. Fiber Optic housings shall provide a means for securing, strain-relieving, protecting, and labeling of fiber optic cable terminations.
2. Rack-Mount Housing Specifications
   a. Housings shall be designed for rack-mounted or frame-mounted applications that support conventional cross-connection and interconnection schemes as well as splicing applications.
   b. Housings shall be available in 1U, 2U, 3U and 4U. See drawings for exact size of housings.
3. The housings shall meet the design requirements of ANSI/TIA/EIA-598 and the plastics flammability requirements of UL 94 V-0.
4. The connector housings shall have a labeling scheme that complies with ANSI/TIA/EIA- 606.
5. The housings shall support cross-connection, inter-connection and/or splicing applications and routing schemes in the same housing.
6. The housing shall contain a front compartment whose function is to protect and manage jumpers that interface with the main housing behind it. The front jumper assembly compartment shall be removable and be accessible via a translucent door.
7. The front compartment shall contain jumper egress openings on both sides that are edged with protective pass-through grommets that provide bend radius support for optical fiber jumpers.
8. The rear assembly housing shall be accessible via a hinged door. The door shall contain a routing and cable sub-unit slack storage bracket for interior management of cable sub-units and buffer tubes.
9. The housing shall contain a brushed entry on both sides of the rear of the housing.
10. The housing shall provide means for strain-relieving fiber optic cables both interior to and exterior on the rear assembly housing.
11. The rear of the housing shall contain provisions for routing and maintaining fiber optic cable components, including cable sub-units and buffer tuber, 900 um optical fiber, and buffer tube transition kits.
12. The floor/base of the rear of the housing shall provide holes or slots for the installation (and removal) of fiber retention or slack management clips.
13. The floor/base of the rear assembly housing shall provide holes or slots for the installation (and removal) of transitional strain-relief clips.

14. Blank adapter panels shall be provided to fill unused space within housings. Housings shall be supplied with blank adapter panels for all available positions. The blank panel shall be attached with at least two spring clips to allow quick installation and removal.

B. Fiber Optic Pigtailed Splice Cassettes
1. Rack mountable housings shall accept an interchangeable pigtailed splice cassette.
2. The splice cassette shall consist of a base constructed from injection-molded black plastic and a removable hinged lid or cover constructed from injection-molded translucent plastic.
3. The splice cassette shall be available with pre-installed connector pigtails and panels.
4. The splice cassette shall allow one connector panel to be installed into the base.
5. The splice cassette shall be able to hold and contain at least one meter of pigtail fiber slack on the interior floor of the base.
6. The splice cassette shall be able to hold and contain up to one meter of 2.0-3.0 mm buffer tube slack or jacketed pigtail slack (up to 24 fiber) on the exterior bottom of the base.
7. The splice cassette shall contain a pivoting (and removable) splice tray above the base in a horizontal position that rotates up into a vertical position at least 90 degrees relative to the base allowing access to the base.
8. The splice tray shall contain one interchangeable splice organizer capable of holding up to (24) splice heat-shrinks, routing tabs and provisions for holding a total of two meters of 250 or 900 micron fiber slack and contain slots and provisions for installing cable ties for securing incoming and outgoing buffer tubes and/or jacketed optical fibers.
9. The pigtailed splice cassette shall contain relief slots for holding up to two buffer tube transition ("fan-out") kits on either side of the base.
10. The pigtailed splice cassette shall contain two fiber retention tabs behind the connector panel location to maintain fiber below the connections and adapters in an installed connector panel.

2.6 PATCH CORDS

A. Provide one (1) fiber optic and (1) Category 6 patch cord per terminated patch panel port of each type. Half of the total shall be three (3) meters in length and half shall be two (2) meters in length.
1. Contractor shall coordinate with Owner to provide the correct fiber optic connector style/type for both the patch panels and patch cords. Selected fiber connector style/types shall be submitted as part of shop drawings to Engineer for final approval.

B. Patch Cords, fiber optic and Category 6 copper, shall meet all conventions and specifications conforming to the premise distribution arrangement described above and shall be factory manufactured and assembled and shall be manufactured and certified by the same manufacturer of the horizontal and backbone cabling.

C. Category 6 patch cords shall be jacket-less (no cover boot on jack end) design.

D. Patch cord colors shall be provided as follows:
1. Gray – GSP Phones

2. Black – Workstations
3. Aqua – Wireless Access Points
4. Purple – Server
5. Brown – UPS SNMP
6. Dark Green – Building Automation System
7. Blue – EASE/CUSS (Common Use)
8. Yellow – Flight Information Display Systems (FIDS)
9. Orange – CCTV Cameras
10. Red – Access Control (ACX)
11. White – Paging Public Address
12. Pink – Tenant Internet
13. Light Green – Tenant Phone

2.7 RACKS AND CABINETS

A. Enclosed Cabinets
1. Size: Fully adjustable 19-inch mounting verticals. Overall minimum dimensions shall be 30” wide, 42” deep with an overall height of 80”, with at least 42 rack mounting units.
2. Panels: Front, side, bottom and top panels shall be fully and easily removable by a latching mechanism. Front and rear panels shall be vented to allow airflow with a keyed locking mechanism. Bottom panel shall be vented for airflow and slotted for cable access from below.
3. Construction: The frame shall be made of extruded aluminum. Adjustable vertical mounting rails shall be drilled and tapped with 12-24 mounting holes at universal EIA spacing.
4. Power Strip: Each cabinet shall contain a vertical mounted, metered, multi-outlet power strips mounted on the interior side wall of the rack so as not to interfere with cable routing. Provide quantity and type of power strips as noted on the drawings.
5. Mounting: All cabinets shall be floor mounted and permanently fixed to the floor with bolt-down kits. Multiple cabinets shall be connected together with side panels removed for routing of cables between cabinets, provide ganging kits as required.
6. Cable Management: Provide horizontal cable management on front of cabinets and vertical cable management on both front and rear of cabinet. Horizontal managers shall be placed above and below each patch panel, minimum size of manager shall be 3.50” high. Provide 9” wide cable runways and all accessories required to mount runways above each cabinet.
7. Bonding: Bond adjacent cabinets together using a #6 AWG bonding strap. Bond a #6 AWG conductor to at least one cabinet and also to the ground bus within each IDF Room.
8. Provide cabinet by Ortronics Model #OR-GXC422942-A1-B or Owner approved equal.

B. Open Frame Relay Racks
1. Size: Fully adjustable 19-inch mounting verticals. Overall height shall be 84" with a minimum of 45 rack mount units.
2. Construction: The frame shall be made of extruded aluminum. Adjustable vertical mounting rails shall be universal EIA channel 1.265” x 3”, drilled and tapped on both sides with 12-24 mounting holes at universal EIA spacing.
3. Mounting: All racks shall be floor mounted and permanently fixed to the floor with bolt-down kits. Multiple racks shall be connected together.

4. Cable Management: Provide horizontal cable management on front of rack and vertical cable management on both front and rear of rack. Horizontal managers shall be placed above and below each patch panel, minimum size of manager shall be 3.50" high.
5. Bonding: Bond adjacent racks together using a #6 AWG bonding straps. Bond a #6 AWG conductor to at least one rack and also to the ground bus within each special system room.
6. Provide cabinet by Ortronics Model #OR-1984-T2SDB or Owner approved equal.

C. Co-Location Cabinets
1. Provide freestanding equipment cabinets with (2) separate secure compartments to store computer, data storage and networking equipment in the data rooms. Each cabinet enclosure shall have a rectangular frame with removable top panel, side panels and doors. Installed cabinets shall include thermal, power, and cable management accessories that control airflow through the cabinet and keep network and power cables separate and organized.
2. The cabinet frame shall be rectangular with four corner posts, manufactured from aluminum with bolted frame construction. The frame shall be divided into three separate compartments. Within each compartment, the sides of the frame shall have two supports located near the top and bottom of the compartment to allow attachment of equipment mounting rails and thermal, cable and power management accessories.
3. The cabinet shall be 24" wide by 40" deep by 81" high when doors, top panel and side panels are installed. Each of the (2) sections shall provide 21 U of mounting space and shall be 37" deep internally.
4. Each compartment in the cabinet shall include two pairs of equipment mounting rails. Mounting rails shall bolt to the supports located near the top and bottom of the compartment and shall be fully adjustable in depth to provide front and rear support for equipment. Equipment Mounting Rails shall be spaced horizontally to support 19" wide EIA-310-D compliant rack-mount equipment and shall provide up to 37" of rail-to-rail depth for equipment. Rack mount spaces or units (RMU) shall be 1-3/4" (44.45 mm) high and shall be marked and numbered on the mounting rails. Numbering shall start at the bottom of the rail. Mounting rails shall provide 21 RMU per compartment for equipment.
5. Each section shall be keyed separately. Combination locks shall not be allowed.
6. Cable Management: Provide 9" wide cable runways and all accessories required to mount runways above each cabinet.
7. Provide cabinets by DSI Model #1242 or Owner approved equal.

D. Exterior Network Equipment Cabinets
1. Construction: Ground mount enclosure equipped with padlockable 3-point latch doors on the front and rear. Space dedicated for interior service entrance, and power strip. Reversible equipment mounting rails to accommodate either 19" or 23" equipment.
2. Solar shield protects roof from direct solar heat.
3. Louvered doors and roof backed by bug screens.
4. 100 CFM Fan provides forced convection cooling of equipment.
5. Wind stops on both prevent doors
6. 14" x 24" Rectangular opening for cable entrance.
7. 19"-23" adjustable rack width

8. Paint enclosure with polyester powder coating. Coordinate exact color with architect.
9. Lighting: internal 15W T-8 fluorescent fixture controlled by door switch.
10. Provide network equipment cabinet by Multilink Model 030-129-10 or Approved Equal.

E. Security Equipment Cabinets
1. For use in outdoor environments requiring a water-tight seal, seamless foam-in-place gasket and screw-down clamps to provide a secure seal against contaminants.
2. Size: as shown on drawings.
3. Construction:
   a. 14 gauge Type 316L stainless steel bodies and doors.
   b. Door, sides, top and bottom have smooth #4 brushed finish.
   c. Seams continuously welded and ground smooth.
   d. Seamless foam-in-place gasket.
   e. Rolled lip around three sides of door.
   f. Stainless steel door clamp assembly with hasp and staple for padlocking.
   g. Exterior hardware shall match enclosure material.
4. Collar studs provided for mounting panels. Mounting panel to be provided.
5. Bonding provision on door; grounding stud on body.

2.8 UNINTERRUPTABLE POWER SUPPLIES (UPS) AND POWER DISTRIBUTION UNITS (PDU)

A. Provide rack-mount UPS units as specified on the drawings.

B. Provide vertical PDU units as specified on the drawings.

2.9 FABRIC INNERDUCT

A. Optical fiber cabling placed in cable tray and/or conduits larger than 3” shall be placed in fabric innerduct. See Section 270528 “Pathways for Communications Systems” for fabric innerduct specification information.

2.10 OUTSIDE PLANT CIRCUIT PROTECTORS

A. Contractor shall provide primary and secondary protection blocks for outside plant, interbuilding copper backbone cable. Protection products and systems shall comply with the applicable parts of NEC Article 800 that cover telecommunications circuit protection. Electrical protection devices supplied by the Contractor shall comply with UL 497 (Primary Protectors), UL 497A (Secondary Protectors). Over-voltage protectors shall be placed on both ends of inter-building cable.

2.11 IDENTIFICATION PRODUCTS

A. Provide self-adhesive vinyl or vinyl-cloth wraparound tape markers, machine printed with alphanumeric cable designators on interior cables and termination ports (patch panels and faceplates).

B. Provide self-laminating cable marker tags for outside plant cables. Tags shall be made of rigid vinyl, rugged material resistant to abrasion and water. Tags shall be attached to cables with velcro tie-wraps at all handholes, manholes and where the cables enter rooms.

PART 3 - EXECUTION

3.1 EXAMINATION

A. General: The Contractor shall ensure that all work performed under these Specifications is in accordance with the requirements and standards defined and referenced in these Specifications. Any work performed in deviation of these Specifications, any of the referenced material, or any applicable standards or requirements, shall immediately be corrected by the Contractor without additional charges, regardless of the stage of completion. The Contractor shall record all inspection observations. As a minimum, the record shall include the name(s) of personnel conducting the inspection, a brief description of the inspection and the observations. These records shall be available for the Owner to review at any time. Also, these records shall be delivered to the Owner before final acceptance.

B. Installation Inspections: Installation inspections shall be undertaken through the performance of pre-installation, in-progress, and final inspections.

C. Pre-Installation Inspection: The Contractor shall make an inspection of all equipment and material to be used prior to installation. All items shall be verified for compliance with the requirements of these Specifications and all other applicable standards. All equipment, cable, and associated hardware identified for installation shall be inspected for damage and completeness utilizing standard practices to determine integrity and acceptability.

D. In-Progress Inspection: At the Owner’s discretion, the Contractor shall perform in-progress inspections that shall include visual inspections of equipment, wiring practices, cabling, placement of equipment, marking of cables and adherence to safety procedures. In addition, the Owner, or his representative, may conduct additional inspections any time.

E. Final Inspection: The Contractor shall conduct a final inspection that encompasses all portions of the installation. This inspection shall be performed to ensure that all aspects of the installation have been performed in accordance with these Specifications, standard industry practices and the publications referenced herein. All non-compliance items shall be noted by the Contractor during this inspection. The Owner, or his representative, shall witness this inspection.

F. Corrective Action and Verification Inspection: The Contractor and the Owner, or his representative, shall perform a corrective action and verification inspection to ensure that all non-compliance items identified during the final inspection have been corrected.

3.2 INSTALLATION

A. Wiring Method: Provide conduit from telecommunication outlet boxes and stub into accessible ceiling spaces, unless noted otherwise on drawings. Unless noted otherwise on drawings, cabling may be routed through accessible ceiling spaces without conduit provided it is installed in accordance with NEC 800-6, TIA/EIA 568-B and is securely

supported at intervals not exceeding 3 feet and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames and terminals. Cabling shall be supported using straps, J-hooks, hangers or similar fittings designed and installed so as not to damage the cable. Provide conduit sleeves with insulated bushings on each end when penetrating walls, ceilings or floors. Penetrations through fire rated walls and floors shall be fire stopped to match rating of the wall and floor.

B. Install cable, connectors and supports using techniques, practices, and methods that are consistent with specified category ratings of components and that ensure performance of completed and linked signal paths, end to end, that comply with those ratings.

C. Install transmission media without damaging conductors, shield, or jacket. Do not bend cable, in handling or installation, to smaller radii than minimum required or recommended by manufacturer.

D. Pre-manufactured elbows and factory bends shall not be used, only 90-degree sweeps, and field bends shall be used

E. Pull cables without exceeding cable manufacturer's required or recommended pulling tensions.
   1. Pull cables simultaneously where more than one is being installed in same raceway.
   2. Use pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation.
   3. Use pulling means, including fish tape, cable, rope, and basket weave wire/cable grips that will not damage media or raceway.
   4. Conduit fill ratio shall not exceed 40%.

F. Install exposed cable parallel and perpendicular to surfaces or exposed structural members and follow surface contours where possible.

G. Wiring within MDF/IDF Rooms and Enclosures: Use exposed cables and provide adequate length of conductors. Train conductors to terminal points with no excess. Use lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.

H. Patch Panels: rack mounted patch panels (fiber optic and copper) and wire managers shall be mounted tight top to bottom with no gaps or blank spaces in between. Contractor shall install panels in same groups together, i.e., horizontal patch panels, backbone patch panels, voice riser patch panels, etc. Horizontal and backbone patch panels shall not be mixed together. Fiber optic and copper patch panels shall not be mixed together. Contractor shall submit as part of the shop drawing submittal a rack elevation drawing with proposed equipment identified for approval by Engineer.

I. Bond shields and drain conductors to ground at only one point in each circuit.

J. Ground Bus: See Section 270526 “Grounding and Bonding for Communications Systems” for communications grounding requirements.

K. Separation of Wires: Comply with EIA/TIA-569 rules for separating unshielded copper communication and data-processing equipment cables from potential EMI sources, including electrical power lines and equipment.

L. Fiber Optic Cable Slack: For fiber optic backbone cabling provide 15 feet of slack located on each end of the cable. The excess fiber will be coiled up and supported by suitable means so that it is suspended above the ceiling or rack.

M. Innerduct: Optical fiber cabling placed in cable tray and/or conduits larger than 3" shall be placed in fabric innerduct.

N. Tracer Wire: provide a #6AWG copper insulated tracer wire with all fiber optic cables installed in existing and new underground conduits. Tracer wire shall not be run inside the same innerduct cell as the fiber optic cable.

O. Make splices, taps, and terminations only at indicated outlets, terminals, and cross-connect and patch panels. Use splice and tap connectors compatible with media types and category ratings.

P. Interface with the Security Systems (ACS and CCTV): Contractor shall coordinate requirements with the Security Integrator to allow the routing of ACS and CCTV cabling via the premise distribution system.

Q. Interface with Building Automation System: Contractor shall coordinate with the Building Automation System Contractor to allow the routing of BAS cabling via the premise distribution system.

R. Define the power source limitations, installation guidelines, insulation properties, applications and allowable cable substitution schedules. Solid conductor materials shall be substituted for the specified 7-strand conductor materials as required by the NEC. All media substitutions shall conform to the NEC and be approved by the Engineer.

S. Cable Splices: All cable runs should be continuous; splices, both optical fiber and copper, shall be done only upon receipt of written approval from the Owner. The Owner reserves the right to reject any splicing request. If any un-approved splices are found before acceptance, the Contractor shall replace the entire spliced cable without any additional charges, regardless of the stage of completion. All splice locations shall be recorded on the "as built" drawings.

T. Fiber Optic Splices: No splices shall be permitted in new fiber installs unless the length of the cable being installed exceeds the maximum cable length available from the manufacturer and prior written approval is obtained from the Engineer. Optical fiber splices if required, shall be fusion type with a maximum insertion loss of 0.05 dB. Cable splices other than fanouts, pigtails or other cable terminations shall be protected with a heat shrinkable splice protector with a stainless-steel insert and housed in a re-enterable splice closure.

U. Category 6 Cable: Total cable length for each location shall not exceed 90 meters. The contractor shall notify the engineer of any location that exceeds this limitation prior to cable installation. Cable installed that exceeds 90 meters without receiving approval from Owner or Engineer shall be removed and replaced at Contractor's expense.

3.3 DOCUMENTATION

A. As-Built Drawings: The Contractor shall supply drawings that accurately depict all equipment and materials to be installed. Contractor shall develop all drawings and all "as-built" drawings using AutoCAD format.
   1. System Wiring Diagrams: These drawings shall show all system components, wire numbers, color codes, pin numbers, component locations and connections, depicting the "as-built", final configuration.
   2. Rack Elevation and Wiring Diagrams: The elevation diagrams shall depict the front views of the equipment racks identifying all equipment installed within. Complete wiring diagrams of the racks shall also be included.

3.4 LABELING AND IDENTIFICATION

A. General Labeling Requirements
   1. All labels shall be typed, and machine printed on permanent vinyl self-adhesive labels. Handwritten labels are expressly forbidden.
   2. All cables and structures (copper, fiber, and innerduct) shall be labeled identically at both ends of the run prior to job completion.
   3. All cables shall be labeled on the visible portion of the cable within three to six inches of the termination point on both ends.
   4. Cable labels shall be visible by removing wall mounted faceplates in each room.

B. Inter-building and Backbone Cable Labeling
   1. Fiber optic backbone cabling labels shall contain the cable origin room number and the destination room number, the number of fiber strands, and the media type.
      a. Example: IDF13-IDF14-SMF001-48 for the first 48 strand bundle of single mode fiber from IDF13 to IDF14.
   2. Copper backbone cabling labels shall contain the cable origin room number and the destination room number, and the total pair of copper wires.
      a. Example: IDF13-IDF14-CU001-50 for the first 50 pair copper feeder from IDF13 to IDF14.

C. Intra-building Category 6 Cable Labeling
   1. Category 6 cables shall be labeled with the architectural drawing room number the wall plate jack is installed in, the IDF room the patch panel is installed in, the service type (ie. Voice/Data) the cabling is intended for, and the patch panel and patch panel port number.
      a. Example: TC254—IDF12—D—F11 for the wall outlet cabled to the F11 data patch panel port in IDF12.

D. Equipment Cabinet and Rack Labeling
   1. Cabinets and racks shall be labeled numerically, with a label affixed to the topmost section of the cabinet/rack.
   2. The cabinet nearest to the entry way door shall be cabinet 1 and shall be labeled C1. Additionally, the rack nearest to the entry way door shall be rack 1 and shall be labeled R1. Cabinet labeling example: C1, C2, C3, etc. Rack labeling example: R1, R2, etc.

3. Multi-sectional colocation cabinets shall be labeled alphabetically to identify each section from top to bottom. Colocation cabinet labeling example: C3a, C3b, C3c.

E. Fiber Patch Panel Labeling
1. Each fiber patch panel enclosure shall be uniquely and sequentially numerically labeled beginning with the first patch panel at the top of the first rack always beginning with 1 and never repeating a number. Example: F1, F2, etc.
    a. The first rack is always the rack nearest to the entry way door (see section 4 "Equipment Cabinet and Rack Labeling").
2. The manufacture printed alpha-numeric port identifiers on each patch panel shall serve as the port identification number/letter. Labels shall not be printed over the manufacture printed port numbers.
3. Fiber patch panel enclosures shall have labeling inside the enclosure door indicating the remote location/termination point.

F. Category 6 Patch Panel Labeling
1. Individual patch panels shall be dedicated to either voice or data and not both.
    a. All wall plate jacks dedicated to 'data' use shall terminate on the data patch panel. All wall plate jacks dedicated to 'voice' use shall terminate on the voice patch panel (see Wall plate labeling section 7 for further information).
2. Each patch panel shall be uniquely and sequentially alphabetically labeled beginning with the first patch panel at the top of the first rack always beginning with A and never repeating a letter.
    a. The first rack is always the rack nearest to the entry way door (see section 4 "Equipment Cabinet and Rack Labeling").
    b. For every two data patch panels, there shall be one voice patch panel. Example: The first patch panel at the top of the rack will be data panel D – A, followed by data panel D – B, followed by voice panel V – C.
3. The manufacture printed port numbers on each patch panel shall serve as the port identification number. Labels shall not be printed over the manufacture printed port numbers.
    a. Example: There will never be an A49 or A50 wall plate jack number, and D-A1 will only ever terminate on the first patch panel port on the first patch panel.

G. Wall Plate Labeling
1. Wall plate jacks shall be labeled indicating the IDF room, service type, patch panel and patch panel port with which the corresponding cable terminates.
2. The third jack in the wall plate shall always be dedicated to voice service and shall terminate on the voice patch panel. The fourth slot shall be a blank or shall serve as an additional jack dedicated to data service and shall continue counting from data jack two.

H. Cable Schedule: Install in a prominent location in each IDF/MDF Room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

I. Outside Plant Backbone Cabling: Tags shall be attached to cables with velcro tie-wraps at all handholes, manholes and where the cables enter rooms. Labels shall depict the building and room endpoints of the backbone cable.

3.5 FIELD QUALITY CONTROL

A. Testing: Upon installation of cable and before energizing, demonstrate product capability and compliance with requirements as contained in ANSI/TIA/EIA-568-B.1 and B.2, B.2-1 and B.3 (including all TSBs) testing and certification standards. All Category 6 cabling shall be bi-directionally tested using a Level III-compliant tester. All fiber optic cable shall be bi-directionally tested using an optical loss test set (OTS), as well as an optical time domain reflectometer (OTDR). Testing shall be performed in accordance with ANSI/TIA/EIA-568-B and with testing equipment manufacturer recommendations.

B. Calibration: Test equipment used shall have been certified calibrated by the manufacturer or an independent test and calibration firm, to the manufacturer's specifications.

C. Copper cable procedures: Inspect for physical damage and test cable for continuity, polarization and shorts.

D. Category 6 Cable: Testing shall be of the Basic Link. However, the contractor shall warrant performance based on the Channel performance and provide patch cords that meet Channel performance. Testing shall be accomplished with a test set with a minimum spectral frequency range of 1 to 350MHz. The test specifications for all installed cables must exceed the specifications for Category 6 cabling that are documented within ANSI/TIA/EIA-568-B.1 and B.2, B.2-1(including all TSBs). Results that indicate a FAIL, *FAIL OR *PASS are unacceptable. Correct malfunctioning cables and retest to demonstrate compliance; otherwise remove and replace with new and retest.

E. Optical Loss Test Set (OTS): Using an OTS, measure each installed fiber link from patch panel to patch panel or patch panel to outlet and report optical loss in dB. Single mode fibers shall be tested bi-directionally at 1310 and 1550 nm. Losses shall be less than or equal to the maximum attenuation values listed in ANSI/TIA/EIA-568-B.3, Table1. Links found to have greater than acceptable values must be tested using an OTDR, with problems corrected and retesting to demonstrate compliance. Provide typed documentation detailing the results of all attenuation testing.
   1. Optical Time Domain Reflectometer (OTDR): Using an OTDR, bi-directionally test every fiber link between Telecommunications Rooms. Also, bi-directionally test each fiber link that fails the OTS attenuation test, is greater than two thousand (2000) meters in length or contains splices. Test links for overall length, faulty connectors, splices, terminations, and the integrity of the cable and its component parts. Singlemode fibers shall be tested at 1310 or 1550 nm. Mated connector pairs with losses more than .75 dB and splices with losses more than .3 dB shall be replaced. Retest to demonstrate compliance. Identify the losses attributed to each individual component of the fiber run.

F. Coaxial Cable: Coaxial cabling shall be tested to confirm adherence with manufacturer specifications. Testing results shall include length, impedance, continuity, opens, shorts and incorrect terminations.

G. Documentation: Test reports shall be submitted in electronic format. Hand-written test reports are not acceptable. Summary reports shall contain the following information on each row of the report: circuit ID, test specification used, length, date of test, and pass/fail result. Electronic reports are to be submitted in PDF format. Proprietary software shall not be required to view test reports. Electronic reports must be accompanied by a Certificate signed by an authorized representative of the Contractor warranting the truth and accuracy of the electronic report. Circuit ID's on test reports shall match the cable ID in the field. Contractor must warrant in writing that 100% of the installation meets the requirements or ANSI/TIA/EIA-568-B. Test reports shall include the following information for each cabling element tested:

1. Wiremap results that indicate the cabling has no shorts, opens, miswires, split, reversed, or crossed pairs, and end to end connectivity is achieved.
2. Attenuation, NEXT, PSNEXT, Return Loss, ELFEXT, and PSELFEXT data that indicate the worst-case result, the frequency at which it occurs, the limit at that point, and the margin. These tests shall be performed in a swept frequency manner from 1 MHz to 250 MHz, using a swept frequency interval that is consistent with TIA and ISO requirements. Information shall be provided for all pairs or pair combinations and in both directions when required by the appropriate standards. Any individual test that fails the relevant performance specification shall be marked as a FAIL.
3. Length (in meters), propagation delay, and delay skew relative to the relevant limit. Any individual test that fails the relevant performance specification shall be marked as a FAIL.
4. Cable manufacturer, cable model number/type, and NVP.
5. Tester manufacturer, model, serial number, hardware version, and software version.
6. Circuit ID number and project name.
7. Autotest specification used.
8. Overall pass/fail indication.
9. Date of test.

H. Test Failures: Any cable that repeatedly fails the testing requirements as outlined by these specifications after all trouble shooting means have been exhausted shall be replaced with a second cable. Acceptable trouble shooting criteria include but are not limited to replacing connectors and/or patch cables.

3.6 CLEANING

A. Upon completion of system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.

3.7 DEMONSTRATION

A. Operate control/signal systems to demonstrate proper functioning. Replace malfunctioning cable with new materials, and then retest and re-commission until satisfactory performance is achieved.

B. Train Owner's maintenance personnel on procedures and schedules for startup and shutdown, troubleshooting, servicing, and preventive maintenance. Include training on

Category 6 wiring requirements and methods. Include training on fiber optic splicing and connector attachment techniques.

C. Schedule training with Owner, through the engineer, with at least seven (7) days' advanced notice.

3.8 ACCEPTANCE

A. Acceptance will be withheld until the following have been completed successfully:
   1. Acceptance of all submittals
   2. Delivery of final documentation
   3. Successful testing

B. Successful demonstration, including operation of systems using the cables, training and manual review.

END OF SECTION 271300

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SECTION 272100 - LOCAL AREA NETWORK

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.

B. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.

C. All sections of Division 27 and 28 of these specifications also apply to this section.

1.2 SUMMARY

A. The scope of work for this project includes all materials, equipment, hardware and labor to install and make ready for use of Local Area Network equipment. The Contractor shall provide all products required in order to ensure a fully operative system and provide proper installation of all equipment.

B. Section Includes:

1. Access level network switches
2. Power supplies
3. Network modules
4. Cables and connectors
5. Wireless access points and mounts
6. Licensing

C. Local Area Network equipment configuration shall be completed by GSP IT Department (Owner).

1.3 DEFINITIONS

A. LAN: Local Area Network

B. Owner: The Owner is Greenville-Spartanburg International Airport, and their designated representative.

C. ACL – Access Control List

D. ANSI – American National Standards Institute

E. BICSI – Building Industry Consulting Service International

F. DiffServ – Differentiated Services

G. EIA – Electronic Industries Alliance

H. Gbps – Gigabits per second

I. IEEE – Institute of Electrical and Electronics Engineers

J. IGMP – Internet Group Management Protocol

K. IP – Internet Protocol

L. IPv6 – Internet Protocol version 6

M. LLDP – Link Layer Discovery Protocol

N. MAC – Media Access Control

O. Mb/s / Mbps – Megabits per second

P. ms – Milliseconds

Q. NECA – National Electrical Contractors Association

R. NFPA – National Fire Protection Association

S. PIM-SM – Protocol Independent Multicast – Sparse Mode

T. PoE – Power over Ethernet

U. RADIUS – Remote Authentication Dial-In User Service

V. SSHv2 – Secure Shell version 2

W. TIA – Telecommunications Industry Association

X. TR – Telecommunication Room

Y. UL – Underwriters Laboratories

Z. VLAN – Virtual Local Area Network

1.4 SUBMITTALS

A. Product Data shall include the following:

1. Submit manufacturer's data on System components

1.5 WARRANTY

A. Period: The Contractor shall warranty all labor, workmanship, and materials for a period of one (1) year from the date of final Owner acceptance. Should a failure occur within this

warranty period, the Contractor shall provide all labor and materials necessary to restore the system to the condition required for the final test and acceptance for this contract, at no cost to the Owner.

B. Provide a one (1) year manufacturer-based warranty (Cisco SmartNet) on all equipment and as new under this contract. If, within one (1) year after the date of Final Acceptance of the Project or by the terms of any applicable special warranty provided by the manufacturer, any of the Project or equipment is found to be defective or not in accordance with the Contract Documents, the Contractor shall correct it promptly including all parts and labor after receipt of notice from the Owner to do so unless the Owner has previously given the Contractor a written acceptance of such defective conditions. The Owner will give such notice promptly after discovery of the condition. Such notice shall be provided by Owner, to be identified either verbally or in writing.

C. All Cisco hardware warranties shall be assigned to the GSP SITE ID, which will be provided by GSP IT to the Contractor. The Contractor must coordinate with GSP IT for the information following contract award.

D. Warranty Service: In the event that defects in the materials and/or workmanship are identified during the Warranty period, the Contractor shall provide all labor, travel expenses and materials as may be required for prompt correction of the defect at no additional charge to the Owner.

E. During the Warranty period, the Contractor shall, upon receipt of a request for service from the Owner, deploy service personnel to the Owner's premises and complete corrective action within twenty-four (24) hours of arriving on site.

F. Repair or replacement service during the warranty period shall be performed in accordance with the following schedule:

1. Seven (7) days, twenty-four (24) hour, four (4) hour on-site response time shall apply for major system failure. A major system failure is defined as a failure that causes multiple portions of a system to be unable to perform the task for which it was intended or creates a potential for an immediate security breach.
2. Next business day response time shall apply for minor component and device failures.

G. The Owner shall be the sole authority to define a failure as a major or minor system failure.

H. If the Contractor is unable to restore system operation during the warranty period within twenty-four (24) hours of a reported failure, the Owner reserves the right to require the Contractor to provide on-site manufacturer's service technicians at no additional cost.

I. Immediately following the completion of a Warranty repair or service call, the Contractor's service personnel shall submit a written report to the Owner which details the service work performed, the cause of the trouble, and any outstanding work which is required to restore complete and normal operation.

J. As part of the warranty, the Contractor shall perform preventative maintenance as required by the manufacturer to keep the warranty in force during the warranty period including installing all firmware/software updates and patches.

K. The Owner reserves the right to expand or add to the environment during the warranty period using people other than the Contractor for such expansion without affecting the Contractor's responsibilities on the components originally provided by them, as long as the expansion is done by people who are authorized by the owner and are certified by the manufacturer. Coordination of work shall be done between the Owner and the Contractor. All work done via both parties shall be completed using the maximum level of auditing, change control and permission tracking as is available at the time of the change.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Network equipment installer must be a certified professional meeting all requirements for the equipment manufacturer's reseller and warranty programs.

B. The Contractor providing the LAN equipment shall assign a project manager that directly reports to the Project Construction Manager to support the specific coordination requirements associated with the installation of the LAN equipment.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Network switches and related equipment must be tested by the Contractor upon receipt at Project site.

1. Verify that equipment received from the manufacturer is not Dead on Arrival (DoA) and parts match what was ordered.
2. Owner must be afforded the option to witness successful testing prior to system acceptance.

1.8 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install switches and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

PART 2 - PRODUCTS

2.1 GENERAL DESCRIPTION

A. The Contractor shall provide all equipment, materials, labor, and design and coordination services necessary to complete or perfect all parts of the Local Area Network Equipment, and to ensure that they are in compliance with requirements stated or reasonably inferred by this Specification. Wherever herein the term provide or provided is used it shall be defined as procure, and install as required for a fully functional and correctly operational System. All equipment under this Section shall be provided, maintained and operated during the construction and implementation period, tested and commissioned by Contractor.

B. The Contractor shall perform all required coordination with the Owner to finalize all functional, operational, and performance requirements of the network design.

C. Manufacturers

1. Network equipment must be manufactured by Cisco and be compatible with existing local area network equipment.

D. The network augment will consist of:

1. Access layer switches located in IDF Rooms
2. Wireless access points

E. Resiliency

1. Switches and switch stacks must provide redundant and load sharing connections to the core or distribution layer switches.
2. In the case which switch stacking is used, network uplinks must be staggered across stack members.
3. Dual switch images
4. Redundant power supply options must be supplied for all switches

F. Performance

1. Devices shall perform at line-rate OSI L2 and L3 - with all ports, uplinks and stack modules operating at 100% utilization
2. Each access-layer switch shall support redundant (load sharing), line-rate 10Gbs uplinks to the core layer switches

G. Authentication and Access Control

1. User authentication via IEEE 802.1x
2. 802.1x – single port MAC based authentication

H. Access Security

1. No performance degradation shall be observed when required to secure the network with one-hundred twenty (120) access control lists
2. Support L2/L3/L4 ACLs shall be provided
3. ACLs shall be able to be applied to port ingress
4. 1Mb/s Ingress rate limiting shall be provided

I. Each switch shall support IPv6

J. Multicast Support

1. Line rate multicast forwarding with 255 multicast groups per device shall be provided
2. Multicast Packet Latency < 10ms with 255 multicast groups, 64byte frames shall be provided
3. Provide RFC 2362 PIM-SM

4. Provide RFC 2236 IGMP v2

K. Quality of Service – Installed network shall:

1. Guarantee delivery of high priority traffic regardless of congestion load
2. Provide a minimum of eight (8) traffic queues per port
3. Support per port rate limiting
4. Adhere to IEEE 802.1D – 1998 (802.1p) packet priority
5. Adhere to RFC 2474 DiffServ precedence, including 8 queues per port
6. Adhere to RFC 2598 DiffServ Expedited Forwarding
7. Adhere to RFC 2597 DiffSev assured forwarding
8. Adhere to RFC 2475 DiffServ core and edge router functions

L. Management and Operations – Installed network shall:

1. Provide secure shell (SSHv2) remote access
2. Provide management access authentication via RADIUS
3. Provide management access authentication via IP access control lists
4. Adhere to IEEE 802.1ab Link Layer Discovery Protocol (LLDP)
5. Adhere to Cisco Discovery Protocol (CDP)

2.2 GENERAL REQUIREMENTS

A. This section includes the minimum requirements for Local Area Network Equipment.

B. The scope of work for this project includes all materials, equipment, hardware, software, and labor to install and make ready for use Local Area Network equipment. It is the responsibility of the Contractor to perform the necessary coordination with the Project Construction Manager, Owner and other contractors performing work associated with this project to ensure all networking requirements are met by the installed LAN equipment.

C. The Contractor shall be responsible for providing the following installation items as they relate to the LAN:

1. Active network components (Access Layer switches and associated components)
2. The coordination with the Project Construction Manager, Owner and the cabling infrastructure installation contractor to review, assess, and perform all necessary coordination with the cabling infrastructure.
3. All fiber and copper patch cords between all networking devices that are described herein and are required for a complete, fully functional system. All patch cords provided by Contractor shall be in conformance with BICSI and ANSI/TIA/EIA standards and approved by the Owner.
4. The coordination of the installation of fiber patch cords with the Owner.
5. The labeling of all newly installed LAN components shall be coordinated with the Owner and approved prior to installation.
6. The coordination of electrical requirements for the LAN with the Project Construction Manager, including specific plug configurations to support the LAN equipment.

D. The Contractor shall verify system operability and proper installation via completion of all required test plans.

2.3 ACCESS LAYER NETWORK EQUIPMENT

A. The access layer networking equipment shall be located in the identified telecommunications rooms on the contract drawings to support end user equipment.

B. Access Layer Switch Equipment – Specific Parts and Pieces

1. Network equipment must be manufactured by Cisco with the following part numbers:

a. Cisco Catalyst 3850 48-Port PoE+ (3850-12X48U) Ethernet Switch

1) Primary Power Supply: PWR-C1-1100WAC
2) Redundant Power Supply: PWR-C1-1100WAC
3) Network Module for 10 Gbps SFP: C3850-NM-10
4) 10 Gig SFP+: SFP-10G-LR-A
5) Stackwise Cable: STACK-T1-50CM
6) Stackwise Power Cable: CAB-SPWR-30CM
7) Network Essentials Licensing (5 years)
8) DNA Essentials Term License (3 Years)
9) Quantity: 4
10) Installation Location: IDF Room 116
11) Mounting: Rack mountable

b. Cisco Catalyst IE-4010 24-Port PoE+ (IE-4010-4S24P) Industrial Ethernet Switch

1) Primary Power Supply: PWR-RGD-AC-DC-H
2) Network Module for 10 Gbps SFP: C3850-NM-10
3) 10 Gig SFP+: SFP-10G-LR-A
4) Stackwise Cable: STACK-T1-50CM
5) Stackwise Power Cable: CAB-SPWR-30CM
6) Network Essentials Licensing (5 years)
7) DNA Essentials Term License (3 Years)
8) Quantity: 2
9) Installation Location: Network Equipment Cabinets
10) Mounting: Rack mountable

c. Cisco Catalyst IE-4000 12-Port PoE+ (IE-4000-4GC4GP4G-E) Industrial Ethernet Switch

1) Primary Power Supply: PWR-RGD-IE170W-PC-AC (DIN rail)
2) GE combination uplink ports (4 total)
3) Network Essentials Licensing (5 years)
4) DNA Essentials Term License (3 Years)
5) Quantity: 1
6) Installation Location: Security Equipment Cabinet

7) Mounting: DIN rail mountable

C. All equipment licensing shall be procured and assigned to the Owner.

2.4 ACCESS POINTS

A. Wi-Fi equipment shall be manufactured by Cisco with the following part numbers:

1. Cisco Aironet 3800 (Manufacturer Part Number: AIR-AP3802i-A-K9)

B. All Licensing shall be procured and assigned to the Owner. All wireless access points shall be procured with three (3) years of Cisco Enterprise licensing at the time of purchase with the support and warranty being in place throughout the implementation phases of the overall project.

C. Recessed mounting enclosures shall be provided for all access points.

1. Drywall Ceiling: Oberon Model 1076-CCOAP3800
2. Suspended Tile Ceiling: Model 1047-CCOAP3800

2.5 IDENTIFICATION PRODUCTS

A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.6 GROUNDING

A. Comply with requirements in Section 27 05 26 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.

B. Comply with TIA-607-B.

PART 3 - EXECUTION

3.1 GENERAL

A. The Contractor shall install all system components including furnished equipment, and appurtenances in accordance with the manufacturer's instructions, NFPA 70, ANSI-C2 and as shown, and shall furnish all cables, connectors, terminators, interconnections, services, and adjustments required for a complete and operable system.

B. Grounding shall be installed as necessary to preclude ground loops, noise, and surges from adversely affecting system operation.

C. The Contractor’s Quality Assurance Inspector shall conduct a visual inspection of all installations to verify that the installations are in accordance with the Owner’s and manufacturer's specifications. Records of the inspections signed and dated by the Quality

Assurance Inspector shall be provided to the Owner. The Owner shall be notified by the Contractor of any inspection(s) and the Owner may elect to participate in any inspection(s).

3.2 CONFIGURATION

A. Configuration of all network equipment specified herein shall be provided by the Owner. It shall be the Contractor's responsibility to procure and furnish the network equipment to the Owner for configuration no less than 30 days prior to required installation of the equipment. Contractor shall be responsible for delivering of equipment to and from Owner's location. After configuration is complete, Contractor shall install equipment as detailed on drawings and per direction from the Owner.

3.3 HARDWARE INSTALLATION

A. Design plans for hardware selection, installation location, and installation details shall be provided for Owner's approval.

B. Installation of hardware shall be coordinated with the Owner.

C. The Contractor shall ensure the ventilation requirements for the all hardware components are met.

D. The Contractor shall install and inspect all hardware required to fully meet the functional, operational, and performance requirements of this Section. Installation of hardware shall be in accordance with the manufacturer's installation instructions.

3.4 GROUNDING

A. Install grounding according to the "Grounding, Bonding, and Electrical Protection" chapter in BICSI's "Telecommunications Distribution Methods Manual."

B. Comply with TIA-607-B and NECA/BICSI-607.

3.5 IDENTIFICATION

A. Labels shall be preprinted or computer-printed type, with a printing area and font color that contrast with equipment exterior color but still comply with TIA-606-B requirements.

END OF SECTION 272100

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SECTION 274010 - DIGITAL DISPLAYS

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.

B. Provide work specified but not shown on drawings, and work shown on drawings but not specified, as though expressly required by both.

C. Section 274010 contains the digital display hardware specifications for connection to an existing Multi-User Flight Information Display System (MUFIDS).

1.2 SUMMARY

A. Section includes:

1. LED Displays

B. Existing MuFIDS system configuration shall be completed by GSP IT Department (Owner). Contractor shall meet with Owner for the coordination and scheduling of equipment required to be configured by Owner.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For digital displays to include in operation, and maintenance manuals.

1.5 WARRANTY

A. Contractor shall submit warranty and hardware support agreement information as part of the bid.

1. Minimum warranty for LED hardware is 3 years, unless standard manufacturer’s warranty exceeds this period.

B. Contractor shall submit maintenance information as part of their proposal.

1. Assume a maintenance period of 1 year to start at the same time as the warranty period.

2. Establish firmware update periods (if available) and help desk availability, at a minimum.

C. Assume maintenance period for hardware. Establish response times for fixes and establish associated levels of criticality.

D. All product warranties shall list Greenville Spartanburg International Airport (GSP) as the Owner upon Final Acceptance of the project.

PART 2 - PRODUCTS

2.1 GENERAL

A. Commercial-Off-The-Shelf (COTS): Hardware shall be commercial-off-the-shelf products. Customized, one-off solutions are not acceptable.

B. Refer to plans for digital display locations and quantities.

C. Refer to Digital Display Schedule on drawings for display size, orientation, display information and data source.

2.2 DIGITAL DISPLAYS

A. LED DISPLAYS

1. This project shall utilize new LED commercial-grade displays. The Contractor shall provide all required cabling as defined in this specification from the data jack to the monitor locations.

2. FID, TID Displays

a. Physical Attributes:

i. Depth: Less than 2.25 inches

ii. Bezel: Less than 0.75 inches

iii. Connections:

- Display Port: IN and OUT
- HDMI: 3
- DVI-D: IN
- USB 3.0: 1
- Ethernet (IP): 1
- RS232C: IN and OUT
- Audio: IN and OUT

b. Display characteristics:

i. Type: IPS (In Plane Switching)

ii. Aspect ratio: 16:9

iii. Resolution: 1920 x 1080 or better

iv. Horizontal Viewing Angle: 178 degrees

v. Vertical Viewing Angle: 178 degrees

vi. Brightness: 450 nit

vii. Contrast Ratio: 1,100:1

viii. Color Range: 16.7 million colors

ix. Response time: 12 milliseconds or faster

x. Presentation: capable of supporting both portrait and landscape presentation

xi. Reliability: The backlight lifetime (to ½ brightness) shall be rated no less than 50,000 hours.

xii. Rated for 24/7/365 continuous operations.

c. Acceptable Manufacturers:

i. LG Model 55SM5KE

ii. Owner Approved Equal

2.3 DISPLAY DEVICE CONTROLLER

A. All hardware requirements given, are the minimum requirements. The Contractor's product shall meet or exceed these requirements. Additionally, the hardware selected shall meet the operational, functional, and performance requirements specified herein.

B. The contractor shall supply all cabling, connectors, adapters, and termination equipment necessary to interconnect all system hardware. All hardware and materials shall be new.

C. Environmental rating: equipment shall be rated for continuous operation under the ambient environmental temperature, humidity, and vibration conditions encountered at the installed location.

D. Display device controllers (DDCs): the DDC shall be used by the MUFIDS to control the display output of video monitors, as identified by the drawings. Each DDC shall have a unique TCP/IP address and shall communicate via the GSP LAN via an Ethernet NIC. DDCs shall be ultra-compact form factor and meet the following minimum requirements:

1. Intel core i3-321 7U 2.6 Ghz, Dual Core with 3MB Cache

2. 16GB Dual Channel DDR3 1066MHz RAM

3. 40 GB MSATA Solid State Hard Disk Drive

4. 10/100/1000mbps Ethernet NIC (auto-negotiating)

5. Intel HD Graphics 630 Integrated High-Speed Graphics

A. Capable of driving multiple displays

B. Capable of minimum 1080p resolution on all displays.

6. PORTS – (2) USB 3.0, (2) HDMI 2.0A

7. Acceptable Manufacturers:

a. Provide Now Micro, Inc. Model DMPN-7i3

b. Owner Approved Equal

8.

2.4 WALL MOUNT DISPLAY BRACKET

A. Provide universal wall mount bracket with computer/media controller storage with the following specific requirements:

1. Universal mounting to support landscape and portrait orientation.

2. Flat and tilt options wall mount functionality up to 20-degree tilt.
3. Mount supports a computer or media controller dive up to 15”x9”x3”.
4. Mount folds open to allow access to computer or media controller without removing display.
5. Access panel opens to 20-degress for serviceability and maintenance.
6. Supports VESA mounting: 100x100mm, 200x100mm, 200x200mm, and 300x300mm.
7. Includes hardware for mounting to wood and metal studs, concrete or block wall. Rated to support 150lbs, maximum.
8. Acceptable Manufacturers:
   a. Provide Peerless Model DST360
   b. Owner Approved Equal

2.5 SPARE PARTS

A. As per project standards, with the following specific requirements:
1. Provide two (2) spare monitors for each size LCD display.
2. The Contractor shall identify any special or recommended spares, including equipment modules, power supplies, and other components.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The Contractor shall install and inspect all hardware required in this Specification in accordance with the manufacturers installation instructions.

B. The Contractor shall provide all tools and test equipment required to install, verify, and test the installation and to determine that it meets the specifications. The Contractor shall furnish all necessary materials required to implement and to achieve the required work performance.

3.2 SYSTEM STARTUP

A. The Contractor shall not apply power to the displays until after:

1. Displays and components have been installed and inspected in accordance with the manufacturer's installation instructions.
2. A visual inspection of the components has been conducted to ensure that defective equipment items have not been installed and that there are no loose connections.
3. System wiring has been tested and verified as correctly connected.
4. All system grounding and transient protection systems have been verified as properly installed and connected.
5. Power supplies to be connected to the system and equipment have been verified as the correct voltage, phasing, and frequency as indicated.

B. Satisfaction of the above requirements shall not relieve the Contractor of responsibility for incorrect installations, defective equipment items, or collateral damage as a result of Contractor work/equipment.

3.3 CONFIGURATION

A. Configuration of digital displays and DDCs specified herein shall be provided by the Owner. It shall be the Contractor's responsibility to procure and furnish the equipment specified herein to the Owner for configuration no less than 30 days prior to required installation of the equipment. Contractor shall be responsible for delivering of equipment to and from Owner's location. After configuration is complete, Contractor shall install equipment as detailed on drawings and per direction from the Owner.

3.4 TRAINING

A. General

1. The Contractor shall prepare training materials and conduct all training for maintenance and GSP IT department.

2. The following general training guidelines shall be followed:

a. All training shall be completed a minimum of two weeks prior to the hardware becoming fully operational.

b. Training shall be conducted by experienced personnel and supported by training aids. A minimum of two (2) two-hour sessions shall be made available by the Contractor for hands-on training as it relates to hardware operation and maintenance. An adequate amount of training material shall be provided by the Contractor. The following is considered a minimum:

1) Overall hardware block diagrams

2) Schematic drawings for each of the hardware components

3) All procedure and operating manuals

3. Participants shall receive individual copies of technical manuals and pertinent documentation 7-days in advance of the training course.

3.5 ACCEPTANCE

A. Acceptance will be withheld until the following have been completed successfully:

1. Acceptance of all submittals

2. Successful testing

3. Delivery of final documentation, including O&M manuals, As-builts

4. Completed Training as per the specifications as well as successful demonstration of the operation of the entire system

END OF SECTION 274010

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SECTION 275116 – PUBLIC ADDRESS SYSTEM

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.

B. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.

1.2 SUMMARY

A. This Section includes the minimum requirements for public address announcement and paging systems to be installed and interfaced to existing systems as part of this project. Contractor shall interface with the existing public address system which is manufactured by Innovative Electronic Designs, Inc. (IED) and shall provide all equipment and cabling necessary for a complete system.

B. Contractor shall include in the Bid all labor, materials, tools, plant, transportation, storage costs, training, equipment, insurance, temporary protection, permits, inspections, taxes and all necessary and related items required to provide complete and operational system shown and described in the Specifications.

C. The Contractor is responsible for providing and coordinating final equipment arrangements, locations, phased activities and construction methods that minimize disruption to Airport operations and provide complete and operational systems.

D. Work Included:

1. All conduit, wiring and cabling.
2. All equipment and materials.
3. Cover-plates for outlet and junction boxes.
4. Extension rings where required to provide a flush surface for cover plate mounting on finished walls.
5. Engraved nameplates on all boxes.
6. Coordination of the paging system Ethernet VLANs with GSP IT Department (Owner).
7. The Paging System acoustical design shall meet or exceed the minimum acoustic performance specifications for each zone. Demonstrate by specified tests that all components and the completed systems meet the specifications including acoustical performance requirements.
8. All conduits, device junction boxes and pull-wires per Division 27.
9. Safety wires for all fixed system equipment.

E. Refer to Construction Drawings for device locations and details.

1.3 REFERENCES

A. References

1. All work and materials shall conform to and be installed, inspected and tested in accordance with the governing rules and regulations of the telecommunications industry, as well as federal, state and local governmental agencies, including, but not limited to the following:

    a. CFR 47 Part 15 Radio Frequency Devices
    b. EIA-160 Sound Systems
    c. cEIA-219 Audio Facilities for Radio Broadcasting Systems
    d. ANSI/TIA/EIA-568-C.1 Commercial Building Telecommunications Cabling Standard Part 1: General Requirements, 02/02/09
    e. ANSI/TIA/EIA –569-B Commercial Building Standard for Telecommunications Pathways and Spaces, May 2009
    f. ANSI/TIA/EIA -606-A Administration Standard for Commercial Telecommunications Infrastructure, 11/24/08
    g. ANSI/TIA/EIA -607 Commercial Building Grounding and Bonding Requirements for Telecommunications, August 1994
    h. ANSI/TIA/EIA – 862 Building Automation Systems Cabling Standard for Commercial Buildings, 2002
    i. FCC 47 Part 68 Code of Federal Regulations, Title 47, Telecommunications
    j. IEC 60849 Sound Systems for Emergency Purposes
    k. IEEE National Electrical Safety Code (NESC); 2007
    l. ISO/IEC 11801 Information Technology - Generic Cabling For Customer Premises
    m. LADBS Los Angeles Department of Building and Safety - City of Los Angeles Electrical Code
    n. NEMA 250 Enclosures for Electrical Equipment (1000 V Maximum)
    o. NFPA-70 National Electric Code; 2008
    p. NFPA 72 National Fire Alarm and Signaling Code
    q. UL 1863 Underwriters Laboratories Standard for Safety – Communications Circuit Accessories

2. References to codes and standards called for in the Specifications refer to the latest edition, amendments, and revisions to the codes and standards in effect on the date of these Specifications.
3. System installation and construction practices shall conform to standard industry practices as defined by the National Association of Broadcasters Engineering Handbook (latest edition), and Sound System Engineering (Don and Carolyn Davis, Howard W. Sams, publisher).

1.4 SUBMITTALS

A. General – Comply with all submittal procedures given in other Sections. The following is in addition to or complementary to any requirements given elsewhere.

B. Product Data:

1. The Contractor shall submit for review a complete and final list of all components that are to be furnished. This list shall be in the same order and format as the Specifications and shall include confirming manufacturers' independent test data for each specified item. A brochure and photograph (unless included in the brochure) of each item shall also be furnished.

2. Submit a detailed bill-of-materials listing all manufacturers, part numbers, and quantities that the Bidder proposes to use in this project.
3. Submit all proposed labeling materials and nomenclature for approval.

C. Shop Drawings:

1. Shop drawings shall be submitted for review on all items that require assembly by the Contractor including, but not limited to all:

   a. Floor plans incorporating the Architect's latest backgrounds indicating equipment, boxes, conduit and cabling. The Contractor's standard nomenclature shall be employed. It shall not be deemed acceptable for the Contractor to use the Consultants electronic drawing files as their shop drawings.
   b. Riser diagrams shall be submitted if applicable and if conduit and cabling information is more readily conveyed this way than in plan format as in #1 above.
   c. Detailed system diagrams with separate drawings for Audio, Video and Control subsystems if appropriate given the complexity of the systems. Diagrams shall include Contractor's labeling, symbols and nomenclature. It shall not be deemed acceptable for the Contractor to use the Consultant's electronic drawing files as their shop drawings.
   d. Equipment room layouts showing equipment locations and dimensions with equipment cabinets and clearances.
   e. Loudspeaker enclosures, aiming and mounting.
   f. Supporting brackets for the suspension and support of speakers and fixed systems components.
   g. Receptacle cover plates indicating connectors, jacks, controls and labeling to scale.
   h. Any equipment custom manufactured by the Contractor and/or manufacturer.
   i. Acoustic performance mapping of each loudspeaker in situ (EASE analysis) for each zone.

2. Submit all testing plans (acceptance, and endurance) for review and approval prior to the performance of any testing.
3. Paging Zone Code Documents:

   a. Submit floor plans which use color coding and shading to indicate all of the individual loudspeaker zones and the codes that access each loudspeaker zone individually and each zone group. Laminated color copies and PDF format software copies shall be provided.
   b. Submit a list of all paging stations, their locations, and which buttons or codes access which zone groups. If the paging stations are of the 12-button type and require a user-access code, the document is to contain a list of the user types, a description of their level of access, and what the access code is. The user types (for instance: emergency, administrator, etc.) and levels of access shall be determined by the Owner and submitted to the Contractor in a timely manner.

D. Closeout Submittals:

1. Operations and Maintenance Manuals
2. Test Reports
3. As-built drawings

4. Record drawings:

a. Project Record Drawings shall be submitted in electronic format. Electronic drawing format shall be AutoCAD® Release 2014 or later. Owner shall have the right and capability to manipulate all electronic file drawings and documentation.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

1. Personnel certified by NICET as Audio Systems Level II Technician.

B. Testing Agency Qualifications: Qualified agency, with the experience and capability to conduct testing indicated.

1. Testing Agency's Field Supervisor: Currently certified by NICET at Level III to supervise on-site testing.

C. Source Limitations: Obtain public address systems from single source from single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NFPA 70.

1.6 WARRANTY

A. Materials and workmanship shall meet or exceed industry standards and be fully guaranteed for a minimum of one (1) years from Final Acceptance. The Contractor shall provide the highest available level of IED maintenance service during the warranty period.

1. The Contractor shall be responsible for and make good, without expense to Owner, any and all defects arising during this warranty period that are due to imperfect materials, appliances, improper installation or poor workmanship.
2. The Contractor shall submit, in writing, provision during the warranty period of one years for on-site availability of service personnel within twenty-four hours of call seven days a week and for exchange of faulty components within 1 additional day. This service requires assurance of commitment by the subcontractors and suppliers of all components.

B. Submit a copy of all manufacturer warranty information.

PART 2 -PRODUCTS

2.1 PAGING SYSTEM GENERAL DESCRIPTION

A. System shall be a professional quality, multi-function system to be used primarily for transmission and broadcast of emergency and audible paging messages. New equipment shall consist of:

1. New loudspeakers, connectors, transformers, crossovers, signal delays, cabling, conduit, boxes, wiring, and appurtenances for a fully functional and operational systems as described herein and shown on the contract drawings. Installation shall include all branch conduits, required for a complete installation including all fittings, pull strings, seismic supports/bracing, etc.
2. Amplifiers, mixers, signal conditioning equipment, digital message repeaters and storage, compressor/limiters, switchers/routers, equalizers, operating software, test equipment, and head end equipment as described herein and shown on the contract drawings.
3. All system operations and controls shall be controlled by a microprocessor and appropriate digital processing. The microprocessor shall manage and control all system functions and hardware such as microphone stations and associated queuing, telephone interfaces, distribution of emergency announcements, local announcements, terminal announcements, recorded announcements, and pre-recorded messages.
4. The equipment listed herein, consists of major equipment for the project. The contractor shall integrate into the system design and provide any additional components, wiring, programming, etc., to complete a functional system operating as described within the specifications and shown on the drawings.
5. In the event that a specified piece of equipment or product has been superseded, discontinued or is no longer available from the manufacturer, the Contractor shall submit a request for substitution of the originally specified product. The substitute product shall be the manufacturer's most current model of the specified product, or if the specific product line has been discontinued, a product by the same manufacturer with specifications meeting or exceeding, and as close as possible to those of the originally specified product.

B. Public address system shall consist of the following:

1. Network Power Amplifier
2. Backup Amplifier/Switcher
3. Ambient Noise Sensors
4. Microphone stations
5. Loudspeakers

C. All audio switching circuits shall be designed and constructed so that no switching transients, clicks, pops or microphone keying tones will be audible.

D. All control system equipment shall be rack mounted in 42” deep standard 19-inch equipment cabinets located within Owner IDF Rooms.

E. Public address system shall incorporate audio and control inputs from the following:

1. Main Terminal Airport Operations Center
2. Telephones (coordinate telephones that will have paging access with Owner)

F. Network Power Amplifier:

1. Supports CobraNet® digital audio inputs
2. Compatible with IED GLOBALCOM systems and 3rd party CobraNet® devices
3. Dual-redundant Ethernet ports
4. 7-band parametric EQ and a high-pass and low-pass filter per channel

5. Signal delay up to 25 ms on each channel
6. Output audio monitoring
7. Four 600 Watt amplifier output channels
8. 70.7 Volt output
9. Built-in supervision of amplifier cards and loudspeaker lines
10. Fault reports and amplifier status available over Ethernet using standard SNMP protocol
11. Supports independent background music for all channels with automatic ducking when paging audio is present
12. Two inputs for ambient noise sensors for each amplifier output channel
13. ETL Listed

G. Backup Amplifier Switcher:

1. 4 channels of backup amplifier switching
2. Multiple units gang to a single backup amplifier when used with the GLOBALCOM system
3. Control and configure using a web browser and GLOBALCOM System Management Center
4. Fully integrated with the IED GLOBALCOM vACS
5. IEEE 802.af Power over Ethernet (PoE)
6. Removable connectors for easy installation
7. Rugged DIN-rail or panel/wall mount enclosure

H. Ambient Sensor:

1. Sensor contains omnidirectional condenser microphone and an analog audio to DC conversion module.
2. Analog conversion module converts the audio signal to a varying DC waveform for use by the system.
3. Includes 2-gang brushed aluminum mounting plate.

I. Telephone Interface:

1. Telephone interface stations, when addressed from a VoIP telephone, shall have capabilities similar to those of the supervisory microphone stations.
2. Provide a minimum of six dual input telephone interface stations.

J. Loudspeakers:

1. Type 1 – Interior Recessed:

a. Power Rating: 50 Watts
b. Transformer Taps: 2, 4, 8, 16, & 32 Watts & 8Ω Bypass
c. Frequency Response: 63Hz – 20kHz (±7dB)
d. Sensitivity: (1W / 1M) 88dB
e. Woofer: 6" Poly Cone with Butyl Rubber Surround
f. HF Driver: 19mm Coaxially Mounted PEI Dome Tweeter
g. Diameter: 12 1/2" (318mm)

2. Type 2 – Pendant Mount

a. Power Rating (RMS): 150 Watts
b. Frequency Response: 75Hz – 16kHz (±3dB)
c. Sensitivity (1W/1M): 93dB
d. Woofer Size: 6 ½”
e. Tweeter Size: 1"
f. Transformer Taps @ 70V: 7.5W, 15W, 30W, 60W
g. Enclosure: High impact polystyrene
h. Suspension: Two identical suspension systems (one as main suspension cableand the other as safety cable), each consisting of 4.5 m (15 ft) long 2 mm (0.077 in) high-tensile galvanized-steel wire rope suspension cable with spring-clips for clipping onto the loudspeaker bracket and Gripple™ brand adjustable-height cable fasteners for infinitely adjustable height.
i. Dimensions: 13.1” diameter x 13.6” height to top of cabinet. 14.5” to top of suspension bracket.
j. Color: white

2.2 GENERAL PERFORMANCE REQUIREMENTS

A. System Performance:

1. Electrical Performance; Source Input to Power Amplifier Output:

a. Frequency Response (Equalizer flat): +/- 0.2 dB 20 Hz to 20 kHz.
b. Total Harmonic Distortion (THD): Less than 0.05%, 20 Hz to 20 kHz, 4 ohms.
c. Noise: At least -105 dB, 20 Hz to 20 kHz, referenced to input of +4 dBm.
d. Crosstalk: At least 60 dB, 20 Hz to 20 kHz.
e. Damping Factor: Greater than 20 (below 1 kHz).

2. Nominal gain from microphone station output to input of Ambient Noise Analysis system shall be 0dB.
3. Nominal voltage at input of Ambient Noise Analysis Systems shall be 1.00 volt RMS.
4. Electro/Acoustic Performance; Distributed Systems: 90 dB maximum RMS single word level, 80 dB average RMS measure at ear level in each zone with test speech source having equivalent RMS voltage equal to that measured at the microphone station output with 65dBA speech at normal microphone distance from the mouth.
5. Intelligibility Performance; objective measurements of intelligibility, as referenced in IEC standard 60268-16, shall be performed in all representative acoustical environments. Representative acoustical environments are defined as major functional areas such as Apparatus Bays (Interior and Exterior), Kitchen/Dining, TV Room and Training Room. Measurements are to meet or exceed standards established by IEC 60849 which calls for a ‘Common Intelligibility Scale’ greater than or equal to 0.7 (STI equivalent of 0.5). Measurements shall be carried out according to all provisions and limitations as provided by IEC 60849.
6. Loudspeakers located near microphone stations in low ceiling areas may need to be tapped down to avoid possible feedback.

B. Ambient Noise Analysis System:

1. Shall be adjusted in each zone to provide variable attenuation in the range of 0 to -10dB. To be calibrated to correspond with minimum and maximum expected ambient noise levels, but not to exceed 10dB, + or – 3dB, above maximum ambient noise level, as measured when area is full of people. Ambient Noise Analysis System must be

calibrated by a manufacturer-approved consultant, and calibration process must include at least 2 follow-up visits which measure all representative acoustical environments. Observations and measurements must be submitted in written form.

2. Contractor shall confirm that ambient microphone positions are not located in close proximity to noise emitting equipment which turns on and off intermittently, providing false ambient noise information to the system.

C. Each output zone shall be adjusted at the corresponding power amplifier and using the system software so that volume levels (using an appropriate pink noise source) from zone to adjacent zone are within 3dB of each other, before any Ambient Noise System auto-attenuation takes place.

D. General Network Requirements: Contractor shall coordinate network requirements with Owner, following are representative requirements:

1. A 100Mbps switched Ethernet network is required for general audio, switched at a layer 2 (MAC) protocol level throughout.
2. Microphone Station to ACS/vACS - One dedicated VLAN at 100Mbps.
3. Digital Amplifier to ACS/vACS - One dedicated VLAN at 100Mbps.
4. Quality of Service - QoS shall be used to give the time sensitive CobraNet data precedence over less sensitive computer traffic, insuring that other transactions occurring over the network do not affect audio delivery.

2.3 MAJOR EQUIPMENT

A. Schedule of Major Equipment (or approved equivalent):

DESCRIPTION:	MANUFACTURER	MODEL
Speakers:		
Type 1: Recessed Ceiling 6” Speaker	Atlas	FAP62T-W
Type 2: Surface Mount Speaker	JBL	67HC/T
Type 3: Recessed High Ceiling 6” Speaker	Atlas	FAP6260T
Amplifiers:		
Digital Network 4 Channel Power Amp	IED	DNA2404CL
Backup Amplifier/Switcher	IED	1544BAS
Sensors and Modules:		
Ambient Noise Sensor	IED	540S

2.4 CABLES

A. Jacketed, twisted pair and twisted multi pair, untinned solid copper.

1. Microphone Cable: (1) Category 6 EIA/TIA compliant cable. Comply with Section 271300 Premise Distribution System.

2. Speaker Cable: Minimum 12 AWG, tinned copper, PVC insulated, with PVC riser rated jacket.

3. Ambient Noise Sensor Cable: One (1) shielded twisted pair 20 AWG tinned copper conductors; color coded, low loss polyethylene insulation; with 20 AWG stranded tinned copper drain wire shield.

4. Plenum Cable: UL 910 Listed for plenum installation.

PART 3 – EXECUTION

3.1 WIRING METHODS

A. Wiring Method: Install cables in pathways and cable trays except within consoles, cabinets, desks, and counters. Conceal pathway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for pathways and boxes specified in Section 270528 "Pathways for Communications Systems."

B. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.2 INSTALLATION OF PATHWAYS

A. Comply with requirements in Section 270528 "Pathways for Communications Systems." for installation of conduits and cable trays.

B. Install manufactured conduit sweeps and long-radius elbows whenever possible.

3.3 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Cable Installation Requirements: Terminate conductors; no cable shall contain unterminated elements. Make terminations only at outlets and terminals.

C. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Cables may not be spliced.

D. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.

E. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

F. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.

G. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used.

H. Separation of Wires: Separate speaker cables and power wiring runs. Install in separate pathways or, where exposed or in same enclosure, separate conductors at least 12 inches (300 mm) apart for speaker cables and adjacent parallel power and data and voice wiring. Separate other communication equipment conductors as recommended by equipment manufacturer.

3.4 INSTALLATION

A. Coordinate layout and installation of system components and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

B. Match signal levels at signal interfaces. Provide matching networks where required.

C. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables so they identify media in coordination with system wiring diagrams.

D. Equipment Cabinets and Racks:

1. Group items of same function together, either vertically or side by side, and arrange controls symmetrically. Mount monitor panel above the amplifiers.
2. Arrange all inputs, outputs, interconnections, and test points so they are accessible at rear of rack for maintenance and testing, with each item removable from rack without disturbing other items or connections.
3. Blank Panels: Cover empty space in equipment racks so entire front of rack is occupied by panels.

E. Volume Limiter/Compressor: Equip each zone with a volume limiter/compressor. Arrange to provide a constant input to power amplifiers.

F. Conductor Sizing: Unless otherwise indicated, size speaker circuit conductors from racks to loudspeaker outlets not smaller than No. 12 AWG.

G. Speaker-Line Matching Transformer Connections: Make initial connections using tap settings indicated on Drawings.

3.5 GROUNDING

A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

B. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.

C. Comply with TIA-607-B Grounding and Bonding standard.

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Schedule tests with at least seven days' advance notice of test performance.
2. After installing public address system and after electrical circuitry has been energized, test for compliance with requirements.
3. Operational Test: Perform tests that include originating program and page messages at microphone outlets, preamplifier program inputs, and other inputs. Verify proper routing and volume levels and that system is free of noise and distortion.
4. Signal-to-Noise Ratio Test: Measure signal-to-noise ratio of complete system at normal gain settings as follows:

    a. Disconnect microphone at connector or jack closest to it and replace it in the circuit with a signal generator using a 1000-Hz signal. Replace all other microphones at corresponding connectors with dummy loads, each equal in impedance to microphone it replaces. Measure signal-to-noise ratio.
    b. Repeat test for each separately controlled zone of loudspeakers.
    c. Minimum acceptance ratio is 50 dB.

5. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 50, 200, 400, 1000, 3000, 8000, and 12,000 Hz into each preamplifier channel. For each frequency, measure distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 3 percent total harmonics.
6. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band filters to measure level at five locations in each zone. For spaces with seated audiences, maximum permissible variation in level is plus or minus 2 dB. In addition, the levels between locations in same zone and between locations in adjacent zones must not vary more than plus or minus 3 dB.
7. Power Output Test: Measure electrical power output of each power amplifier at normal gain settings of 50, 1000, and 12,000 Hz. Maximum variation in power output at these frequencies must not exceed plus or minus 1 dB.
8. Signal Ground Test: Measure and report ground resistance at public address equipment signal ground. Comply with testing requirements specified in Section 270526 "Grounding and Bonding for Communications Systems."

D. Inspection: Verify that units and controls are properly labeled, and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging speaker-line matching transformers.

E. Public address system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

1. Include a record of final speaker-line matching transformer-tap settings and signal ground-resistance measurement certified by Installer.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements.
2. Complete installation and startup check according to manufacturer's written instructions.

3.8 ADJUSTING

A. On-Site Assistance: Engage a factory-authorized service representative to provide on-site assistance in adjusting sound levels, resetting transformer taps, and adjusting controls to meet occupancy conditions.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.9 TRAINING

A. The Contractor shall prepare training materials and conduct all training for Owner’s users and administrators.

B. The Contractor shall supply the appropriate training for designated Owner personnel. The training shall provide personnel with a working knowledge of the system design and layout and shall provide troubleshooting methods and techniques. In addition, the training shall cover testing, maintenance, and repair procedures for all equipment, which is provided under this Section.

C. The Contractor shall supply a detailed plan of user training and system administrator training. The Contractor shall provide a course outline, course materials and syllabus to Owner for approval 30-days prior to the scheduled training date. Each course shall require Owner approval prior to presentation.

D. Course materials shall be delivered to Owner for future presentation. Final delivery of the course materials shall include a master hard copy of all materials and an electronic copy in a format approved by Owner. The Contractor shall supply a videotape of each training course.

E. The following general training guidelines shall be followed:

F. By means of training classes augmented by individual instruction as necessary, the Contractor shall fully instruct Owner’s personnel in the operation, adjustment and maintenance of all products, equipment and the system. The Contractor shall be required to provide all training aids (e.g., notebooks, manuals).

G. All training shall be completed a minimum of two weeks prior to the system becoming operational and utilized by tenants. Training schedule subject to Owner approval.

H. Training shall be conducted by experienced personnel and supported by training aids. An adequate amount of training material shall be provided by the Contractor. The following is considered a minimum.
   a. Functional flow charts, overall block diagrams, and descriptive material for all software
   b. Schematic drawings for each of the hardware components
   c. All procedure manuals, specification manuals, and operating manuals
   d. As-built drawings.

I. Participants shall receive individual copies of technical manuals and pertinent documentation 7-days in advance of the training course. The courses shall be scheduled such that airport personnel can participate in all courses (no overlap).

J. A final course schedule and syllabus shall be prepared by the Contractor for each course to be conducted for airport personnel and submitted for review at least four (4) weeks prior to the scheduled date of the course commencement.

K. All training requirements identified are minimum requirements.

L. Additional training shall be bid on a per person per hour basis.

M. User Training: shall be specific to the operation of the system installed under this contract and shall be supplemental to the training previously performed when the system was originally installed. A minimum of two (2) hours of basic user training shall be provided.

N. Technician Training: shall be specific to the operation of the system installed under this contract and shall be supplemental to the training previously performed when the system was originally installed. A minimum of two (2) hours of basic technician training shall be provided. Training for maintenance technicians shall be provided on site, and shall include, but not be limited to, installation, operation, renovation, alteration, inspection, maintenance and service on each system and subsystem provided, so as to enable troubleshooting and repair to the component level.

O. System Administrator Training: shall be specific to the operation of the system installed under this contract and shall be supplemental to the training previously performed when the system was originally installed. A minimum of two (2) hours of basic user training shall be provided.

3.10 ACCEPTANCE

A. Final acceptance shall be withheld until the successful completion of the following:
   1. Acceptance of all submittals
   2. Delivery of manuals and training material
   3. Delivery of as-built / installed drawings
   4. Passing System Test
   5. Successful Training

END OF SECTION 275116

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SECTION 280513 - CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY

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.

B. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.

1.2 SUMMARY

A. Section Includes:

1. RS-232 cabling.
2. RS-485 cabling.
3. Low-voltage control cabling.
4. Control-circuit conductors.
5. Identification products.

B. Reference Section “Premise Distribution System” for UTP (Category 6), fiber optic and coaxial cables and terminating devices.

C. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.

1.3 DEFINITIONS

A. BICSI: Building Industry Consulting Service International.

B. EMI: Electromagnetic interference.

C. IDC: Insulation displacement connector.

D. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.

E. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).

F. RCDD: Registered Communications Distribution Designer.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:

1. Vertical and horizontal offsets and transitions.
2. Clearances for access above and to side of cable trays.
3. Vertical elevation of cable trays above the floor or bottom of ceiling structure.

C. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.

D. Seismic Qualification Certificates: For pathways, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Source quality-control reports.

F. Field quality-control reports.

G. Operation and Maintenance Data: For wire and cable to include in operation and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Allowable pulling tension of cable.
2. Cable connectors and terminations recommended by the manufacturer.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1.7 PROJECT CONDITIONS

A. Do not install conductors and cables that are wet, moisture damaged, or mold damaged.

1. Indications that wire and cables are wet, or moisture damaged, include but are not limited to, discoloration and sagging of factory packing materials.

B. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating

and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

PART 2 - PRODUCTS

2.1 PATHWAYS

A. Reference Division 27 Sections “Pathways for Communications Systems”.

B. All cabling for the Access Control System and CCTV System shall be installed in conduit.

2.2 CABLE AND CONDUCTORS

A. Rating: Provide Type CMR for riser applications where cable is run inside conduit.

B. RS-232 CABLE

1. Standard Cable: NFPA 70, Type CM.
   a. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
   b. Polypropylene insulation.
   c. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
   d. PVC jacket.
   e. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.

C. RS-485 CABLE

1. Standard Cable: NFPA 70, Type CM.
   a. Paired, 2 pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors.
   b. PVC insulation.
   c. Unshielded.
   d. PVC jacket.

D. LOW-VOLTAGE CONTROL CABLE

1. Paired Cable: NFPA 70, Type CMG.
   a. 1 pair, twisted, No. 16 AWG, stranded (19x29) tinned copper conductors.
   b. PVC insulation.
   c. Unshielded.
   d. PVC jacket.

E. 4-ELEMENT COMPOSITE SECURITY CABLE

1. General: where possible, provide a 4-element composite cable from the door interface box (DIB) to the access control panel (ACP) with the following sub-cables under one sheath:
2. Element 1 – Lock Power, 4/C #18AWG

3. Element 2 – Card Reader, 6/C #22AWG
4. Element 3 – Door Contact, 2/C, #22AWG
5. Element 4 – REX/Spare, 4/C, #22AWG
6. Manufacturer: SmartWire #4461140 or approved equal. Orange color jacket for non-plenum applications.

F. CONTROL-CIRCUIT CONDUCTORS

1. Class 1 Control Circuits: Stranded copper, Type THHN-THWN, complying with UL 83, in raceway
2. Class 2 Control Circuits: Stranded copper, Type THHN-THWN, complying with UL 83, in raceway Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or TF, complying with UL 83.

G. CATEGORY 6 UTP CABLE

1. Reference Section “Premise Distribution System” for UTP (Category 6) and terminating devices.

H. FIBER OPTIC CABLE

1. Reference Section “Premise Distribution System” for single mode fiber optic cable and terminating devices.

2.3 IDENTIFICATION PRODUCTS

A. Reference Division Section “Premise Distribution System”.

PART 3 - EXECUTION

3.1 INSTALLATION OF PATHWAYS

A. Comply with TIA-569-B for pull-box sizing and length of conduit and number of bends between pull points.

B. Reference Division 27 Section “Pathways for Communications Systems”.

3.2 WIRING METHOD

A. Install all security systems wiring in conduits. Conceal raceway except in unfinished spaces and as indicated. Minimum conduit size shall be 3/4 inch. Control and data transmission wiring shall not share conduit with other building wiring systems.

B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Use lacing bars and distribution spools. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer. Install conductors parallel with or at right angles to sides and back of enclosure. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with intrusion system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all

connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1.

B. Conductors: Size according to system manufacturer's written instructions unless otherwise indicated.

C. General Requirements for Cabling:

1. Comply with TIA/EIA-568-B.1.
2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
3. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
4. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
5. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
6. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
7. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
8. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

D. Cable Installation:

1. Security systems (Access Control System and CCTV System) cabling shall not be run open or exposed. All cabling shall be installed in conduits.

E. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569-B recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.

b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.

4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
5. Separation between Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
6. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.4 POWER AND CONTROL-CIRCUIT CONDUCTORS

A. 120-V Power Wiring: Install according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables" unless otherwise indicated.

B. Minimum Conductor Sizes:

1. Class 1 remote-control and signal circuits, No. 14 AWG.
2. Class 2 low-energy, remote-control and signal circuits, No. 16 AWG.
3. Class 3 low-energy, remote-control, alarm and signal circuits, No. 12 AWG.

3.5 CONNECTIONS

A. Comply with requirements in Division 27 Section "Premise Distribution System" for connecting, terminating, and identifying wires and cables.

B. Comply with requirements in Division 28 Section "Access Control System" for connecting, terminating, and identifying wires and cables.

C. Comply with requirements in Division 28 Section "CCTV System" for connecting, terminating, and identifying wires and cables.

3.6 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for communications installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Firestopping."

3.7 TELECOMMUNICATION GROUNDING

A. For communications wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. For low-voltage wiring and cabling, comply with requirements in Division 27 Section "Communications Equipment Room Fittings"

3.8 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Division 27 Section " Premise Distribution System."

3.9 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect all cable jacket materials for NRTL certification markings. Inspect cabling terminations to confirm color-coding for pin assignments and inspect cabling connections to confirm compliance with TIA/EIA-568-B.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test low voltage control and data cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross connection.
4. Test all Category 6 cable per Section 27 “Premise Distribution System”.
5. Test all fiber optic cabling per Section 27 “Premise Distribution System”.
6. Test all coaxial cable per Section 27 “Premise Distribution System”.

B. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide or transfer the data from the instrument to the computer, save as text files, print, and submit.

C. End-to-end cabling will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 280513

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SECTION 281300 – ACCESS CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to this section.

B. Related Sections:

1. Division 1 – Allowances
2. Division 27 – Premise Distribution System
3. Division 28 - Conductors And Cables For Electronic Safety And Security
4. Division 28 – CCTV System

C. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.

1.2 SUMMARY

A. This section includes the extension of the existing Tour-Andover, Inc. Continuum Access Control System. The system is a CyberStation ver. 1.94 system using ACX intelligent access control panels and xP I/O modules. Communication from head-end servers to access control panels are IP over an existing local area network. This section will specify access control panels, field devices, cabling and system testing procedures.

B. Work under this specification has been defined under a Lump Sum Allowance to be used to employ the services of a Security System Integrator (hereinafter referred to as Integrator). See Section 012100 – Allowance for more information.
1. For this project the approved Security System Integrator:

Convergint Technologies
7445 Cross County Rd Suite 10
North Charleston SC 29418
Contact: Ross Motley
843-554-7622
Ross.Motley@convergint.com

1.3 SYSTEM DESCRIPTION

A. General: This contract requires extension of an existing distributed ACS system. The ACS components are specified here to be compatible with the existing ACS system. This contract includes purchasing compatible ACS equipment. Operating features of hardware and software specified in this section are intended to limit the ACS components to compatible Tour-Andover, Inc. equipment.

B. Testing of installed components is included: This contract includes the provision, programming, installation and testing of new access control panels (IFP) and their IP connection to the existing LAN. The IFP is capable of stand-alone operation, and its proper

stand-alone operation and control of all devices included under this contract shall be required for final acceptance. This project shall provide all hardware, software, cable and other components necessary for a full functioning system capable of stand-alone operation.

C. Database Modifications: This Contractor shall be responsible for updating and integrating all existing databases affected by the extension of the system. A certified Tour-Andover, Inc. representative shall perform all database modifications, uploading and integration between the existing main ACS head-end and all components, new or existing, affected by the extension.

D. Alarm Programming: This Contractor shall coordinate with the Airport Police on specific alarm programming requirements. Contractor shall be responsible for programming alarm and trouble text for each door and respective door device. Coordinate with Airport Police on descriptors and tag numbers for each device and door.

E. The ACS and card readers shall be capable of reading and processing existing Owner proximity cards. Coordinate with Airport Police on exact type of card in use.

1.4 SCOPE OF WORK

A. This project consists of the extension of an existing ACS to secure, monitor and control secured doors and portals. The extension of this system shall be seamless in that access points installed under this project will operate, alarm and report in the same manner as existing access points. It is the Contractor's responsibility to meet with Airport Police and coordinate the exact operation and integration of access points.

B. This project shall provide for the integration of the ACS to the following systems:

1. Fire Alarm System: for automatic release of electrified locking devices on emergency egress doors.
2. CCTV System: for automatic call-up of CCTV cameras located throughout the project limits. The existing CCTV system is a Pelco Digital Sentry ver. 7.3 system.

1.5 QUALITY ASSURANCE AND SECURITY CLEARANCES

A. Tour-Andover, Inc. equipment shall be installed by an authorized Tour-Andover, Inc. installer trained in the application of institutional grade hardware, electronic components, and window-based software. The Integrator shall have experience on projects with installation work similar to that required for this project.

B. Security Clearance: The Contractor and Integrator, all direct and contract employees, subcontractors, vendors and manufacturer's representatives shall obtain all required Transportation Security Administration clearances via the Airport Police in order to work on the ACS, including programming and remote access to the existing ACS head-end. The Contractor and Integrator shall be responsible for all direct and indirect costs associated with obtaining this clearance. Reference Division 1 Section of these specifications for more information concerning security clearance requirements.

C. Code Compliance: Comply with all required Local and National Codes as applicable to construction and installation of security system components and accessories.

D. UL Compliance and labeling: Provide system components that are UL-listed and labeled.

1.6 SUBMITTALS

A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification sections:

1. Shop Drawings: Provide shop drawings showing equipment locations, and arrangements.
2. Product Data: Submit manufacturer's data on Access Control System components including, but not limited to, electrical specifications, mechanical specifications, rough-in diagrams and instructions for installation, operation and maintenance, suitable for inclusion in maintenance manuals.
3. Wiring Diagram: Provide wiring diagrams showing all point-to-point field-installed wiring.
4. Plan Drawings: Provide plan drawings showing locations of all active components.
5. Assembly Drawings: Provide an assembly drawing of every equipment rack with location and dimensions shown.
6. Testing: Prepare and submit Test Plans, Test Procedures and Test Reports according to this Section, for Installation Test, System Test, and Integration Test.

1.7 INTELLECTUAL PROPERTY

A. Patents: Should patented articles, methods, materials apparatus, etc., be used in this work, the Integrator shall acquire the right to use patented materials. The Integrator shall hold the Owner and its agents harmless for any delay, action, suit, or cost growing out of the patent rights for any device on this project.

B. Copyrights: Should copyrighted software be used in this work, the Integrator shall acquire the right to use copyrighted software. The Integrator shall hold the Owner and its agents harmless for any delay, action, suit, or cost growing out the copyrights for any software on this project.

C. License to use: All software required for the complete operation of the system as specified herein shall be delivered with either full ownership transferred to the Owner a non-time-limited

license to use on each machine it is installed on, including the right to make back-up copies.

1.8 WARRANTY

A. Period: The Integrator shall guarantee all labor, workmanship, and materials for a period of one (1) years from date of final acceptance. Should a failure occur within this warranty period of the system, the Integrator shall provide all labor and materials necessary to restore the system to the condition required for testing and acceptance for this contract, at no cost to the Owner.

B. Tie-ins: During the warranty period, additional keys and door contacts will be connected and their use entered in database. New devices will be connected in the same manner as shown on the drawings for this contract and the existence of the new connections shall not void this guarantee.

1.9 RADIO/TELEVISION INTERFERENCE

A. Expected RF Environment: This security system shall be installed in a major airport and will be subject to background RF levels which are expected in such an area. It is the Integrator's responsibility to protect the system specified here from interference with other systems present, and through FCC compliance listed above, prevent interference with other systems.

PART 2 – PRODUCTS

2.1 GENERAL

A. Manufacturers and Part Numbers: provide manufacturer and part numbers as listed in this specification. Integrator may submit alternates or substitutions for approval by Engineer and Owner's Representative. All submittals must follow Owner guidelines and be submitted on official documentation. Submission of alternate or substitute item does not guarantee acceptance.

B. HARDWARE

1. Proximity Card Reader with Integral Keypad: Provide card reader with integral keypad at locations shown on drawings. The card readers shall be capable of reading existing Airport cards. The card reader shall have the following characteristics:

   a. Manufacturer: HID iClass
   b. Keypad: 12 button, weatherized keypad built-in to the card reader.
   c. Construction: Weatherized, polycarbonate, vandal resistant enclosure with conformal coating. Provide built-in heater on all exterior units.
   d. Mounting: Reader shall mount to a standard single gang mounting plate attached to a double-gang outlet box.
   e. Interface Technology: iClass, FIPS 201 compliant, 13.5MHz contactless smart card technology. Match existing readers at airport.
   f. Audio/Visual Indicators: Reader shall be equipped with multicolor LEDS and beeper for audio/visual feedback to user. LEDS shall change state upon presentation of valid card (green) and invalid card or pin number (red and audio beep).
   g. Certifications: UL294/1076, CE, CSA
   h. Warranty: Two years minimum.

2. Passive Infrared Detector: Passive Infrared (PIR) Motion Detectors shall be furnished and installed as indicated on the plans. PIR shall be used as a REX device where indicated on the plans. Provide devices with the following characteristics:

    a. 12 or 24 VAC or VDC operation (typical 26 mA @ 12 VDC).
    b. Two form "C" contacts.
    c. Relay latch time adjustable up to 60 seconds.
    d. Operating temperatures of -20 degrees to + 120 degrees F.
    e. Externally visible activation LED.
    f. Adjustable "look down" coverage pattern to minimize nuisance activations.

3. Door Hardware: All door hardware (electrified and non-electrified) shall be furnished and installed by the Division 8 Contractor. The Integrator shall meet and coordinate with the Door Hardware Contractor on the proper interface and wiring of all electrified door hardware to the ACS. The Integrator shall wire and test all electrified door hardware including but not limited to:

    a. Door position switches
    b. Electrified strikes and lever sets
    c. Request-to-Exit switches integral to the locking device

2.2 ACS INTELLIGENT FIELD PANEL (IFP)

A. Provide IFP panels as shown on drawings. IFP panels shall have the following characteristics:

B. Manufacturer: Tour-Andover, Inc. Model ACX 5720

C. Certifications: UL/ULC 294/1076, CSA, CE

D. Communication Availability: LAN/WAN, 10 Base-T, TCP/IP, Ethernet Compliant, Echelon LON, EIA RS-232, Dial-up Modem, EIA RS-485. This project shall utilize dual Ethernet network interface cards for communication to the local area network in a redundant mode.

E. Capacity: Provide IFP with Access Control Modules (ACM) to support the following devices and I/O:

    1. Card Readers: 4
    2. Supervised Inputs: 8
    3. Outputs (Suitable for Door Control): 8
    4. Memory: 128MB, suitable for use with current firmware version.

F. Enclosure: NEMA 4Xenclsoure suitable for outdoor installation, hinged, lockable cover with tamper switch. Tamper switch shall be monitored by ACS.

G. Power Requirements: Input: 90-240VAC, 0.5A Max. Output: 12VDC @3.3A maximum.

2.3 READER AND ADD-ON MODULES

A. General: All required reader modules and expansion modules shall be manufactured by Tour-Andover, Inc. and compatible with the IFP. Provide all required reader and expansion I/O modules as needed to support, monitor and control all points and devices on the project.

2.4 IFP POWER SUPPLY

A. Provide a dedicated power supply for each IFP. Power supplies shall be provided with the following characteristics:

1. Manufacturer: Securitron
2. Certifications: UL/ULC 294/1076, CSA, CE
3. Input Power 120-220VAC. 50/60Hz, 2.5A, max.
4. Output Power 13.8VDC, 3.75A.
5. Battery backup: Provide sufficient battery backup to power the IFP and all door security devices connected to that IFP for a period of not less than eight (8) hours. Provide the following alarm outputs and connect to input of assigned IFP for transmission of trouble signal to system head-end:

a. AC Fault on blown fuse.
b Low Battery (below 10.3 VDC)

2.5 MULTI-OUTPUT DOOR HARDWARE POWER SUPPLY

A. The Integrator shall be responsible for interfacing the lock power supply to the power transfer hinge and locking mechanism. Provide all cabling and electrical connectors as required.

B. Provide power supplies for fail-safe operation of all electric locking mechanisms as required by local codes. Fail-safe locking devices shall unlock automatically under the following conditions:

1. Any building fire alarm
2. Failure of the power supply

C. Provide power supplies with the following characteristics:

1. Manufacturer: Securitron ACM8CB, or approved equal
2. Input power 120VAC.
3. Battery backup: Provide sufficient battery backup to power the ACP and all door security devices connected to that ACP for a period of not less than 4 hours.
4. Output power eight (8) individually fused 12 or 24VDC outputs for lock power, one (1) fused output (voltage and power as required) to power ACP.
5. Two (2) NO outputs, loss of AC and low battery.
6. Diagnostic LEDs for power and blown fuse indication.
7. Cabinets shall be lockable and provided with tamper switches. Provide signage warning that an alarm will sound if access is attempted and giving the telephone number of the security monitoring desk.

2.6 ACS HEAD-END INTERFACE VIA LOCAL AREA NETWORK (LAN)

A. LAN equipment required for the communication of IFP panels provided under this project shall be provided by the Owner. Integrator shall coordinate with Airport IS Department as required for network setup and configuration.

B. Integrator shall provide all required programming, software and graphic map updates required for the extension of the ACS. All programming, software updates, database modifications,

graphic user maps, etc. shall be provided and installed/programmed by an authorized and certified Tour-Andover, Inc. representative.

2.7 WIRE AND CABLE

A. Provide wire and cable as required to install the ACS as indicated on the drawings and specified herein.

B. All wire and cable shall be Underwriter's Laboratories (UL) listed, and shall meet all national, state and local code requirements for its application.

C. All wire and cable shall meet individual system or subsystem manufacturer specifications.

D. All ACS wire and cable shall be installed in conduit.

E. All insulated wire and cable shall conform to the minimum requirements of Insulated Cable Engineer Association (ICEA) Standards.

F. Wire and cable shall comply with the applicable requirements of the National Electrical Code (NEC), latest edition, in regard to cable construction and usage.

G. The conductors of wires shall be copper and have conductivity in accordance with the standardization rules of the Institute of Electrical and Electronics Engineers, Inc. (IEEE). The conductor and each strand shall be round and free of kinks and defects.

H. All cable carrying data or voice transmissions shall be shielded. All other cable shall be shielded where necessary for interference-free signals.

I. Insulation shall be rated for a minimum of 300 V.

J. Color coding shall be accomplished by using solidly colored insulation. Grounding conductors, where insulated, shall be colored solid green or identified with green color as required by the National Electric Code (NEC).

2.8 CONDUITS AND RACEWAYS

A. All ACS cables shall be installed in conduit. Install all conduit necessary for a complete installation. Conduit and boxes in finished areas shall be concealed in chases, furrings, below concrete slabs and/or above suspended ceilings. No exposed conduit shall be installed within public areas. Exposed exterior conduit shall be painted to match surrounding surfaces.

2.9 CIRCUIT AND DEVICE SURGE PROTECTION

A. All inputs shall be protected against surges induced on device wiring. Outputs shall be protected against surges induced on control and device wiring installed outdoors and as shown. All communications equipment shall be protected against surges induced on any communications circuit. All cables and conductors, except fiber optics, which serve as communications circuits from security console to field equipment, and between field equipment, shall have surge protection circuits installed at each end.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Manufacturer's Instructions: Install Access Control System in accordance with equipment manufacturer's written instructions and complying with applicable portions of the National Electrical Code.

B. Grounding: All pair shields shall be grounded at one point only. Cables that originate from equipment in IDF Rooms and serve field devices shall be grounded to the signal ground terminal in the IDF.

C. Protection: Integrator shall provide protection as required of installed devices to prevent damage until final testing and acceptance. Installed equipment, devices, cabling, etc. that is damaged during the construction process and before final acceptance by Owner shall be replaced by the Integrator at no cost to Owner.

3.2 PROGRAMMING OF EXISTING ACS HEAD-END COMPUTER

A. All work associated with modifications, upgrades or changes to the existing head-end shall be done in such a manner that the ACS is never off-line. Any work that requires the ACS to be off-line must be scheduled with Airport Police a minimum of 30 days prior to the outage.

B. This Integrator shall be responsible for updating and integrating all existing databases affected by the extension of the ACS. A certified Tour-Andover representative shall perform all database modifications, uploading and integration between the main ACS head-end and all components new or existing, affected by the extension.

3.3 INTEGRATION WITH CCTV SYSTEM

A. Integrator shall provide a complete and operational interface between the ACS and the CCTV cameras provided under this contract. Activation of a secured door alarm and/or an emergency call station push-to-call switch shall initiate an alarm on the Alarm Monitoring Workstation in the Airport Operations Center (AOC).

B. Integration between the two systems shall be via a software interface. Integration utilizing a relay or hardwired system shall not be allowed.

C. Integrator shall coordinate with the Owner for required messaging or data to be transferred from the CCTV System to the ACS.

3.4 INSTALLATION OF CONDUCTORS

A. General: Installation of conductors is specified in Division 27 and 28.

3.5 SYSTEM TESTING

A. The system will be operationally tested using valid and invalid cards with the IFP in the on-line and off-line mode. Valid card shall result in the secured door and/or gate arm operating; an invalid card shall result in the secured door and/or gate arm not operating. The communication status of the IFP shall not matter during these tests. After completion of off-line tests, the IFP will automatically download to the server all events that occurred while off line.

B. Tamper switches will be actuated on security enclosures so equipped. The removal or opening of a cover from a tamper equipped box shall result in a tamper alarm indication.

C. At the completion of operational testing, a burn-in test will occur. The system additions must function without fail for fourteen (14) days. A report shall be created from the system database to demonstrate the frequency and type of failures that occurred. All failures related to equipment or installation shall be corrected and the burn-in test restarted till it successfully completes the entire duration without failure.

D. Successful completion of the test is a prerequisite to final acceptance of the ACS.

3.6 OPERATION AND MAINTENANCE MANUALS

A. Intent: The intent of this section is to require complete documentation of the Access Control System for the purpose of system operation and maintenance during and after the warranty period. It is intended that the operation and maintenance manuals be exhaustive in the coverage of the system to the extent they may be used as the sole guide to the trouble shooting, identification, and repair of defective parts.

B. Scope: The Contractor shall provide the Owner with six complete drawing books and maintenance and operation manuals on the completed system. These manuals shall include basic wiring diagrams, schematics, and functional details such that any component, wire, or piece of equipment in the system may be easily identified by going to the actual equipment and making reference to this manual. It is required that everything in the system be neatly labeled and easily identifiable. Every terminal, wire, component, or piece of equipment, relay, and other such items shall have a number or letter designation. All of these identification characteristics shall be included in the maintenance and operation manuals.

C. Maintenance Manuals, Manufacturer’s Literature:

D. General: The maintenance manual requirement of this section is in addition to shop drawing requirements. Maintenance manuals and drawing sets shall be compiled after system fabrication and testing and shall incorporate any changes made after shop drawing submittal. The maintenance manuals and drawing books shall be permanently bound in hard plastic covers.

E. Maintenance Manuals, Manufacturer’s Literature: Provide manufacturer’s standard literature, covering all equipment included in the system. The maintenance manuals shall contain specifications, adjustment procedures, circuit schematics, component location diagrams, and replacement parts identification. All references to equipment not supplied on this project shall

be crossed out.

F. Drawing Books: All drawings developed specifically for this project shall be reduced to 11" X 17", folded and bound with hard plastic covers. Provide component identification and cross reference on the drawings for the maintenance department to understand the function of each item (the block diagram), find the room where the device is mounted (contract document plans), find its location in a rack (arrangement drawings), find how it is wired (wiring diagrams), and its detailed specifications (vendor data sheets), and how to repair it (spare part lists). Include the following drawings as a minimum:

G. Functional Block Diagram: Provide an overall block diagrams showing the major interconnections between subsystems.

H. Arrangement Drawings: Provide drawings showing the physical arrangement of all major system components.

I. Elevation drawings of all equipment racks showing the location of each component in the racks. Components in the racks shall be identified as in the functional block diagrams.

J. Wiring Diagrams: Provide wiring diagrams showing all field-installed interconnecting wiring. Wire identification on the diagrams shall agree with the wire markers installed on the equipment.

3.7 TRAINING AND INSTRUCTION

A. Provide training to Owner personnel on the operations of the ACS. Include standard operating procedures as well as operational requirements during alarm and trouble modes of the system for all portal/door types.

B. Provide training at the Airport Operation Center for incoming alarms and trouble signals to the ACS Main Computer.

3.8 ACCEPTANCE

A. Acceptance will be withheld until the successful completion of the following:

1. Acceptance of all submittal.
2. Delivery of final documentation.
3. Successful testing.
4. Successful demonstration, training and documentation review.

END OF SECTION 281300

SECTION 282300 - CLOSED CIRCUIT TELEVISION (CCTV)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Related Sections:

1. Division 1 – Allowances
2. Division 27 – Premise Distribution System
3. Division 28 - Conductors and Cables for Electronic Safety and Security
4. Division 28 – Access Control System

C. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.

1.2 SUMMARY

A. Components specified herein are to be compatible with the existing CCTV and Network Video (NVR) Recording system. Operating features of hardware and software specified in this section are intended to limit the CCTV components to compatible equipment.

B. General: This contract shall provide for installation and testing of pan-tilt-zoom (PTZ) and fixed IP-based cameras, mounts, housings and all required power supplies, cabling and fiber optic transceivers as shown on the drawings.

C. Transportation of digital (IP) signals for viewing and recording shall be via an existing Virtual LAN (VLAN). Coordinate IP addressing, Ethernet switch port assignments, fiber optic cable use and bandwidth utilization with GSP IS Department. Include cost for this coordination in the cost of this contract.

D. The programming, testing, owner training and documentation of the installed CCTV system as shown on the Drawings and specified herein are part of this contract. All costs associated with programming, testing, training and documentation of the system shall be included in the contract.

E. The integration of the CCTV system with the Access Control System as described herein is part of this contract. All costs associated with the integration of these systems with the CCTV system shall be included in the contract.

F. Work under this specification has been defined under a Lump Sum Allowance to be used to employ the services of a Security System Integrator (hereinafter referred to as Integrator). See Section 012100 – Allowance for more information.

1. For this project the approved Security System Integrator:

Convergint Technologies
7445 Cross County Rd Suite 10
North Charleston SC 29418

Contact: Ross Motley
843-554-7622
Ross.Motley@convergint.com

1.3 INTEGRATION

A. The CCTV system shall be integrated with the Access Control System (ACS) as specified for this project. The CCTV system shall immediately respond to alarm events associated with the ACS by calling designated camera views near the site of the alarm to designated alarm monitors in the Airport Operations Center (AOC). If the designated view is from a PTZ style camera, the CCTV system shall be capable of selecting a programmed preset position at the direction of the ACS to allow the PTZ to rotate and zoom in on the area of the alarm event or the specific emergency call station. If the area is capable of being viewed from several cameras, the closest view will be called up to the designated alarm monitor with additional images being called up in sequence to a designated alternate alarm monitor.

B. This integration shall be accomplished through a software data exchange; contact closure interfaces to the ACS shall be prohibited.

C. The CCTV system shall interface with the NVR such that during alarm events as determined by the ACS, the NVR shall switch into a real-time high resolution mode and record the images from the primary camera viewing the area associated with the alarm event.

1.4 SUBMITTALS

A. General: Partial submittals are not acceptable. Submit all documentation in accordance with Conditions of Contract and Division 1 Specification Sections as well as this section.

B. “As Equal” requests: All submittals seeking approved equal status prior to bid must be received by the Engineer two weeks prior to the bid date to allow adequate time for the Engineer to evaluate them. The proposed “as Equal” product requires full technical details be submitted no later than fourteen (14) days prior to bid deadline to allow time for the Engineer to evaluate them and issue an addendum notifying all bidders of the accepted or rejected alternate. Submittals from the manufacturer will be rejected. In addition to technical literature, the Integrator must detail point-by-point all specification items listed herein and if the product fails to meet, meets or exceeds the specification item in order to be considered for approval. Failure to follow this format will result in the submittal being rejected.

C. Informational Data: The successful bidder shall submit the following documents a minimum of ten (10) Days prior to the Pre-Construction Conference:

1. Proposed Construction Schedule in accordance with Construction Progress Documentation.

2. Integrator Qualification Data demonstrating licenses, capabilities and experience of the firm. Include lists of completed projects as indicated in the “Quality Assurance” section below with information on project name and address, name and addresses of Owners, consultants or Owners involved in these projects.

3. Installer Certifications on manufacturer’s letterhead indicating that installer complies with the manufacturer’s requirements necessary to install the equipment specific to this project.

D. Product Data: At the Pre-Construction Conference the successful bidder shall submit manufacturer's data on CCTV System components as follows:

1. Manufacturers data sheets
2. On data sheets that illustrate multiple models, the particular model proposed for the application shall be encircled or underlined. Individual copies shall be included for each proposed model number indicating areas of application.
3. Deviations from Specifications shall be encircled or underlined on the documents and be marked as deviations.
4. Color highlighters shall not be permitted.

E. Installation Work Plan: At the Pre-Construction Conference, the successful bidder shall submit for approval by the Engineer a plan detailing how the Work will be accomplished, highlighting minimal interruption to ongoing passenger and aircraft activities. The plan shall provide a daily work schedule, details for the protection of existing equipment, cleanup of work areas and restoration of exposed ceilings on a daily basis, and other activity that assures continuity of Airport operation with minimal impact on airlines, tenant and passenger activities.

F. Shop Drawings: No later than ten (10) days after the Pre-Construction conference, the successful bidder shall provide Shop Drawings showing equipment quantities, locations, types and arrangements including but not limited to:

1. Dimensions
2. Product identification
3. Fabrication and installation Drawings
4. Rough-in diagrams
5. Wiring diagrams showing field-installed wiring
6. Schedules and Tables
7. Design calculations and methods
8. Compliance with specified standards
9. If rack mounted equipment is used, provide an assembly Drawing of every equipment rack with locations, quantities, model numbers of individual components contained in the rack, and dimensions shown on the Drawing.

G. The successful bidder shall submit for review and approval, by the Engineer or designated representative a test plan no later than fourteen (14) days prior to anticipated substantial completion. The test plan shall detail test procedures and test reports that indicate testing methods, testing device calibration, and interpretations of test results for Field Acceptance Tests. The test plan shall detail the objectives of all tests. The tests shall clearly demonstrate that the CCTV system and its components fully comply with the requirements specified herein.

H. Training: The Integrator shall provide a training schedule for approval by the owner no later than ten (10) days prior to anticipated substantial completion. Include course outline and training material planning to be used in the training for approval by the consultant. Plan on holding (2) two sessions focused on administration and maintenance of the system and a minimum of (4) four sessions focused on user training. Some of the training sessions will be conducted after normal business hours to accommodate those on evening, weekend and night shifts.

1.5 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of CCTV systems, components and accessories, of types, capacities and characteristics required for this job, whose products have been in satisfactory use in similar installations for not less than two (2) years.

B. Installer's Qualifications: Firms with at least two (2) years of successful installation experience with projects of similar size and environments utilizing the brand of CCTV equipment proposed for this project.

C. Code compliance: Comply with NEC and municipal codes as applicable to construction and installation of CCTV equipment and signal distributions systems. When there is a conflict between codes, the more stringent will apply.

1.6 INTELLECTUAL PROPERTY

A. Patents: Should patented articles, methods, materials apparatus, etc., be used in this Work, the Integrator shall acquire the right to use it. The Integrator shall hold the Airport and its agents harmless for any delay, action, suit, or cost growing out of the patent rights for any device on this Project.

B. Copyrights: Should copyrighted software be used in this Work, the Integrator shall acquire the right to use it. The Integrator shall hold the Airport and its agents harmless for any delay, action, suit, or cost growing out of the copyrights for any software on this Project.

C. License to Use: All software required for the complete operation of the system as specified herein shall be delivered with either full Ownership transferred to the Airport or a License to use at this site, including the right to make back up copies.

1.7 RADIO/TELEVISION INTERFERENCE

A. FCC Compliance: All equipment that uses radio frequency energy shall be certified to comply with Subpart J of Part 15 of Federal Communication Commission rules CFR 47 as those rules define a class "B" computing device.

B. Expected RF Environment: This CCTV system is to be installed in a major airport and is subject to background RF levels expected in such an area. It is the Integrator's responsibility to protect the systems specified here from interference by other systems, and through FCC compliance listed above, to prevent interference with other systems. All costs for any RF mitigation shall be included in the cost of this proposal.

1.8 WARRANTY

A. Period: The Integrator shall guarantee all labor, workmanship, and materials for a period of one (1) year from the date of final acceptance. Should a failure to the system occur within this first year, the Integrator shall provide all labor and materials necessary to restore the system to the condition required for the final test and acceptance for this contract, at no cost to the Owner.

B. Software Maintenance: During the warranty period the operating system software and CCTV software shall be maintained at the most current version available from the manufacturer at no cost to the Airport.

C. During the warranty period, all periodic and routine maintenance of the installed components to maintain the factory warranty shall be provided at no additional cost under this contract.

D. Tie-ins: During the warranty period, components may be connected/disconnected from the system as applicable. New devices will be connected in a similar manner as shown on the drawings for this contract by a qualified company and the existence of the new connections shall not void the system warranty on the original system.

E. Response Times: For the Warranty Period, response times shall adhere to the current response times in place for the CCTV system.

PART 2 - PRODUCTS

2.1 CAMERAS

A. General: Provide material of types, sizes, capacities and electrical characteristics indicated. Except as otherwise indicated, provide manufacturer's standard Closed Circuit Television system components as indicated by their published product information, designed and constructed as recommended by manufacturer. All equipment supplied shall be UL Listed and labeled.

B. Fixed, IP-Based Dome Camera: Provide fixed dome cameras as indicated on the drawings (for both indoor and outdoor applications) with the following capabilities:

1. Manufacturer: Pelco Sarix IME Series or Owner/Engineer approved equal.
2. Recessed dome with 1/3" progressive scan megapixel CCD, 2,530,000 [1296(H) x 976(V) x 2] pixels, minimum.
3. Minimum illumination of 1.0 lux color in 1.3 megapixel mode or 2.0 lux color in 3 megapixel mode.
4. Capable of generating and transmitting images to meet the following specifications.
   A. 3 Megapixel Mode:
      1. JPEG: 2,048 x 1,536 / 1,280 x 960 / VGA (640 x 480), up to 15 fps
      2. H.264: 1,280 x 960 / VGA (640 x 480) / QVGA (320 x 240), up to 15 fps
      3. MPEG-4: VGA (640 x 480) / QVGA (320 x 240), up to 15 fps
   B. 1.3 Megapixel Mode:
      1. JPEG: 1,280 x 960 / VGA (640 x 480), up to 30 fps
      2. H.264: 1,280 x 960 / VGA (640 x 480) / QVGA (320 x 240), up to 30 fps
      3. MPEG-4: VGA (640 x 480) / QVGA (320 x 240), up to 30 fps
5. Independent automatic color-to-black & white switching modes for switchover on light threshold.
6. Automatic back focus mechanism (ABF) for automatic and remote back focus adjustment.
7. Intelligent digital back light compensation, digital wide dynamic range circuit, digital noise reduction and electronic sensitivity-up for real surveillance purposes under severe conditions.
8. Shall incorporate a CS-mount, 1/3", automatic iris, variable focal lens. Focal length shall be decided in field per each cameras' required field of view.
9. Built-in shutter with following settings: off, 1/100, 1/250, 1/500, 1/1000, 1/2000, 1/4000 and 1/10000 sec. A web browser menu shall allow fine adjustment of chrominance, pedestal and aperture level.
10. Support uni-cast and multi-cast transmission.
11. Full duplex two-way audio feature and be capable of transmitting and receiving the audio stream through the same Ethernet connection as the video.

12. Camera shall support IPV4 and IPV6 network addressing.
13. Power source shall be PoE (IEEE 802.3af) 7.6W or 12V DC @ 630mA.
14. UL listed.
15. Mounting: Provide the required brackets and housings for the following mounting configurations:
16. Interior Recessed: Fully flush mounted. Provide all required mounting brackets and housings so that only the dome portion of the camera is exposed.
17. Exterior Recessed: Provide suitable housing for outdoor, recessed installation into an exterior soffit. Camera shall be rated for outdoor use or include heater and defroster option.

C. Indoor, PTZ, IP-Based Dome Cameras: Provide PTZ dome cameras as indicated on the drawings with the following capabilities:

1. Manufacturer: Pelco SD4N-W0 or Owner/Engineer approved equal.
2. 1/3" Progressive Scan MOS Imager with 1,228,800 [1,280(H) x 960(V)] pixels effective.
3. The camera shall have a minimum illumination of 0.5 lux color.
4. Unitized camera/dome assembly shall be a self-contained unit that incorporates an integral color camera, pan-and-tilt motor, zoom lens and receiver/driver.
5. Digital Signal Processor (DSP) shall automatically apply each exposure pattern to bright and dark areas. The Digital Signal Processor (DSP) shall feature images with a dynamic range of up to128 times with 1.3Megapixel.
6. The camera shall be capable of generating and transmitting images to meet the following specifications.
   A. 1.3 Megapixel Mode:
   B. JPEG: 1,280 x 960 / VGA (640 x 480)
   C. H.264: 1,280 x 960 / VGA (640 x 480) / QVGA (320 x 240) , up to 30 fps
   D. MPEG-4: VGA (640 x 480) / QVGA (320 x 240) , up to 30 fps
7. Independent automatic color-to-black & white switching modes for switchover on light threshold.
8. Intelligent digital back light compensation, digital wide dynamic range circuit, digital noise reduction and electronic sensitivity-up for real surveillance purposes under severe conditions.
9. 18X optical zoom at 1.3 megapixel. Additional zoom will provide 36X maximum magnification with VGA resolution. The camera shall provide continuous digital zoom (12X) for a total maximum magnification of 432X. The minimum aperture throughout this range shall vary from a minimum of f/1.6 at the wide angle setting.
10. The pan-and-tilt motor shall be a high-speed unit allowing 360° rotation with a tilt range of -30 to +90°. Gear-driven motor assembly. Belt driven unitized camera units shall not be acceptable.
11. The pan-and-tilt shall allow for preset sort and sequence rotation speed of approximately 300° per second. Minimum of 64 preset positions.
12. Built-in digital motion detector with four areas per scene and level adjustment capability.

13. Capable of automatically tracking and following a single moving indoor target, in indoor light conditions greater than 2 lux. Auto tracking function shall not require an external video processor to control the camera. The Automatic Tracking mode shall be able to be interrupted by manual operator control and automatically resume to its previous tracking mode.
14. The pan-and-tilt section shall feature automatic panning mode. The automatic panning limits and speed adjustment shall be selectable from an on-screen menu. The Automatic Preset Sequence or Sort mode shall be able to be interrupted by manual operator control and automatically resume to its previous mode.
15. Power source shall be PoE (IEEE802.3af) compliant (12W) or 12VDC @ 1A.
16. Dual Streaming Codec with MJPEG and MPEG-4 Part 2 Video Compression.
17. Able to support uni-cast and multi-cast transmissions.
18. Built in web server so that access to the IP video stream can be obtained using Internet Explorer Version. The web browser shall permit the user to make adjustments and settings to the camera.
19. Built in Audio input and output jacks and be capable of transmitting and receiving the audio stream through the same Ethernet connection as the video.
20. Integral SDHC Card slot which can support a maximum of a 32Gbytes SDHC card and SD card that can cache images in the event of a network failure. The camera shall provide bandwidth controls with at least the following throughput levels. The camera shall also support manual recording to the optional SDHC or SD Memory Card
21. The bandwidth Limit shall be adjustable to:
    64/128/256/512/768/1024/2048/4096/8192kbps or unlimited.
22. Shall support IPV4 and IPV6 network addressing.
23. UL Listed
24. Mounting: Provide the required brackets and housings for the following mounting configurations:
    A. Recessed: Fully flush mounted. Provide all required mounting brackets and housings so that only the dome portion of the camera is exposed.
    B. Surface: Provide pendant mount to support camera from exposed ceiling structure. Coordinate exact pendant length in field to ensure camera view is not block by building structure.

D. Outdoor, PTZ, IP-Based Dome Cameras: Provide PTZ dome cameras as indicated on the drawings with the following capabilities:

1. Manufacturer: Pelco S6230 or Owner/Engineer approved equal.
2. Outdoor PTZ shall have the same capabilities as the indoor model with the added features:
    A. IP66 rated water and dust resistant.
    B. Housings shall be equipped with a sunshield and integral heater/blower to accommodate for environmental changes.
    C. Housing heaters, blowers and defrosters shall be powered from a dedicated 120VAC power source. Provide low-voltage power supply as required.

E. Camera Power Supplies

1. Camera power supplies shall be UL listed units supplying the proper voltage required by the attached camera and housing.
2. Low voltage outputs shall have automatically resetting over current protection devices.
3. Each output shall be electrically isolated from other outputs on the supply.
4. Power supplies shall be mounted locally in exterior rated enclosures.

2.2 MOUNTS AND BRACKETS

A. Heavy-Duty Wall Mount:

1. Load capacity: Mount shall support 75-lbs.
2. Dome Mount: 1-1/2" NPT pipe thread.
3. Cable Feed-Through: cables shall be capable of being fed through mount arm and not exposed.
4. Provide polyester powder coat of steel.
5. Coordinate finish with Owner.

B. Pole Mount Adapter: Provide heavy-duty pole mount adapter for pole mounted cameras.

1. Suitable for use with wall mount bracket above.
2. Load Capacity: Mount shall support 75lbs
3. Finish: Aluminum with powder coat finish
4. Cable feed through hole to allow cabling to pass through mount and into wall bracket.

2.3 VIRTUAL MATRIX SOFTWARE

A. The existing virtual matrix software in place is Pelco Digital Sentry ControlPoint ver. 7.3 software. Cameras installed under this project shall provide the same functionality currently in place. Any camera shall be capable of being viewed on any monitor or one camera on all monitors without limitations.

2.4 TRANSIENT VOLTAGE SURGE SUPPRESSION

A. External in-line module required on both ends of all exterior copper based circuits.

B. Response time less than 1 nanoseconds

C. Peak Pulse Current 60A

D. Must protect all conductors in cable without degrading signal/power

E. Automatically reset after each lightning surge or electrical transient

F. Hybrid technology combining gas tube/MOV with transient voltage suppression diodes

G. Failure of surge suppression capabilities will result in open circuit to indicate module needs replacing.

2.5 CABLES AND CONDUCTORS

A. All CCTV cabling shall be installed in conduit.

B. All media shall be listed for the application, marked and protected as per the NEC. Articles 645, 725, 760, 770, 800 and 820 shall define the power source limitations, installation guidelines, insulation properties, applications and allowable cable substitution schedules. Solid conductor materials shall be substituted for the specified 7-strand conductor materials as required by the NEC. All media substitutions shall conform to the NEC and be approved by the engineer. Provide required cables for video, control data and LAN connections as identified on drawings. Cables shall meet following requirements:

1. Single Conductor Coaxial Video Cable: 75 ohm characteristic impedance, solid polyethylene core, 97 percent coverage, copper braid quad shield, polyethylene jacket; conforming to MIL C 17, Type RG 6A/U.
2. Multiconductor Cable: Quantity of conductors indicated; No. 18 AWG tinned-copper conductors; color-coded, low-loss PVC insulation; aluminum/Mylar shield; No. 22 AWG tinned-copper drain wire; PVC jacket.
3. Category 6 Cable: See Specification Section 271300.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Manufacturer's Instructions: Install Closed Circuit Television systems and components where indicated, in accordance with equipment manufacturer's written instructions, in compliance with National Electrical Code, Local Codes and with recognized industry practices, to ensure that the CCTV system complies with requirements and serves intended purposes.

B. Field of View Adjustment: Aim each fixed CCTV camera for the optimum view of the area that it is intended to cover per the drawings and schedules, using a monitor to view the camera output to aid in camera adjustment. Final aiming shall be approved and accepted by the Engineer and Owner prior to project close out. PTZ camera preset positions shall be approved and accepted by the Engineer and Owner prior to project close out.

C. Design Conductor Size: The sizes of conductors shown in the drawings and referred to in the specifications are required minimum cable sizes. The Integrator shall calculate actual cable size based on the equipment bid and increase the size the conductors if required. The Integrator's bid price shall reflect any increased cost required to provide larger than the minimum cable sizes required by the drawings and specifications including larger conduit if required.

3.2 CONDUITS AND RACEWAYS

A. All CCTV cables shall be installed in conduit. Install all conduit necessary for a complete installation. Conduit and boxes in finished areas shall be concealed in chases, furrings, below concrete slabs and/or above suspended ceilings. No exposed conduit shall be installed within public areas. Exposed exterior conduit shall be painted to match surrounding surfaces.

3.3 OPERATION AND MAINTENANCE MANUAL

A. Intent: The intent of this section is to require complete documentation of the CCTV System for the purpose of system operation and maintenance during and after the warranty period. It is intended that the operation and maintenance manuals be exhaustive in the coverage of the system to the extent that they may be used as the sole guide to the troubleshooting, identification and repair of defective parts.

B. Scope: The Integrator shall provide six (6) complete maintenance and operation manuals on the completed system. These manuals shall include basic wiring diagrams, schematics, and functional details such that going to the actual equipment and making reference to this manual may easily identify any component, wire, or piece of equipment in the system. It is required that everything in the system be neatly labeled and easily identifiable. Every terminal, wire, fiber, component, or piece of equipment, and other such items shall have a number or letter designation. All of these identification characteristics shall be included in the maintenance and operation manuals. The Integrator shall provide one set of all drawings on vellum for reproduction, and where the drawings are CAD generated; provide the drawing files in AutoCAD 2004 format. Provide one set of all schedules and tables in Microsoft Excel format.

C. The maintenance manual requirement of this section is in addition to shop drawing requirements. Maintenance manuals and drawing sets shall be compiled after system fabrication and testing and shall incorporate any changes made after shop drawing submittal. The maintenance manuals and drawing books shall be permanently bound in hard plastic covers.

D. Maintenance Manuals, Manufacturer's Literature: Provide manufacturer's standard literature, covering all equipment included in the system. The maintenance manuals shall contain specifications, adjustment procedures, circuit schematics, component location diagrams, and replacement parts identification. All references to equipment not supplied on this project shall be crossed out.

E. Drawing Books: This documentation is intended to be the system specific supplement to the maintenance manual.

F. All drawings developed specifically for this project shall be reduced to 11" X 17", folded, and bound with hard plastic covers. Provide component identification and cross reference on the drawings to allow technicians who follow to understand the function of each item (the block diagram), find the room where the device is mounted (contract document plans), find its location in a rack (arrangement drawings), find how it is wired (wiring diagrams), and its detailed specifications (vendor data sheets), and how to repair it (spare part lists). Include the following drawings as a minimum:

G. Functional Block Diagram: Provide an overall block diagrams showing the major interconnections between subsystems components.

H. Arrangement Drawings: Provide drawings showing the physical arrangement of all major system components. This shall include:

I. Provide elevation drawings of all equipment racks showing the location of each component in the racks. Components in the racks shall be identified as in the functional block diagrams. Drawing shall show the routes of all cables connecting its components.

J. Wiring Diagrams: Provide wiring diagrams showing all interconnecting wiring. Wire identification on the diagrams shall agree with the wire markers installed on the equipment.

K. Spare Parts: Provide manufacturers recommended spare parts to maintain the complete CCTV system with a minimum of down time. This shall be no less than one of every type

of electronic field device installed including but not limited to: cameras, lenses, power supplies and network switches. Parts are the property of the Airport and shall be stored on site. Any parts used prior to final testing and acceptance shall be replaced before final acceptance will be granted. Parts used from the on-site spare parts supply in support of the warranty shall be replaced within two (2) business days of their use.

L. Special Tools List: Submit a list of special tools required to maintain the CCTV system. Include on the list the name, part number, and source for all special tools.

M. Special Test Equipment List: Submit a list of special test equipment required to prove that all components of the system are functioning per specification.

3.4 ACCEPTANCE

A. Final acceptance shall be withheld until the successful completion of the following:

1. Acceptance of all submittals
2. Delivery of manuals and training material
3. Delivery of as built / installed drawings
4. Proper spare parts inventory
5. Camera aiming verification
6. Passing System Test
7. Successful Training
8. Successful demonstration of alarm interface operation

END OF SECTION 282300

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SECTION 283010 - FIRE DETECTION AND ALARM GENERAL

PART 1 - GENERAL

1.1 DESCRIPTION

A. Refer to the General and Supplementary Conditions and Division 01 for special requirements and conditions which apply to all Sections of Division 28.

B. These fire alarm and detection general provisions apply to the following:

1. Section 283100, Fire Alarm System.

C. This Section includes responsibilities and obligations in support of the performance verification in Section 283090, Fire Detection and Alarm Performance Verification..

1.2 QUALITY ASSURANCE

A. Conform to the following:

1. National Electrical Code-2014 with South Carolina Modifications-2016.
2. NFPA 72-2013.

B. Codes, standards and regulations referred to are minimum standards. Where the requirements of these specifications or drawings exceed those of the codes, standards and regulations, the drawings or specifications govern.

C. Adhesives and Sealants:

1. Adhesives, sealants, and sealant primers used inside the building (defined as inside the weatherproofing envelope and applied on site) shall comply with SCAQMD Rule 1168-2017 for volatile organic compound content limits.
2. Aerosol adhesives shall comply with GS 36-2013 for volatile organic compound content limits.

D. Paints and Coatings:

1. Anticorrosive and antirust paints applied to interior ferrous metal shall not exceed a volatile organic compound content limit of 250 g/L per GS 11-2015.

1.3 SPACE CONDITIONS

A. Drawings are diagrammatic in nature and, unless explicitly dimensioned, indicate appropriate locations of apparatus, equipment and raceways. Changes in the location, and offsets, of same to accommodate building conditions and coordination with the work of other trades, shall be made during the preparation of coordination drawings and prior to initial installation, without additional cost to the Owner.

B. Locations of motors, starters, equipment and apparatus as indicated on the Drawings are approximate; connections shall be made to such equipment as actually installed.

C. Provide access to equipment and apparatus requiring operation, service or maintenance throughout the life of the system.

D. Install fire alarm panels such that no piping, ductwork or mechanical equipment is installed in the space equal to the width and depth of the equipment from floor to structure above. In addition, fire alarm panels shall be installed such that the working space in front shall be a minimum depth of 42" horizontally, the width of the equipment or 30", whichever is greater, and the height of the equipment or 78", whichever is greater.

1.4 ENVIRONMENTAL AIR-HANDLING SPACES

A. Electrical power conductors installed in environmental air-handling spaces shall be approved for installation in plenum areas.

B. Communications, data, control, and signal cable not in conduit or enclosed wireways shall be approved for installation in plenum areas.

1.5 ASBESTOS MATERIALS

A. Materials containing asbestos or any trace of asbestos related materials shall not be used on this Project.

1.6 DEFINITIONS

A. Exposed raceways are those which can be seen when the base building and tenant fit-up is complete without opening or removing access doors or panels or accessible ceiling components.

B. Other raceways are considered to be concealed.

1.7 CONTINUITY OF EXISTING SERVICE AND SYSTEMS

A. Schedule work and provide temporary service and connections so existing systems will not be interrupted. when they are required for usage of the existing building. Obtain approval from the Owner and the Architect at least 7 days prior to any interruption or connection.

B. Perform work at such time and in such manner as to cause minimum inconvenience to the Owner and as approved by the Architect. No allowance will be made for lack of knowledge of existing conditions.

C. Submit a detailed description of the procedure proposed for making the cutover, including estimated outage time to the Owner.

1.8 RELATED WORK DESCRIBED IN OTHER DIVISIONS

A. Building automation system.

B. Cutting, coring, waterproofing, and patching of walls, floors, ceilings, roofs and structure of existing buildings.

C. Elevators.

D. Fire suppression systems.

E. Heating, ventilating and air conditioning systems.

F. Installation of access panels in wall and ceiling construction.

G. Kitchen and food serving equipment.

H. Painting, except as specified herein.

I. Power-operated doors.

J. Sprinkler waterflow and valve monitor switches.

K. Demolition, including removal of apparatus and equipment.

1.9 SUBMITTALS

A. Within 15 days after notice to proceed, submit a schedule indicating the proposed submission date of each submittal specified herein. Schedule shall anticipate the submittal review time, the possible need for resubmittals, and the time required for fabrication, shipping and integration into the construction sequence. Architect will advise of any conflicts in reviewing submittals that the proposed schedule presents.

B. Submittals shall be prepared in a line-by-line format corresponding to these Specifications and shall indicate compliance with each requirement specified herein and indicated in the Drawings.

1. In addition to any other transmittal or cover sheet used, fill out and attach to each individual submittal a copy of the Cover Sheet for Submittals to Newcomb & Boyd included at the end of this Section.
2. Indicate manufacturer's installation instructions.
3. Indicate deviations, if any, including any from the manufacturer's installation instructions.
4. Reproductions or electronic versions of design drawings shall not be used in the preparation of shop drawings.
5. Resubmittals that are required to address review comments shall include a cover transmittal with a written explanation of how each review comment has been addressed.
6. Submittals not specifically required, or not complying with the format requirements, will be returned unreviewed.
7. Shop drawings and submittals shall be provided in portable document format (PDF). PDF files containing multiple drawings or components shall include an index of the file contents and electronic bookmarks.

C. Submittals shall include the following:

1. Performance verification supervisor qualifications.
2. Fire alarm system.

3. Seismic restraint devices, including calculations, restraint selection, installation details and written confirmation that a licensed engineer prepared the calculations.

1.10 EQUIPMENT AND INSTALLATION REQUIREMENTS

A. Devices, equipment and materials, except as otherwise specified herein, shall be new and shall be of the customary standard and quality furnished by the designated manufacturer for that catalogue number.

B. Materials and equipment shall be UL listed, and shall bear the UL listing mark on products for which standards have been established and for which listing is regularly furnished by UL.

1. In lieu of the UL listing, or where standards have not been established by UL and UL listing is not regularly furnished, materials and equipment shall be listed by a laboratory recognized under the OSHA Nationally Recognized Testing Laboratory Program or by a laboratory accredited by International Accreditation Service. Examples include:

a. Canadian Standard Association.
b. ETL Testing Laboratories, Inc.
c. MET Electrical Testing Company, Inc.

PART 2 - PRODUCTS

2.1 SEISMIC RESTRAINTS

A. Seismic force design shall be determined in accordance with the following seismic design criteria:

1. Seismic Design Category: A. B. C. D. E. F.
2. Risk Category: I. II. III. IV.
3. Component Importance Factor, I_p: 1.5.

B. Provide restraint devices as required for fire detection and alarm components. Provide calculations to determine restraint loadings for specific equipment to be installed resulting from seismic forces on equipment. Seismic restraint calculations shall be signed by a licensed engineer in the employ of the seismic restraint device manufacturer.

C. For roof-mounted equipment and components the seismic acceleration load shall be calculated and utilized for the design of the seismic restraints.

D. Exceptions for fire detection and alarm components listed within the applicable project building code may be utilized. However, use of exceptions shall be noted with submitted seismic restraint calculations.

E. Suspended Restraints:

1. Restraints for nonvibration isolated suspended equipment, conduit, and raceways shall consist of steel angle or unistrut with anchor bolts and end connection fittings designed to swivel to the final installation angle.
2. Manufacturer: B-Line, International Seismic Application Technology, Kinetics Noise Control, Mason, Tolco, VMC Group, Vibration Eliminator, or Vibro-Acoustics.

2.2 CONCRETE

A. Normal weight concrete (145 pcf) using Type I Portland Cement, 1" maximum size coarse aggregate to provide a minimum 28 day compressive strength of 3000 psig.

2.3 GROUT

A. Nonshrink type, conforming to ASTM C1107/C1107M-2017 when tested at fluid consistency. Grout shall exhibit zero bleeding at every age when mixed to fluid consistency. Minimum 28 day compressive strength, when mixed to fluid consistency, shall be 7000 psig.

B. Manufacturer: Cormix, or Master Builders.

2.4 ACCESS PANELS - BUILDING

A. Refer to Section 083100, Access Door and Panel.

2.5 SLEEVES

A. Wall sleeves shall be galvanized rigid metal conduit or electrical metallic tubing.

B. For floor slabs above grade, plastic core form block-outs shall be used.

2.6 PENETRATION SEALS

A. Firestops:

1. Refer to Section 078400, Fire Stopping.

B. Expansion Seals:

1. Waterproof, modular, mechanical expansion type consisting of synthetic rubber grommets or interlocking links shaped to continuously fill the annular space between the penetrating item and the opening. Sizing of links and sleeve shall be determined by the manufacturer.
2. Manufacturer: Calpico Pipe Linx, Metraflex MetraSeal, or Thunderline Link Seal.

C. Seal Assemblies:

1. Seal assemblies shall consist of a frame, compression mechanism, and insert modules. Assemblies shall be waterproof and shall be designed to allow easy addition or deletion of penetrating items.
2. Seal assemblies for multicable penetrations of fire and smoke rated construction shall comply with the requirements of firestops as specified herein.
3. Manufacturer: Nelson Multi-Plug.

2.7 UNDERGROUND WARNING TAPE

A. Tape shall be acid- and alkali-resistant polyethylene film tape, 6" wide with minimum thickness of 0.004", specifically designed for marking and locating of underground utilities.

B. Tape shall be manufactured with integral wires, foil backing or other means to enable detection by metal detectors when the tape is buried up to 3' deep. The metallic core of the tape shall be encased in a protective jacket or provided with other means to protect it from corrosion.

C. Tape color shall be orange and shall bear a continuous printed inscription describing the specific utility.

D. Manufacturer: Brady, Boddingtons, Carlton Industries, Seton, or Thor Enterprises.

2.8 IDENTIFICATION MATERIALS

A. Conduit markers: self-adhesive vinyl tape, minimum 3 mil thick x 1.5" wide, color-coded orange unless otherwise indicated on the Drawings.

B. Tags: preprinted or partially preprinted accident prevention and operational tags, on plasticized card stock with matte finish for writing, approximately 3.25" x 5.625", with brass grommets and wire fasteners, and appropriate wording.

C. Signs: 14" x 10" size, 0.04" thick aluminum base with baked enamel finish for indoor or outdoor use.

D. Nameplates and Labels:

1. White core plastic laminate with engraved lettering.
2. Nameplate background color shall be black for normal power equipment and red for emergency power equipment.
3. Nameplates for individual devices shall have 0.25" high letters.
4. Nameplates for panels and equipment shall have 0.5" high letters.
5. Labels shall have minimum 0.25" high letters.

2.9 MISCELLANEOUS

A. Diagram framing system: 0.125" thick acrylic with satin finish aluminum frames.

2.10 PAINTING

A. Paint for high temperature equipment shall be high temperature-resistant, designed for the temperatures at which the equipment will operate.

PART 3 - EXECUTION

3.1 PROTECTION OF EQUIPMENT AND MATERIALS DURING CONSTRUCTION

A. Provide protective covers, skids, plugs or caps to protect equipment and materials from damage or deterioration during construction.

B. Store equipment and material under cover, and off the ground or floors exposed to rain.

C. For outdoor storage, protective covers of 10 mil thick black sheet plastic shall be fitted over equipment and materials. Covers shall be reinforced to withstand wind and precipitation. Set

equipment and material on skids or platforms of height to avoid damage or deterioration from spattering and ground water.

D. Provide dust and debris protection for devices and equipment operated during construction.

3.2 EXISTING EQUIPMENT AND SYSTEMS

A. General:

1. The existing installation shall remain as is except as otherwise indicated on the Drawings or specified herein. Perform work to tie in the new work with the existing work and to adapt the existing work to the changes in the building and systems.
2. Remove equipment, apparatus, and exposed wiring and raceways rendered useless due to changes.
3. Where existing ceilings are removed, remove electrical and signal apparatus mounted to the ceiling or ceiling supports, including associated raceways and wiring.
4. Existing devices and equipment which are removed and not reused in the new work shall be turned over to the Owner.
5. Material and equipment which has been removed and not accepted by the Owner shall become the property of the Contractor and shall be removed from the site.
6. Existing fire detection and alarm equipment removed and not reused shall be handled and disposed of in accordance with applicable state and federal regulations.
7. Material and equipment which has been removed shall not be used in the new work, except as specified herein.
8. Where existing raceways and equipment are indicated on the Drawings, size and location shall be verified prior to bidding.
9. Should the installation of new ductwork, piping or other equipment conflict with existing devices, shift the devices and make changes in the fire detection and alarm installation to remedy the conflicts, as approved by the Architect and at no extra cost.
10. Provide circuit continuity for existing wiring devices and equipment outside the renovation area served from or through the renovation area.

B. Wiring and Raceways:

1. Remove concealed wiring and raceways which are exposed by the removal of walls, partitions, and ceilings. Provide new concealed wiring and raceways to serve existing loads presently served by the removed wiring and raceways.
2. Sleeves left open by removal of conduit or raceways shall be cut flush with the finished slab, and filled with grout flush with both sides of slab.
3. Concealed raceways in masonry walls rendered useless by revisions shall be cut flush with wall surface and sealed with grout.

C. Mechanical Equipment:

1. Where existing mechanical equipment is removed, remove fire detection and alarm devices associated with the equipment.
2. Where existing mechanical equipment is modified or relocated, modify the fire detection and alarm connections to the equipment to adapt it to its new function or location.

3.3 EQUIPMENT AND INSTALLATION REQUIREMENTS

A. Cut and repair walls, floors and ceilings for the installation of the fire detection and alarm work.

B. Exterior building walls below grade shall not be pierced by hanger bolts.

C. Except where specific instructions are included herein, install and connect equipment in accordance with the manufacturers' instructions and recommendations.

D. Refer to manufacturer's or equipment supplier's shop drawings for exact type, number, location, dimensions and size of connections to equipment, including but not limited to:

1. Fire suppression equipment.
2. Heating, ventilating, and air conditioning equipment, including power supplies to automatic temperature control systems.
3. Vertical transportation equipment.

E. Coordinate the location of fire detection and alarm equipment in elevator machine rooms with the approved elevator machine room shop drawings.

3.4 SEISMIC RESTRAINTS

A. Restraints shall be installed after the equipment is mounted, connected, and operating to ensure that no contact occurs during normal equipment operation.

B. Installation of seismic restraints shall not cause any change of position of equipment, conduit, or raceways, resulting in stress and misalignment.

C. Do not brace a system to two different structures, such as a wall and a ceiling.

D. After installation, manufacturer shall verify that seismic restraints are installed and operating properly, and shall submit a certificate so stating.

3.5 ACCESS PANELS - BUILDING

A. Where fire detection and alarm work is concealed by walls or ceilings, or is inaccessible, provide an access panel to provide access for service and maintenance.

B. Fire detection and alarm work located above ceilings is considered accessible if the ceiling is the accessible type and is arranged for access to the equipment.

C. Fire rated access panels shall be provided in fire barriers, with ratings to match the construction fire rating.

D. Access doors providing access to equipment access doors shall allow for service and maintenance of the intended equipment.

E. Installation of access panels is specified under another Division.

3.6 SLEEVES

A. Provide where conduits pass through elevated floor slabs if conduits are not a part of the slab pour, and for future cable or conduit risers.

1. Install in raised foundations at least 2" high.

B. Provide where communications and other cables, not installed in conduits, pass through walls and elevated floor slabs.

C. Wall sleeves shall extend 4" from each side of the wall.

D. Sleeves shall be secured in place. Provide insulating bushings on both sides of sleeves for cables.

E. Provide ground bushings on both sides of sleeves containing ground conductors.

3.7 PENETRATION SEALS

A. General:

1. Install in accordance with the manufacturer's published instructions to achieve ratings and classifications specified herein. A copy of these instructions shall be maintained and available on site.

B. Expansion Seals:

1. Install to seal single conduit or cable penetrations of walls below grade.

C. Seal Assemblies:

1. Install to seal the penetration of walls below grade by multiple cables in the same opening.

3.8 PAINTING

A. Except where otherwise specified herein, painting shall be done under another Division. Surfaces shall be left clean and free from oil.

B. Equipment factory finishes damaged or deteriorated during construction shall be repaired to match original finish.

C. Where galvanizing is broken during fabrication or installation, recoat exposed areas with zinc-rich paint.

D. Exterior ferrous equipment and supports shall be painted 2 coats of rust preventive paint, color selected by the Architect.

E. Exposed interior ferrous equipment, and exposed nongalvanized ferrous accessories and metal shall be prepared and painted 1 coat of corrosion resisting paint prior to other painting or identification, or 2 coats of corrosion resisting paints if no other painting is specified herein.

3.9 EXCAVATION AND BACKFILLING

A. Determine exact location of existing underground utilities before excavation.

B. Excavation shall be no longer or deeper than necessary. Backfill material shall be free from rocks and debris.

C. Compact backfill as the excavation is filled.

D. Excavation, shoring, bracing, backfilling, and compaction, cutting and patching of hardscape, and restoration of landscape shall conform to Division 31, Earthwork.

3.10 COORDINATION

A. Provide offsets, transitions, and fittings to coordinate the work of each trade with that of other trades, including HVAC, plumbing, fire suppression, electrical, communications, structural, and architectural.

3.11 UNDERGROUND WARNING TAPE

A. During backfilling, install tape continuously at 6" to 8" below finished grade, above buried power, communications, or signal cables and conduits.

B. Install multiple markers where cables are installed in groups exceeding 16" width.

3.12 CLEANING

A. Equipment and Equipment Rooms:

1. Remove dust, dirt, rust, stains, and temporary covers.
2. Foreign matter shall be blown, vacuumed, flushed, or cleaned out of and from equipment, raceways, devices, controls and panels.
3. Clean and polish identification plates.
4. In equipment rooms, clean equipment, conduit, and room surfaces from dust and dirt and maintain in a clean condition from date of substantial completion the until final completion of work and corrective work.
5. Remove excess material from Project site.

3.13 IDENTIFICATION

A. General:

1. Identification shall consist of upper case letters.
2. Where identification is applied to surfaces which require a finish, identification shall be installed after surface has been finished.

B. Conduit Markers:

1. Install on conduits and raceways exposed or above ceilings at connections to junction boxes, pull boxes, equipment, each side of wall, floor, and roof penetrations, and at 50' intervals along straight runs.
2. On parallel conduits (grouped), markers shall be placed on each conduit in line with each other. Markers shall be positioned in such a manner as to ensure visibility.

C. Box Color-Coding:

1. Paint connectors, couplings, bushings, hubs, entire conduit within 6" of a box, and panel backboxes red.

D. Cable identification: install cable identification on each communication or signal cable.

E. Danger signs: install in areas constituting a danger for persons in or about the Project.

F. Install a nameplate on the fire alarm panel to indicate the panel and circuit number supplying the fire alarm system.

3.14 OPERATION AND MAINTENANCE DOCUMENTATION PACKAGE

A. These operation and maintenance manual requirements supplement operation and maintenance manual documentation requirements of other Sections of these specifications.

B. Operation and maintenance documentation, in hardback 3-ring loose-leaf binders except full size drawings and CDs, shall cover the fire detection and alarm systems. Documentation shall include the following: operation and maintenance documentation directory; emergency information; operation manual; maintenance manual; test reports; and construction documents.

C. The operation and maintenance documentation package shall be submitted as one comprehensive package to the Owner 3 months before systems start-up, and shall be updated, revised and completed at completion of construction.

D. Documentation shall be typewritten and shall contain, at a minimum, the following information.

1. Introduction:

a. Project name, contractors' and subcontractors' names, addresses, and telephone and facsimile numbers.

b. Index.

2. Operation and Maintenance Documentation Directory:

a. Explanation of the identification system used, including lists of systems, equipment and component identifiers and names.

3. Emergency Information:

a. Information for technical and nontechnical personnel about actions recommended during emergency situations to protect life and property and to minimize disruption to the building occupants. Emergencies shall, at a minimum, include:

1) Fire.
2) Security breach.
3) Power failure.
4) Emergency power system failure.

4. Operation Manual:

a. General Information:

1) Building function.
2) Building description.
3) Operating standards and logs.

b. Technical Information:

1) System description.
2) Operating routines and procedures.
3) Routine operational testing program and procedures.
4) Special procedures.
5) Basic troubleshooting.

5. Maintenance Manual:

a. Descriptions (specifications) of the equipment and components.
b. Description of function, as applicable: the function of the equipment, procedures before start-up, functional parameters (input, output) at the design load and at part loads, and performance verification procedures.
c. Recommended maintenance procedures and their recommended frequency for this Project.
d. Name, address and contact of at least one qualified service company.
e. Recommended list of spare parts, part numbers, and the place(s) from which they can be obtained.
f. Original purchase order number; date of purchase; name, address, and the telephone number of the vendor; and warranty information.
g. Installation information.
h. Any other information needed for the preparation of documents supporting the management of operation and maintenance programs.

6. Test Reports and Certifications:

a. Copies of tests and certifications performed during manufacture and construction including, but not limited to, the following:

1) Certification of fire alarm system operation.
2) Certification of seismic restraints.
3) Receipt of O&M documentation package.
4) Receipt for instruction of operating personnel.
5) Fire alarm system test report.

7. Construction Documents:

a. Record drawings.
b. Approved submittals, including revised shop drawings indicating field and as-installed conditions.
c. Equipment identification charts and schedules.
d. Warranty certificates.
e. Inspection certificates.
f. Performance verification report.

E. Submit a receipt signed by the Owner acknowledging receipt of the operation and maintenance documentation package.

F. Provide metal cabinets mounted on the wall adjacent to system control unit to house the operation and maintenance documentation package. Cabinets shall be approximately 12" wide x 18" high x 6" deep constructed of 18 gauge sheet metal with hinged door with latch. Cabinets shall be painted red and shall be labeled with 0.5" stenciled letters.

3.15 RECORD DRAWINGS

A. Refer to Section _____, _____.

B. A record of field and as-installed conditions shall be maintained at the site, shall be kept current throughout the Projects, and shall be used in the preparation of the final record drawings. Field and as-installed conditions shall be recorded on design drawings and shall be marked to include indicate addenda, change orders, field changes and selections made during construction.

C. Upon completion of the Project, submit marked-up design drawings indicating field and as-installed conditions, and shop drawings incorporating changes made during construction for wiring and equipment. Submit the following.

1. _____ sets of bound prints.
2. Full size PDFs on CDs.

3.16 MAINTENANCE

A. Equipment operated prior to the date of substantial completion shall be maintained in accordance with manufacturers' recommendations.

3.17 INSTRUCTION OF OPERATING PERSONNEL

A. Conduct formal instruction sessions for operating personnel. Conduct two similar sessions. The first session shall be conducted at the time of start-up and check-out, and the second session shall be approximately 2 months later. Sessions shall be a minimum of 2 days duration for basic electrical systems, and as specified herein for other systems and equipment. Sessions shall be conducted at the site.

B. Prepare and submit a syllabus describing an overview of the program, describing how the program will be conducted, when and where meetings are to be held, names and company affiliations of lecturers, description of contents and outline for each lecture, and recommended reference material and outside reading. Obtain direction from the Owner on which operating personnel shall be instructed in each system. Proposed training schedules, materials, and lesson plans shall be submitted to the Owner for review.

C. Sessions shall include:

1. General familiarization and operating procedures for the entire fire detection and alarm installation.
2. Routine maintenance procedures for equipment.

D. Factory-trained technicians shall give operating and maintenance instructions on the following systems and equipment:

System/Equipment	Minimum Session Duration, hours
Fire alarm system	8

E. Provide DVD format video recordings of training sessions and a complete record copy of all training materials, handouts, and other printed materials used in each training session.

F. Training shall occur after testing is complete, unless approved otherwise by the Architect.

G. Obtain receipt acknowledging completion of each item of instruction.

END OF SECTION 283010

COVER SHEET FOR

SUBMITTALS TO NEWCOMB & BOYD

Project: _____ Date: _____

Item: _____ Submittal Number: _____

Manufacturer: _____ Model: _____

Specification Paragraph and/or Drawing Number: _____

Capacity: _____

Electrical Characteristics (including identification of all separate connections or services required): _____

_____

_____

_____

Accessories: _____

_____

_____

_____

Options: _____

_____

_____

_____

Deviations (if any; if none, state so): _____

_____

General Contractor Approval: _____

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SECTION 285100 – EMERGENCY CALL STATION SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Related Sections:
   1. Division 27 – Premise Distribution System

C. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.

1.2 SUMMARY

A. This contract requires extension of an existing Emergency Call Station System (ECSS). The ECSS components are specified here to be compatible with the existing system. This contract includes purchasing compatible ECSS equipment. Operating features of hardware and software specified in this section are intended to limit the ECSS components to compatible Gai-Tronics equipment.

B. Section includes the provision of emergency call stations consisting of a weather-proof, vandal-resistant emergency call station with an integral or remote blue light/strobe. The call stations shall be ADA-compliant, externally powered two-way (duplex) communication device.

C. The programming, testing, Owner training and documentation of the Emergency Call Station System (ECSS) as specified herein are part of this contract. All costs associated with programming, testing, training and documentation of the system shall be included in the contract.

1.3 INTEGRATION

A. The ECSS shall operate over an existing ShoreTel Voice Over Internet Protocol (VoIP) telephone system. Analog speakerphones shall be connected to a VoIP Gateway provided by the Airport. Contractor shall coordinate connection of the analog station to the VoIP Gateway with Airport IT Department.

1.4 SUBMITTALS

A. Informational Data: The successful bidder shall submit the following documents a minimum of ten (10) Days prior to the Pre-Construction Conference:
   1. Proposed Construction Schedule in accordance with Construction Progress Documentation.
   2. Installer Certifications on manufacturer’s letterhead indicating that installer complies with the manufacturer’s requirements necessary to install the equipment specific to this project.

B. Product data sheets

1. On data sheets that illustrate multiple models, the particular model proposed for the application shall be encircled or underlined. Individual copies shall be included for each proposed model number indicating areas of application.
2. Deviations from Specifications shall be encircled or underlined on the documents and be marked as deviations.

C. Shop Drawings: No later than fourteen (14) days after the Pre-Construction conference, the successful bidder shall provide Shop Drawings showing equipment quantities, locations, types and arrangements including but not limited to:
1. Dimensions
2. Product identification
3. Fabrication and installation Drawings
4. Rough-in diagrams
5. Wiring diagrams showing field-installed wiring
6. Design calculations and methods

D. Test Plan: The successful bidder shall submit for review and approval, by the Engineer or the District's representative a test plan no later than fourteen (14) days prior to anticipated substantial completion. The test plan shall detail test procedures and test reports that indicate testing methods, testing device calibration, and interpretations of test results for Field Acceptance Tests. The test plan shall detail the objectives of all tests. The tests shall clearly demonstrate that the ECSS system and its components fully comply with the requirements specified herein.

E. Training: Contractor shall provide training for the updates and additions to the existing ECSS and management software.

1.5 QUALITY ASSURANCE

A. Code compliance: Comply with NEC and municipal codes as applicable to construction and installation of ECSS equipment and signal distributions systems. When there is a conflict between codes, the more stringent will apply.

1.6 INTELLECTUAL PROPERTY

A. Patents: Should patented articles, methods, materials apparatus, etc., be used in this Work, the Contractor shall acquire the right to use it. The Contractor shall hold the District and its agents harmless for any delay, action, suit, or cost growing out of the patent rights for any device on this Project.

B. Copyrights: Should copyrighted software be used in this Work, the Contractor shall acquire the right to use it. The Contractor shall hold the District and its agents harmless for any delay, action, suit, or cost growing out of the copyrights for any software on this Project.

C. License to Use: All software required for the complete operation of the system as specified herein shall be delivered with either full ownership transferred to the District or a License to use at this site, including the right to make backup copies.

1.7 RADIO/TELEVISION INTERFERENCE

A. FCC Compliance: All equipment that uses radio frequency energy shall be certified to comply with Subpart J of Part 15 of Federal Communication Commission rules CFR 47 as those rules define a class “B” computing device.

B. Expected RF Environment: This ECSS system is to be installed in an area that is subject to background RF levels expected in such an area. It is the Contractor’s responsibility to protect the systems specified here from interference by other systems, and through FCC compliance listed above, to prevent interference with other systems. All costs for any RF mitigation shall be included in the cost of this proposal.

1.8 WARRANTY

A. Period: The Contractor shall guarantee all labor, workmanship, and materials for a period of one (1) year from the date of final acceptance. Should a failure to the system occur within this first year, the Contractor shall provide all labor and materials necessary to restore the system to the condition required for the final test and acceptance for this contract, at no cost to the District.

B. During the warranty period, all periodic and routine maintenance of the installed components to maintain the factory warranty shall be provided at no additional cost under this contract.

C. Tie-ins: During the warranty period, components may be connected/disconnected from the system as applicable. New devices will be connected in a similar manner as shown on the drawings for this contract by a qualified company and the existence of the new connections shall not void the system warranty on the original system.

1.9 FUNCTIONAL OPERATION

A. General: basic functionality of the ECSS shall provide for calls to be initiated by pressing an activation button. The activation button shall always override all other operations to automatically dial the pre-programmed number immediately. When the call is connected, communication shall be hands-free, speakerphone operation. The phone shall be compliant to the Americans with Disabilities Act (ADA).

B. Communication: call stations shall direct-dial the Airport Operations Center once the button is activated.

C. Call Placed Indicator: a visual LED indicator the speakerphone faceplate shall flash after the activation button is pressed to indicate that the call is being connected. The LED indicator lights steady when the audio is detected to provide positive confirmation that the connection is complete.

D. Caller Identification: call stations shall be capable of being programmed to provide basic location information through a caller identification text or script. Provide any additional software as required to provide caller identification features.

E. Management Software:
1. Existing management software shall be updated for all call stations installed under this project. The purpose of management software is to provide call history and reporting,

system monitoring, troubleshooting and the ability to run self-tests. The following features shall be provided at a minimum:

a. Automatic polling of hardline connected speakerphones.
b. Monitor and report status, health and activity of speakerphones.
c. Report speakerphone faults, line faults, etc.
d. Capable of sending an email when faults arise.
e. Capable of generating reports of all call logs, faults, etc.
f. Software shall support analog and VoIP speakerphones.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. GAI-Tronics

B. No Equal

2.2 SPEAKERPHONE UNITS

A. General Description:
1. The unit shall be an outdoor-rated, vandal-resistant, ADA-compliant, full duplex, analog speakerphone and intercom. It shall have user programming capabilities, auxiliary functions, fault monitoring and reporting.
2. The unit shall be programmable from a remote location and have a two number dialing capability per button, reverting to the second number if the first is busy or does not respond. The unit shall be totally hands-free on both sides after connection is initiated at site or by attendant.

B. Construction:
1. The faceplate or enclosure shall be constructed of cast-aluminum or stainless steel with custom-designed, vandal-resistant microphone and speakerphone openings. All openings shall be screened and weather-proof. Weather-proof, rubber gaskets shall be provided where faceplates or enclosures are mated together.
2. A weatherproof speakerphone shall be integral to the faceplate or enclosure.
3. Weather-proof buttons that are self-monitoring shall be flush mounted in the faceplate bezel. A single black button shall be provided for each unit and shall be labeled "HELP" or "PUSH FOR HELP". A light emitting diode (LED) shall be provided that will inform the caller that the call has been placed and received.
4. ADA Compliant faceplate with equivalent Braille lettering and call placed/received labels.
5. Non-volatile memory: if the unit is required to retain programming data then all data shall be retained during a power loss.
6. Input/Outputs: provide a minimum of two (2) normally open (NO) and two (2) normally closed (NC) outputs for future control/interface to auxiliary systems.
7. Enclosure and faceplate shall meet NEMA 3R rating.
8. Operational Temperature Range: -4 deg F (-20 deg C) to 150 deg F (65 deg C)
9. Power: 120VAC Power: Provide transformers/power supplies as required to provide proper supply voltage.
10. UL Listed
11. Provide Gai-Tronics Model #397-001, no equal.

2.3 FREE-STANDING STANCHION/PEDESTAL WITH INTEGRAL BLUE LIGHT

A. Provide an ADA compliant, free standing stanchion/pedestal mount constructed of highly vandal-resistant steel, with a LED blue light and lighted faceplate. The tower shall house an ADA-compliant speakerphone as specified above. The LED blue light shall be continuously lit and shall flash for the duration of a call when emergency button is pressed on the communication device.

B. Construction: steel with multi-coat rust inhibitive coating.

C. Coating: High-gloss, multi-layer, corrosion-inhibitive system with resistance to UV-fade and graffiti protection.

D. Colors: Enclosure shall be painted a custom color as determined by the District.

E. Signage: 3" high reflective "EMERGENCY" lettering with wide-angle visibility is standard. Verify exact wording with the District prior to ordering.

F. Lighting:
1. LED Blue Light: see Blue Light section of this specification.
2. LED Panel Light: Ultra bright LEDs, 50,000 hour lifetime

G. Communication: communication for these units shall be interfaced to the existing ShoreTel VoIP telephone system in place at the Airport. Due to cabling distance from the units to the nearest network switch, a Category 6 cable shall be provided from the speakerphone unit to the Network Equipment Cabinet where it will be connected to a VoIP Gateway provided by the Airport. Contractor shall coordinate connection of the analog station to the VoIP Gateway with Airport IT Department.

H. Power: Power: 120VAC for both LED blue light and panel light. Power supplies/transformers shall be housed in same wall mount enclosure as call station, separate enclosure for transformer/power supply shall not be allowed.

I. Mounting: stanchion/pedestal shall be mounted to a concrete foundation. Contractor shall provide concrete base and mounting equipment as required.

J. UL Listed

K. Provide Gai-Tronics Model 234-500CAM, no equal.

2.4 BLUE LIGHT

A. General Description:
1. Blue light strobes shall be placed at all call stations. Call stations located in surface parking lots shall be provided with a remote blue light that is extended above the speakerphone unit to allow the light to be seen above larger vehicles. Call stations located in parking garages and stanchion/pedestal enclosures shall have a blue light that is integral with the call station and speakerphone enclosure.
2. Blue lights shall be designed with a combined constant-on and flashing operation. The constant-on operation will occur when external power is applied. The strobe shall connect to a control output of the speakerphone that will initiate the flashing operation when the

telephone is active. The flash shall remain active until the call is ended at which time the strobe shall return to a constant-on state.

B. Construction:
1. Light Source: LED strobe, 209 lumens peak, min.
2. Life Expectancy: 100,000 hours, min.
3. NEMA 3R rated.
4. Power: input power shall be routed directly to the strobe and not through the controlling speakerphone. Power for the strobe shall be provided from the same external source powering the speakerphone.
5. Input/Output: provide a minimum of one (1) dry contact closure output for interface to auxiliary systems.

2.5 VOIP INTERFACE

A. Analog speakerphones shall be connected to a VoIP Gateway that will be furnished by the Airport and installed by the Contractor. Contractor shall coordinate installation and connection of speakerphones with Airport IT Department.

2.6 RACEWAYS, FITTINGS AND BOXES

A. General Description:
1. All communication and power cabling for this project shall be installed in conduits. Exposed or open cabling is not permitted. Communication and power cabling shall not share the same conduit or pull box.

2.7 CONDUCTORS AND CABLES

A. Communication Cabling:
1. Reference specification 271300 Premise Distribution System for cabling specifications.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Manufacturer’s Instructions: Install ECSS in accordance with equipment manufacturer’s written instructions and complying with applicable portions of the National Electrical Code.

B. Grounding: All pair shields shall be grounded at one point only. Cables that originate from equipment in IDF Rooms and serve field devices shall be grounded to the signal ground terminal in the IDF.

C. Protection: Contractor shall provide protection as required of installed devices to prevent damage until final testing and acceptance. Installed equipment, devices, cabling, etc. that is damaged during the construction process and before final acceptance by the District shall be replaced by the Contractor at no cost to the District.

3.2 OPERATION AND MAINTENANCE MANUAL

A. Intent: The intent of this section is to require complete documentation of the ECSS System for the purpose of system operation and maintenance during and after the warranty period. It is intended that the operation and maintenance manuals be exhaustive in the coverage of the system to the extent that they may be used as the sole guide to the troubleshooting, identification and repair of defective parts.

B. Scope: The Contractor shall provide three (3) complete maintenance and operation manuals on the completed system in a bound, 3-ring binder. In addition to the bound, hardcopy set, provide an electronic copy on USB drive. These manuals shall include basic wiring diagrams, schematics, and functional details such that going to the actual equipment and making reference to this manual may easily identify any component, wire, or piece of equipment in the system. It is required that everything in the system be neatly labeled and easily identifiable. Every terminal, wire, cable, component, or piece of equipment, and other such items shall have a number or letter designation. All of these identification characteristics shall be included in the maintenance and operation manuals.

C. The maintenance manual requirement of this section is in addition to shop drawing requirements. Maintenance manuals and drawing sets shall be compiled after system fabrication and testing, and shall incorporate any changes made after shop drawing submittal. The maintenance manuals and drawing books shall be permanently bound in hard plastic covers.
   1. Maintenance Manuals, Manufacturer's Literature: Provide manufacturer's standard literature, covering all equipment included in the system. The maintenance manuals shall contain specifications, adjustment procedures, circuit schematics, component location diagrams, and replacement parts identification. All references to equipment not supplied on this project shall be crossed out.

D. Drawing Books: This documentation is intended to be the system specific supplement to the maintenance manual.
   1. All drawings developed specifically for this project shall be reduced to 11" X 17", folded, and bound with hard plastic covers. Provide component identification and cross reference on the drawings to allow technicians who follow to understand the function of each item (the block diagram) how it is wired (wiring diagrams), and its detailed specifications (vendor data sheets), and how to repair it (spare part lists). Include the following drawings as a minimum:

      a. Functional Block Diagram: Provide an overall block diagrams showing the major interconnections between subsystems components.
      b. Arrangement Drawings: Provide drawings showing the physical arrangement of all major system components.
      c. Wiring Diagrams: Provide wiring diagrams showing all interconnecting wiring. Wire identification on the diagrams shall agree with the wire markers installed on the equipment.

3.3 TESTING

A. The Contractor shall develop and submit for review by the District and Engineer a system test plan no later than fourteen (14) days prior to anticipated substantial completion. The test plan shall detail test procedures and test reports that indicate testing methods, testing device calibration, and interpretations of test results for Final Acceptance Tests. The test plan shall detail

the objectives of all tests. The tests shall clearly demonstrate that the ECSS system and its components (hardware and software) fully comply with the requirements specified herein.

3.4 ACCEPTANCE

A. Final acceptance shall be withheld until the successful completion of the following:
   1. Acceptance of all submittals
   2. Delivery of manuals and training material
   3. Delivery of as-built / installed drawings
   4. Passing System Test
   5. Successful Training

END OF SECTION 285100

SECTION 31 20 00 - EARTH MOVING

PART 1 - GENERAL

1.1 SUMMARY

A. This section covers all work associated with stripping, subgrade preparation, filling, backfilling, compaction and disposition of surplus soil materials.

1.2 DEFINITIONS

A. Subgrade: Existing, in-situ soil or other material that is remaining after stripping or excavation. The subgrade is always existing material on which fill or new structures are to be placed.

B. Excavation: The removal of soil or material to obtain a specified depth or elevation, including pavements and other obstructions visible on the ground surface, underground structures and utilities indicated to be demolished and removed, and unsuitable subgrade material.

C. Borrow: Material that must be transported to the site. A material that must be developed by others and transported to the site. Not available on site.

D. Fill: Soil or material placed above the subgrade to the point of new construction such as a sub-base, base course, pavement, foundation, footing, or building component.

E. Backfill: Fill material used in refilling a cut, trench or other excavation.

F. Lift: A layer or course of material placed on top of a previously prepared or placed material.

G. Rock: Solid, homogeneous interlocking crystalline material with firmly cemented, laminated or foliated masses or conglomerate deposits, neither of which can be removed without systematic drilling and blasting, drilling and the use of expansion jacks or feather wedges, or the use of backhoe mounted pneumatic hole punchers or rock breakers; also large boulders, buried masonry, or concrete other than pavement, exceeding 25 cubic yards in volume. Removal of hard material will not be considered rock excavation because of intermittent drilling and blasting that is performed merely to increase production.

H. Topsoil: In natural or undisturbed soil formations, the fine grained, weathered material on the surface or directly below any loose or partially decomposed organic matter. Topsoil may be dark-colored, fine, silty or

sandy material with a high content of well decomposed organic matter, often containing traces of the parent rock material. The material shall be representative of productive soils in the vicinity.

I. Unsuitable Material: Existing, in situ soil or other material which can be identified as having insufficient strength characteristics or stability to carry intended loads in fill or embankment without excessive consolidation or loss of stability. Materials classified as PT, OH, or OL by ASTM D 2487 are unsuitable. Unsuitable materials also include man-made fills, refuse, frozen material, uncompacted backfills from previous construction, unsound rock or soil lenses, or other deleterious or objectionable material.

J. Granular Material: Soils classified as GW, GP, SW or SP by ASTM D 2487. Materials classified as GM and SM will be identified as granular only when fines have a plasticity index of zero.

K. Compaction: The process of mechanically stabilizing a material by increasing its density at a controlled moisture condition. "Degree of Compaction" is expressed as a percentage of the maximum density obtained by the test procedure described in ASTM D 1557 for general soil types or ASTM D 4253 or ASTM D 4254 for isolated cohesionless materials, abbreviated in this specification as "__ percent maximum density."

1.3 SUBMITTALS

A. Plans

1. Dewatering Plan: Describe methods for removing collected water from open trenches and diverting surface water or piped flow away from work area. Describe equipment and procedures for installing and operating the dewatering system indicated. Describe the basic components of the dewatering system proposed for use and its planned method of operation. Record performance and effectiveness of method or system in use. The dewatering plan shall address, as a minimum, the requirements identified in the paragraph titled "Drainage and Dewatering"

2. Shoring and Sheeting Plan: Describe the materials of the shoring system to be used. Indicate whether or not components will remain after filling or backfilling. Provide plans, sketches, or details along with calculations by a professional engineer. Indicate sequence and method of installation and removal.

B. Certifications

1. Independent Laboratory

2. Material Certifications: Provide manufacturer or supplier certification of compliance indicating conformance to this specification or the referenced standard(s) for the following:

    a. Topsoil
    b. Gravel
    c. Sand

C. Laboratory Testing: Submit testing data as identified in the paragraph titled "Laboratory Testing" for any of the following materials to be used on the project. Obtain approval before any material is delivered to the site.

1. Subgrade
2. Common fill
3. Controlled fill
4. Granular fill

D. Field Testing: Submit field testing data as identified in the paragraph titled "Field Testing" for the following:

1. Subgrade compaction & density
2. Excavation compaction & density
3. Fill/backfill compaction & density

1.4 DELIVERY, STORAGE AND HANDLING

A. Deliver and store materials in a manner to prevent contamination or segregation. Do not stockpile materials in a manner or location that will cause excessive wetting or transporting of materials off-site or into storm drainage collection systems.

1.5 REGULATORY REQUIREMENTS

A. Materials and workmanship specified herein with reference to SC DOT State Standards shall be in accordance with the referenced article or section of the standard except that contractual and payment provisions do not apply. Where the term "State" is used, it shall mean "Owner."

B. Comply with federal, state, and local regulations.

C. Comply with the requirements of the land disturbance permit and approved plans issued for this project by South Carolina Department of Health and Environmental Control (SCDHEC) and/or the MS4.

1.6 CRITERIA FOR BIDDING

A. The items listed in the proposal shall be considered as sufficient to complete the work in accordance with the plans and specifications. Any portion of the

work not specifically listed in the bid form shall be deemed a part of the item with which is it associated and shall be included in the lump sum price. The price shall be full compensation for the removing and replacing of topsoil and all excavating, filling, transporting of material, compaction, shaping, finishing, dressing, disposal of surplus material, testing, staking, construction supervision and all other work required for satisfactory completion of the grading operation. The building pad shall include all areas to 10' outside the building wall and the area under all footings including trench walls and bottom. Also included in this price shall be that necessary to complete the grubbing and root raking operation as required by this section and elsewhere. Base bids on the following criteria:

1. Surface elevations as indicated.
2. No pipes or other man-made structures other those indicated will be encountered. The utility locations shown are based on available information and are approximate and shall be field verified prior to beginning any work.
3. The character of the material to be excavated or used for subgrade is as indicated.
4. Ground water elevations indicated are those existing at the time of subsurface investigations and do not necessarily represent ground water elevation at the time of construction.
5. Borrow material in the quantities required are not available on site and must be developed and obtained by the Contractor.

B. Unit Prices

Payment for the unit shown on the bid form shall be considered to cover the cost of all labor, material, equipment, testing, and performing all operations necessary to complete the work in place. Payment shall be made based upon the actual quantity multiplied by the unit prices. Measurement will be made by means acceptable to the Owner and the Engineer. Direction to perform work must be given by the Owner and the Engineer.
Unit price shall be full compensation for all material, staking, cross sectioning, digging, hauling, spreading and compacting at the site. Material is to be paid for in its final position after placement or compaction by means acceptable to the Owner or Engineer.

1. Unsuitable Material Removal and Replacement with Controlled Fill: The Contractor shall include in the total project cost an assumed quantity for 1,500 CY of removal of unsuitable material and replacement with controlled fill.

1.7 QUALITY ASSURANCE

A. Materials: The Contractor will furnish the Engineer and Owner a description of all materials before ordering. The Engineer will review the Contractor's

submittals and provide in writing an acceptance or rejection of material.

B. Manufacturer: Material and equipment shall be the standard products of a manufacturer who has manufactured them for a minimum of 2 years and who provides published data on the quality and performance of the projects.

C. Subcontractor: A subcontractor for any part of the work must have experience on similar work. At the option of the Engineer, a list of projects and the Owners or Engineers who are familiar with his competence may be required to be submitted to verify experience.

D. Design: Devices, equipment, structures, and systems not designed by the Engineer that the Contractor wishes to furnish shall be designed by either a registered professional engineer or by someone the Engineer accepts as qualified. Complete design calculations and assumptions shall be furnished to the Engineer or Owner before acceptance.

E. Testing Agencies: Mill certificates of tests on materials made by the manufacturers will be accepted provided the manufacturer maintains an adequate testing laboratory, makes regularly scheduled tests that are spot checked by an outside laboratory, and furnishes satisfactory certificates with the name of the one making the test. Agencies to be used shall be submitted to the Engineer for review prior to engagement.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. Provide materials free from debris, roots, wood, scrap materials, vegetable matter, refuse or frozen material. Maximum particle size permitted is 3 inches. Use excavated material from the site for the work indicated when material falls within the requirements specified herein. When materials available on site do not meet the quantity required nor the requirements specified herein, the Contractor shall obtain borrow materials from off-site.

1. Common Fill: Provide a soil material from the site or borrow that can be readily compacted to the specified densities. Materials shall be unclassified. Soft, spongy, highly plastic, or otherwise unsuitable material is prohibited. Material shall be unclassified but shall contain sufficient fines to ensure proper compaction.
2. Controlled Fill: Provide materials classified as GW, GP, GC, SW, SP, SM or SC by ASTM D 2487 where indicated. Not more than 15 percent by weight shall be finer than the No. 200 sieve when tested in accordance with ASTM D 1140. The minimum dry density shall be 100 PCF when tested in accordance with ASTM D 1557.
3. Granular Fill: A dense, well graded aggregate mixture of sand, gravel

or crushed stone mixed individually, in combination with each other, or with suitable binder soil. Granular fill may also consist of poorly graded sands or gravels.

4. Gravel: Clean, coarsely graded natural gravel, crushed stone or a combination thereof classified as GW or GP in accordance with ASTM D 2487 as indicated. The maximum particle size shall not exceed 3 inches
5. Sand: Clean, coarse-grained sand classified as SW or SP by ASTM D 2487 as indicated.
6. Topsoil: Salvaged topsoil form stockpile created during stripping operations. Add necessary soil modifiers to bring material within the ranges specified in Table 1 Furnish additional topsoil meeting the requirements in Table 1 if stockpiled material is insufficient to complete the work indicated.
7. Soil materials shall be free of subsoil, stumps, roots larger than ¾ inch in diameter (with maximum 3 percent retained on the ¼ inch sieve, brush, weeds, toxic substances, and other material or substance detrimental to plant growth.

TABLE 1

DOA SSIR Soil Survey Investigation Report No. 1, Laboratory Test for	Acceptable Limits
Sand Content	20 - 45 percent by weight
Silty Content	25 - 50 percent by weight
Clay Content	10 - 30 percent by weight
Organic Material (Walkley-Block)	5 percent
Ph	5.0 to 7.6
Soluble Salts	600 ppm maximum
Absorption Rate	0.5 inch per hour minimum

2.2 GEOTEXTILE FABRICS

A. Filter Fabric

1. Provide a pervious sheet of polyester, nylon, glass or polypropylene, ultraviolet resistant filaments woven, spun bonded, fused, or otherwise manufactured into a nonraveling fabric with uniform thickness and strength. Fabric shall have the following manufacturer certified minimum average roll properties as determined by SCDOT Specification 804:

TABLE 2: S t r e n g t h Property Requirements

Property	Class 1 Fabric Protected*	Class 2 Fabric Unprotected

Grab Strength ASTM D 4632	90 lbs	200 lbs
Seam Strength ASTM D 4632**	80 lbs	180 lbs
Puncture Strength ASTM D 4833	40 lbs	80 lbs.
Burst Strength ASTM D 3786	140 psi	250 psi
Trapezoidal Tear Strength ASTM D	40 lbs	80 lbs
Elongation at failure ASTM D 4632	40 lbs	80 lbs
Ultraviolet Degradation at 500 HoursASTM D 4355	50% Strength Retained	50% Strength Retained
*Fabric is protected when cushioned from rock placement by a sufficient layer of sand or gravel at least 6 inches thick or by zero height of placement. All other conditions are unprotected. **Values apply to both field and manufactured seams. Sew seams upwards for inspection.		

PART 3 - EXECUTION

3.1 STRIPPING

A. Perform tree removal operations as specified in Section "SITE CLEARING".

B. Strip topsoil from the site where excavation or grading is indicated and stockpile separately from other excavated material. Material unsuitable for use as topsoil may be used for common fill provided that those requirements are met. Locate topsoil so that material can be used readily for the finished grading. Protect and store in segregated piles until needed.

3.2 EXCAVATIONS

A. Excavate to contours and dimensions indicated. Keep excavations free from water while construction is in progress. Notify the Engineer immediately in writing in the event that it becomes necessary to remove rock, hard material, or other material defined as unsuitable to a depth greater than indicated. Refill excavations cut below the depths indicated with controlled fill and compact as specified herein. Excavate soil disturbed or weakened by construction operations or soils softened from exposure to weather. Refill with controlled fill or concrete and compact as specified herein.

B. Excavations for Structures and Spread Footings

1. Excavate to depth indicated. If excavation is deeper than indicated, then fill with concrete when the foundations or footings are placed or backfill with controlled fill material prior to placement of footings.

C. Pile Supported Foundations

1. Excavate to elevation of bottom of pile cap. Backfill and compact over excavations and changes in grade due to pile driving operations in accordance with the requirements for filling and backfilling for structures. Place and compact backfill adjacent to pile caps in a manner that prevents displacement of the pile cap.

D. Disposal of Excavated Material

1. Surplus or other soil material not required or suitable for filling, backfilling, or embankment shall be removed from the property. Comply with all federal, state and local laws regarding the transportation and disposal of such material.

2. Dispose of excavated material in such a manner that it will not obstruct the flow of runoff, streams, endanger a partly finished structure, impair the efficiency or appearance of facilities, or be detrimental to any property or work.

3.3 PREPARATION OF SUBGRADE

A. Subgrade Proof Rolling

1. After removal of topsoil or other overburden, proof roll the existing subgrade with six passes of a minimum 15 ton pneumatic-tired roller. Operate the roller in a systematic manner to assure the number of passes over all areas, and at speeds between 2.5 and 3.5 miles per hour.
2. When proof rolling under structures, one-half of the passes made with the roller shall be in a direction perpendicular to the other passes.
3. Rutting or pumping shall indicate unsuitable material and that material shall be undercut as directed by the Engineer, to a depth of 24 inches, and replaced with the appropriate fill material. Unsuitable material removal shall be done in accordance with the paragraph titled "Excavations."
4. Perform proof rolling only when weather conditions permit. Do not proof roll wet or saturated subgrades. Materials degraded by proof rolling a wet or saturated subgrade shall be replaced by the Contractor as directed by the Engineer at no cost to the Owner.
5. Proof rolling shall be done in the presence of the Engineer. Notify the Engineer 3 days prior to proof rolling.

B. Preparation of Subgrade

1. Scarify the underlying subgrade surface to a depth of 6 inches before the fill is started. Step, bench, or break up sloped surfaces steeper

than one vertical to 4 horizontal so that the fill material will bond with or be securely keyed to the existing material. Scarify existing surface to a minimum depth of 6 inches if subgrade density is less than the degree of compaction specified and recompact.

2. When the subgrade is part fill and part excavation or natural ground, scarify the excavated or natural ground portion to a depth of 12 inches and recompact as specified for the adjacent or overlying fill. Compact with equipment well suited to the soil being compacted. Moisten or aerate material as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used.

C. Compaction of Subgrade

1. The subgrades shall be compacted to the following maximum densities:

Location	Percent Maximum Density
Under sidewalks and grassed areas	95
Under building slabs, foundations, footings, pavements and base courses (Greater than 12 inches below bottom of structure or pavement)	95
Under building slabs, foundations, footings, pavements and base courses (Less than 12 inches below the bottom of structure or pavement)	95

2. Protect subgrade from excessive wheel loading during construction, including concrete trucks and dump trucks.
3. Remove areas of finished subgrade found to have insufficient compaction density to depth necessary and replace in a manner that will comply with compaction requirements by use of a material equal to or better than best subgrade material on site.
4. Surface of subgrade after compaction shall be hard, uniform, smooth, stable, and true to grade and cross section. Maintain subgrade for area to be paved and building pad subgrade, whether previously graded by others and accepted by Contractor or constructed by Contractor. Make adjustments that may be required in accordance with the Specifications at no additional expense to the Owner.

D. Tolerances

1. Grade to finished grades indicated within 0.10 foot. Grade area to drain water away from structures. Existing grades which are to remain but are disturbed by the Contractor’s operations shall be restored to original condition.
2. Finish surface of subgrade to the elevation and cross section indicated.

Finished surface shall be smooth and of uniform texture. Lightly scarify or blade the finished surface to bring the finished surface to within 0.10 foot of the indicated grade and to eliminate imprints made by compaction and shaping equipment. Surface shall show no deviations in excess of ½ inch when tested with a 10 foot straightedge.

3. Finished subgrade shall be verified to ensure proper elevation for construction above subgrade. Grading of building and pavement areas shall be checked by string line from grade stakes (blue tops) set at not more than 50’ centers. Contractor is to provide engineering and field staking necessary for verification of lines, grades, and elevations.

3.4 FILL AND BACKFILL

A. Place required fill and backfill material adjacent to structures and compact in a manner that prevents wedging action or eccentric loading upon or against the structures.

B. Step or serrate slopes bounding or within areas to be filled or backfilled to prevent sliding of the fill.

C. Moisten or aerate material as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction and slopes with the equipment used. Do not place material on surfaces that are muddy, frozen, or contain frost.

D. Do not use equipment for filling or backfilling operations or for the formation of embankments against structures that will overload the structure. Filling or backfilling against structures will be done only after the structure has attained sufficient strength to withstand the loads anticipated during and after backfilling operations.

E. Fill and backfill operations shall be performed with the following materials:

1. Common Fill

a. Construct fill, backfill and embankment at the locations and to lines and grades indicated. Use only approved materials in constructing fill on the prepared subgrade. Place satisfactory material in horizontal lifts not exceeding 8 inches in loose depth. Do not place material on surfaces that are muddy, frozen, or contain frost. Compact with equipment well suited to the soil being compacted. Moisten or aerate material as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction and slopes with the equipment used. Compact each lift as specified before placing the overlaying lift.

2. Controlled Fill

   a. Place controlled fill under footings, concrete slabs not pile supported, structures, pavements and where indicated in maximum loose lifts of 8 inches. Do not place material on surfaces that are muddy, frozen, or contain frost. Compact with equipment well suited to the soil being compacted. Moisten or aerate material as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction and slopes with the equipment used. Compact each lift as specified herein before placing the overlaying lift. Compaction shall be accomplished continuously over the entire area. Sufficient passes shall be made to ensure that specified density is obtained.

3. Granular Fill, Gravel and Sand

   a. Granular fill, gravel and sand shall be placed where indicated. Do not dump material, but place in maximum loose 12 inch lifts and compact as indicated.

F. Compaction of Fill/Backfill

1. Fill and backfill shall be compacted to the following maximum densities:

Location	Percent Maximum Density
Under sidewalks and grassed areas	95
Under building slabs, foundations, footings, pavements and base courses (Greater than 12 inches below bottom of structure or pavement)	95
Under building slabs, foundations, footings, pavements and base courses (Less than 12 inches below the bottom of structure or pavement)	95

2. Protect compacted fill from excessive wheel loading during construction, including concrete trucks and dump trucks. Remove areas of compacted fill found to have insufficient compaction density to depth necessary and replace in a manner that will comply with compaction requirements by use of a material meeting the specifications. Surface of compacted fill after compaction shall be hard, uniform, smooth, stable, and true to grade and cross section. Maintain compacted fill for area to be paved and building pad subgrade, whether previously graded by others and accepted by Contractor or constructed by Contractor. Make adjustments that may be required in

accordance with the Specifications at no additional expense to the Owner.

G. Tolerances

1. Grade to finished grades indicated within 0.10 foot. Grade area to drain water away from structures. Existing grades which are to remain but are disturbed by the Contractor's operations shall be restored to original condition.

   Finish surface of fill or backfill to the elevation and cross section indicated. Finished surface shall be smooth and of uniform texture. Lightly scarify or blade the finished surface to bring the finished surface to within 0.10 foot of the indicated grade and to eliminate imprints made by compaction and shaping equipment. Surface shall show no deviations in excess of ½ inch when tested with a 10 foot straightedge

3.5 TOPSOIL

A. Clear areas to receive topsoil for the finished surface of materials that would interfere with planting and maintenance operations. Scarify subgrade to a depth of 2 inches. Do not place topsoil when the subgrade or fill is frozen, extremely wet or dry, or in other conditions detrimental to seeding, planting, or grading. Spread topsoil to a uniform depth of 4 inches over the designated areas

3.6 PROTECTION

A. Shoring and Sheeting

1. The Contractor is responsible for the design of all shoring and sheeting systems. Provide shoring, bracing or sheeting where required. In addition to the requirements of Section 25 A and B of COE EM-385-1-1, and other requirements of this contract meet the following:
   a. Prevent the undermining of pavements, foundations and slabs.
   b. Slope banks where space permits.
   c. Where shoring and sheeting materials remain in place in completed work to prevent settlements or damage to adjacent structures as directed, backfill the excavation to 3 feet below the finished grade and remove the remaining portion of the shoring before completing the backfill.

B. Drainage and Dewatering

1. Plan for and provide structures, equipment and construction for the collection and disposal of surface and subsurface water encountered during construction.

a. Drainage

1) Dispose of surface water which may accumulate in open excavations, unfinished fills, or other low areas. Remove water by trenching where approved, pumping, or other methods to prevent softening of exposed surfaces.
2) Surface dewatering plan shall include rerouting of any storm water runoff or natural drainage if necessary.
3) Collect and dispose of surface and subsurface water encountered in the course of construction.

b. Dewatering

1) Groundwater flowing toward or into excavations shall be controlled to prevent sloughing or excavation slopes and walls, boils, uplift and heave in the excavation and to eliminate interference with orderly progress of construction.
2) French drains, sumps, ditches or trenches will not be permitted within three feet of the foundation of any structure, except with specific written approval, and after specific contractual provisions for restoration of the foundation area have been made.
3) Control measures shall be taken by the time the excavation reaches the water level in order to maintain the integrity of the in situ material. While the excavation is open, the water level shall be maintained continuously, at least one foot below the working level.
4) Operate the dewatering system continuously, 24 hours per day, 7 days per week until construction work below existing water levels is complete. Have a back-up pump and system available for immediate use.

C. Erosion Control

1. Protect existing streams, ditches, and storm drain inlets from water-borne soil by the means indicated on the contract drawings and as required to prevent sedimentation of downstream features.
2. Dust control at an operational airfield is of the utmost importance because excessive dust can restrict sight distance and damage aircraft engines. The Owner reserves the right to shut down or restrict construction operations when excessive dust, as determined by the Owner, could impact air navigation or airfield operations. Such a restriction or shutdown may not be the basis for additional costs or contract time.

D. Existing Utilities

1. All known utility facilities are shown schematically on the plans and are not necessarily accurate in location as to plan or elevation. Utilities such as service lines or unknown facilities not shown on plans will not relieve the Contractor of his responsibility under this requirement. "Existing Utilities Facilities" means any utility that exists on the project in its original, relocated or newly installed position. The Contractor will be held responsible for the cost of repairs to damaged underground facilities; even when such facilities are not shown on the plans.

2. The Contractor shall contact all utility companies prior to beginning work and request accurate field location of their respective utility lines.

3. Movement of construction machinery and equipment over pipes during construction shall be at the Contractor's risk. Repair or remove and provide new pipe for existing or newly installed pipe that has been displaced or damaged.

E. Structures and surfaces

1. Graded areas shall be protected from traffic, erosion, settlement, or any washing away that may occur from any cause prior to acceptance.
2. Any repair or reestablishment of final grades shall be made prior to final acceptance.

3.7 INSPECTION AND TESTING

A. Inspections

1. The Engineer will have the right to require that any portion of the work be done in his presence and if the work is covered up after such instruction, it shall be exposed by the Contractor for observation. However, if the Contractor notifies the Engineer that such work is scheduled and the Engineer fails to appear within 72 hours, the Contractor may proceed without him. All work done and materials furnished shall be subject to review by the Engineer or the Resident Project Representative, and all improper work shall be reconstructed, and all materials which do not conform to the requirements of the specifications shall be removed from the work upon notice being received from the Engineer for the rejection of such materials. The Engineer shall have the right to mark rejected materials so as to distinguish them as such.
2. The Contractor shall give the Engineer or Resident Project Representative a minimum of 72 hours notice for all required observations or tests.

B. Testing

1. All testing shall be made at the Contractor's expense. The Engineer shall approve test locations.
2. Test results shall be furnished to the Contractor, Engineer and Owner within 72 hours after field tests are taken.
3. The testing laboratory, Engineer, and Owner shall be given a minimum of 72 hours notice for all tests.
4. Laboratory testing

    a. Independent Testing laboratory shall operate in accordance with ASTM E 329 (latest edition) and shall be submitted to the engineer for approval.
    b. Laboratory testing for maximum density and optimum moisture content shall be performed in accordance with ASTM D 1557 for general soil types or ASTM D 4253 or ASTM D 4254 for isolated cohesionless materials.
    c. Laboratory testing for mechanical analysis shall be performed in accordance with ASTM D 2487.
    d. Laboratory testing for plasticity index shall be performed in accordance with ASTM D 4318
    e. Frequency of laboratory testing

        1) Native soil subgrade - One maximum density, optimum moisture content, mechanical analysis and plasticity index test for each material encountered that will serve as subgrade.
        2) Fill/Backfill - One maximum density, optimum moisture content, mechanical analysis and plasticity index for each source and type of material to be used.
5. Field testing

    a. Independent Testing Laboratory shall prepare test reports that indicate test location, elevation data, and test results. The Owner, Engineer, and Contractor shall be provided copies of reports within 72 hours of the time the test was performed. In the event that any test performed fails to meet these specifications, the Owner, Engineer and Contractor shall be notified immediately by Independent Testing Laboratory. The Owner reserves the right to employ an Independent Testing Laboratory and to direct any testing that it may deem necessary. The Contractor shall provide free access to the site for testing activities.
    b. Field density tests for in-place materials shall be performed in accordance with one of the following:

1) Sand Cone Method - ASTM D 1556
2) Balloon Method - ASTM D 2167
3) Nuclear Method - ASTM D 6938

c. Frequency of field testing

1) Subgrade

a) One test per 5,000 square feet within building footprint (minimum of 3)
b) One test per 1,000 square yards of pavement (minimum of 3)
c) One test per 250 linear feet of footing (minimum of 4 - one each face of building)

2) Fill/Backfill

a) One test per 5,000 square feet per lift within building footprint (minimum of 4 per lift)
b) One test per 1,000 square yards of pavement per lift (minimum of 3 per lift)
c) One test per 250 linear feet of footing (minimum of 4 - one each face of building

C. Acceptance

1. In the event that a tested material does not meet or exceed the specified requirements, the Contractor shall perform additional testing as directed by the Engineer to adequately define the limits of the material not meeting the specifications. Materials shall be re-tested to the satisfaction of the Engineer until specified requirements are met.
2. All additional testing and work which is the result of a failed test shall be performed by the Contractor at no additional cost to the Owner.

END OF SECTION 31 20 00

SECTION 313116 - TERMITE CONTROL

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. Soil treatment.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components, and profiles for termite control products.
2. Include the EPA-Registered Label for termiticide products.
3. Include certificate of registration with South Carolina Department Pesticide Regulation.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer of termite control products, including licensing records and application reports as required by local authorities.

B. Product Certificates: For each type of termite control product, from manufacturer.

C. Soil Treatment Application Report: After application of termiticide is completed, submit report for Owner's records and include the following:

1. Date and time of application.
2. Moisture content of soil before application.
3. Termiticide brand name and manufacturer.
4. Quantity of undiluted termiticide used.
5. Dilutions, methods, volumes used, and rates of application.
6. Areas of application.
7. Water source for application.

D. Sample Warranties: For special warranties.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: A specialist who is licensed according to regulations of authorities having jurisdiction to apply termite control treatment and products in jurisdiction where Project is located.

1. Installer shall be licensed as a Pest Control Operator (PCO) by SC Department of Pesticide Regulation as required by state and local authorities.

B. Regulatory Requirements: Formulate and apply termicides and termicide devices according to the EPA-Registered Label.

C. Source Limitations: Obtain termite control products from single manufacturer for each product.

1.6 FIELD CONDITIONS

A. Soil Treatment:

1. Environmental Limitations: To ensure penetration, do not treat soil that is water saturated or frozen. Do not treat soil while precipitation is occurring. Comply with requirements of the EPA-Registered Label and requirements of authorities having jurisdiction.
2. Related Work: Coordinate soil treatment application with excavating, filling, grading, and concreting operations. Treat soil under footings, grade beams, and ground-supported slabs before construction.

1.7 COORDINATION

A. Coordinate soil treatment applications with excavating, filling, grading, and concreting operations. Treat soil under footings, grade beams, and ground-supported slabs before construction.

1.8 WARRANTY

A. Soil Treatment Special Warranty: Manufacturer's standard form, signed by Applicator and Contractor, certifying that termite control work, consisting of applied soil termiticide treatment, will prevent infestation of subterranean termites. If subterranean termite activity or damage is discovered during warranty period, re-treat soil and repair or replace damage caused by termite infestation.

1. Warranty Period: Three years from Substantial Completion.

1.9 MAINTENANCE SERVICE PROPOSAL

A. Provide a proposal for continuing service, including monitoring, inspection, and retreatment for occurrences of termite activity, from applicator to Owner, in the form of a standard yearly (or other period) continuing service agreement, starting on the date of Substantial Completion. State services, obligations, conditions, and terms for agreement period and for future renewal options.

PART 2 - PRODUCTS

2.1 SOIL TREATMENT

A. Termiticide: EPA- and NCDOA- registered termiticide complying with requirements of authorities having jurisdiction, in an aqueous solution formulated to prevent termite infestation. Provide quantity required for application at the label volume and rate for the maximum termiticide concentration allowed for each specific use, according to product's EPA-Registered label.

1. Use compatible dye in termiticide to provide visible evidence of treatment.
2. Service Life of Treatment: Soil treatment termiticide that is effective for not less than three years against infestation of subterranean termites.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Applicator present, for compliance with requirements for moisture content of soil per termiticide label, interfaces with earthwork, slab and foundation work, landscaping, utility installation, and other conditions affecting performance of termite control.

B. Proceed with application only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. General: Comply with the most stringent requirements of authorities having jurisdiction and with manufacturer's written instructions for preparation before beginning application of termite control treatment. Remove all extraneous sources of wood cellulose and other edible materials such as wood debris, tree stumps and roots, stakes, formwork, and construction waste wood from soil within and around foundations.

B. Soil Treatment Preparation: Remove foreign matter and impermeable soil materials that could decrease treatment effectiveness on areas to be treated. Loosen, rake, and level soil to be treated except previously compacted areas under slabs and footings. Termiticides may be applied before placing compacted fill under slabs if recommended in writing by termiticide manufacturer.

1. Fit filling hose connected to water source at the site with a backflow preventer, complying with requirements of authorities having jurisdiction.

3.3 APPLYING SOIL TREATMENT

A. Application: Mix soil treatment termiticide solution to a uniform consistency. Distribute treatment uniformly. Apply treatment at the product's EPA-Registered Label volume and rate for maximum specified concentration of termiticide to the following so that a continuous horizontal and vertical termiticidal barrier or treated zone is established around and under building construction.

1. Slabs-on-Grade: Underground-supported slab construction, including footings, building slabs, and attached slabs as an overall treatment. Treat soil materials before concrete footings and slabs are placed.
2. Foundations: Soil adjacent to and along the entire inside perimeter of foundation walls; along both sides of interior partition walls; around plumbing pipes and electric conduit penetrating the slab; around interior column footers; and along the entire outside perimeter, from grade to bottom of footing.
3. Masonry: Treat voids.
4. Penetrations: At expansion joints, control joints, and areas where slabs and below-grade walls will be penetrated.

B. Post warning signs in areas of application.

C. Reapply soil treatment solution to areas disturbed by subsequent excavation, grading, landscaping, or other construction activities following application.

3.4 PROTECTION

A. Avoid disturbance of treated soil after application. Keep off treated areas until completely dry.

B. Protect termiticide solution dispersed in treated soils and fills from being diluted by exposure to water spillage or weather until ground-supported slabs are installed. Use waterproof barrier according to EPA-Registered Label instructions.

END OF SECTION 313116

SECTION 32 12 16 - ASPHALT PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. This section covers all work associated with:

1. Subbase Course
2. Aggregate Base Course
3. Intermediate Course
4. Base Course
5. Prime Coat
6. Tack Coat
7. Asphaltic Concrete

1.2 DEFINITIONS

A. Compaction: The process of mechanically stabilizing a material by increasing its density. "Degree of Compaction" is expressed as a percentage of the maximum density obtained by the test procedure described in ASTM D 1557 for general soil types or ASTM D 4253 or ASTM D 4254 for isolated cohesionless materials, abbreviated in this specification as "__ percent maximum density." "Degree of Compaction" is expressed as a percentage of the maximum density obtained by the test procedure as described in SCDOT standard specification SC-D-400."

B. Course: A layer or lift of soil or asphaltic concrete placed on top of a previously prepared or placed surface.

C. Lift: A layer or course of soil or asphaltic concrete placed on top of a previously prepared or placed surface.

D. Subgrade: Existing, in-situ soil or other material that is remaining after stripping or excavation. The subgrade is always existing material on which fill or new structures are to be placed.

1.3 SCDOT Reference Documents

A. SCDOT Standard Specifications for Highway Construction: Current version located here: https://www.scdot.org/business/pdf/2007_full_specbook.pdf

B. SCDOT Supplemental Technical Specifications: Current Versions located here: https://www.scdot.org/business/road-technical-specs.aspx

1.4 SUBMITTALS

A. Asphaltic Concrete Mix Design: For each mix to be used on the project by course, submit a mix design prepared within 12 months of the date of the submittal in accordance with one of the following:

1. For each mix and with materials to be used, submit a mix design and volumetric calculation following SCDOT Supplemental Technical Specification SC-T-80 and AASHTO 312.
2. Mix designs in compliance with requirements of the "South Carolina State Highway Department Standard Specification for Highway Construction". All materials listed in the mix design shall be the materials used to produce the asphaltic concrete. Mix design shall be submitted to the engineer for approval.

B. Laboratory Testing: Submit laboratory testing data for approval as identified in the paragraph titled "Laboratory Testing" for any the following materials to be used on the project before any material is delivered to the site.

1. Asphaltic Concrete (asphalt base course, intermediate course and surface course)
    a. Maximum density

C. Field Testing: Submit field testing data as identified in the paragraph titled "Field Testing" for the following:

1. Asphaltic Concrete (asphalt base course, intermediate course and surface course)

    a. In place density
    b. Mix Design Compliance
    c. Grade
    d. Straight Edge

D. Certifications: Provide manufacturer or supplier certification of compliance indicating conformance to this specification or the referenced standard(s) for the following:

1. Tack coat
2. Prime coat
3. Asphaltic Concrete (asphalt base course, intermediate course and surface course)
    a. Coarse aggregate
    b. Fine aggregate
    c. Mineral filler
    d. Asphalt cement

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver and store materials in a manner to prevent contamination or segregation. Do not stockpile materials in a manner or location that will cause excessive wetting or transporting of materials off-site or into storm drainage collection systems.

1.6 REGULATORY REQUIREMENTS

A. Comply with federal, state and local regulatory requirements.

1.7 CRITERIA FOR BIDDING

A. Lump Sum Price

1. The items listed in the proposal shall be considered as sufficient to complete the work in accordance with the plans and specifications. Any portion of the work not specifically listed in the bid form shall be deemed a part of the item with which is it associated and shall be included in the lump sum price. The price shall be full compensation for the material, compaction, shaping, finishing, dressing, disposal of surplus material, testing, construction supervision and all other work required for satisfactory completion of the asphaltic concrete pavement system.

B. Unit Prices

1. None this Section.

C. Options

1. As specified herein, options are provided for use of materials specified in the applicable sections of the "South Carolina Department of Transportation Standard Specification for Highway Construction". Execution, administration, contractual and payment provisions do not apply. Where the term "State" is used, it shall mean "Owner."

1.8 QUALITY ASSURANCE

A. Materials: All material submittals shall be submitted by the contractor and reviewed and accepted in writing by the Engineer prior to ordering of any materials.

B. Manufacturer: Material and equipment shall be the standard products of a manufacturer who has manufactured them for a minimum of 2 years and who provides published data on the quality and performance of the projects.

C. Subcontractor: A subcontractor for any part of the work must have experience on similar work. At the option of the Engineer, a list of projects and the Owners or Engineers who are familiar with his competence may be required to be submitted to verify experience.

D. Design: Devices, equipment, structures, and systems not designed by the Engineer that the Contractor wishes to furnish shall be designed by either a registered professional engineer or by someone the Engineer accepts as qualified. Complete design calculations and assumptions shall be furnished to the Engineer or Owner before acceptance.

E. Environmental Conditions: Place bituminous mixture only during dry weather and on dry surfaces. Place asphaltic concrete only when surface temperature of underlying course is greater than 45 degrees F for course thicknesses greater than one inch and 55 degrees F for course thickness' one inch or less.

F. Equipment: Shall be well maintained, suited for the intended work and capable of delivering the finished product to the standards shown on drawings and as specified herein.

PART 2 - PRODUCTS

2.1 ASPHALTIC CONCRETE BASE COURSE

A. Shall comply with requirement for Hot Mix Asphalt Aggregate Base Course as specified in Section 310 of the "South Carolina Department of Transportation Standard Specification for Highway Construction and addendums.

2.2 TACK COAT

A. Asphalt emulsion conforming to ASTM D 977, Grade RS-1, MS-1, MS-2, HFMS-1, HFMS-2, SS-1, CRS-1, CMS-2 or CSS-1. Except RS-1 and CRS-1 emulsion may be diluted with not more than 50 percent water.

B. Shall comply with requirement for Tack Coat specified in Section 401 of the "South Carolina Department of Transportation Standard Specification for Highway Construction".

2.3 ASPHALTIC CONCRETE

A. Shall be hot mixed, hot laid asphaltic concrete of the compacted thickness indicated on the plans.

B. Surface Course and Intermediate course

1. Mix design shall be prepared in accordance with SCDOT Supplemental Technical Specification SC-M-402.

C. Intermediate course

1. Shall comply with one of the following:

a. Shall comply with requirements for Hot Mix Asphalt Intermediate course Type B as specified in Sections 401 and 402 of the "South Carolina Department of Transportation Standard Specification for Highway Construction".

D. Surface Course:

1. Shall comply with requirements for Hot Mix Asphalt Surface Course Type C as specified in Sections 401 and 403 of the "South Carolina Department of Transportation Standard Specification for Highway Construction".

PART 3 - EXECUTION

3.1 SAWCUTTING OF EXISTING PAVEMENTS

A. Provide full depth sawcuts through existing asphaltic concrete pavements where new asphaltic concrete pavements are to join. Sawcuts shall be straight and vertical and shall be located a minimum of 3 inches from the existing edge or as indicated on the drawings.

3.2 PREPARATION OF SUBGRADE OR FILL

A. Prepare subgrade and/or fill as specified in SECTION "EARTH MOVING".

3.3 TACK COAT

A. Application

1. Apply not more than 0.15 gallon square yard nor less than 0.05 gallon per square yard to indicated contact surfaces as measured by SC-T-86. Apply half-rate application to prime coats that have been contaminated by traffic or dust. The tack coat shall only be applied when the contact surface is dry and when the temperature has not been below 35 degrees F for 12 hours immediately prior to application. The tack coat shall only be applied when the temperature of the air in the shade is 55 degrees F or above. Work shall be planned so that no more tack coat than is necessary for

the day's operation is placed on the surface. In places where the distributor bars cannot reach, it will be necessary to apply the tack coat with a hand sprayer attached to the distributor by a hose. When hand spray methods are used, care should be taken to give the surface a very light application of the asphalt.

B. Protection

1. Except paving equipment, do not permit any traffic on tacked surfaces.

3.4 ASPHALTIC CONCRETE

A. Mixing and Preparation of Bituminous Mixture

1. Plant mix bituminous mixture to comply with requirements specified herein.

B. Transportation of Bituminous Mixture

1. Transport bituminous mixture in trucks having, tight, clean, smooth beds that have been coated with a minimum amount of a concentrated solution of hydrated lime and water to prevent adhesion of the mixture to the truck bodies. Each load shall be covered with canvas or other approved material of ample size to protect he mixture from the weather and to prevent loss of heat. Deliveries shall be made so that the spreading and rolling of all mixture prepared for one day's run can be completed during daylight, unless adequate, approved artificial lighting is provided. The mixture shall be delivered to the area to be paved in such a manner that the temperature at the time of dumping into the spreader will not be less than 250 degrees F. Any loads that are below minimum temperature, that have crusts of cold, unworkable material, or that have been wet excessively by rain will be rejected. Hauling over freshly laid material will not be permitted.

C. Machine Spreading

1. Prior to the laying of the asphaltic concrete, clean underlying course of foreign or objectionable matter with power blowers or power brooms, supplemented by hand brooms and other cleaning methods where necessary.

2. The range of temperatures of the mixtures at the time of spreading shall be between 250 degrees F and 300 degrees F. Bituminous concrete having temperatures less than minimum spreading temperature when dumped into the spreader will be rejected. Adjust spreader and regulate speed so that the surface of the course is smooth and continuous without tears and pulling, and of such depth

that, when compacted, the surface conforms with the cross section, grade, and contour indicated. Unless otherwise directed, begin the placing along the centerline of areas to be paved on a crowned section or on the high side of areas with a one-way slope. Place mixture in consecutive adjacent strips having a minimum width of 10 feet, except where the edge lanes require strips less than 10 feet to complete the area. Construct longitudinal joints and edges to true line markings. Establish lines parallel to the centerline of the area to be paved, and place string lines coinciding with the established lines for the spreading machine to follow. Provide the number and location of the lines needed to accomplish proper grade control. When specified grade and smoothness requirements can be met for initial lane construction by use of an approved long ski-type device of not less than 30 feet in length and for subsequent lane construction by use of a short ski or shoe, in-place string lines for grade control may be omitted. Place mixture as nearly continuous as possible and adjust the speed of placing as needed to permit proper rolling

D. Shoveling, Raking, and Tamping After Machine Spreading

1. Shovelers and rakers shall follow the spreading machine. Add or remove hot mixture and rake the mixture as required to obtain a course that when completed will conform to requirements specified herein. Broadcasting or fanning of mixture over areas being compacted is prohibited. When segregation occurs in the mixture during placing, suspend spreading operation until the cause is determined and corrected. Correct irregularities in alignment left by the spreader by trimming directly behind the machine. Immediately after trimming, compact edges of the course by tamping laterally with a metal lute or by other approved methods. Distortion of the course during tamping is prohibited.

E. Hand Spreading in Lieu of Machine Spreading

1. In areas where the use of machine spreading is impractical, spread mixture by hand. The range of temperatures of the mixtures when dumped onto the area to be paved shall be between 250 and 300 degrees F. Mixtures having temperatures less than minimum spreading temperature when dumped onto the area to be paved will be rejected. Spread hot mixture with rakes in a uniformly loose layer of a thickness that, when compacted, will conform to the required grade, thickness, and smoothness. During hand spreading, place each shovel full of mixture by turning the shovel over in a manner that will prevent segregation. Do not place mixture by throwing or broadcasting from a shovel. Do not dump loads any faster than can be properly handled by the shovelers and rakers.

F. Compaction of Mixture

1. Compact mixture by rolling. Rollers shall conform to the requirements of Section 401 of the South Carolina Department of Transportation Standard Specifications for Highway Construction. Begin rolling as soon as placement of mixture will bear rollers. Delays in rolling freshly spread mixture shall not be permitted. Start rolling longitudinally at the extreme sides of the lanes and proceed toward center of pavement, or toward high side of pavement with a one-way slope.
   Operate rollers so that each trip overlaps the previous adjacent strip by at least one foot. Alternate trips of the roller shall be of slightly different lengths. Conduct tests for conformity with the specified crown, grade and smoothness immediately after initial rolling. Before continuing rolling, correct variations by removing or adding materials as necessary. If required, subject course to diagonal rolling with the steel wheeled roller crossing the lines of the previous rolling while mixture is hot and in a compactible condition. Speed of the rollers shall be slow enough to avoid displacement of hot mixture. Correct displacement of mixture immediately by use of rakes and fresh mixture, or remove and replace mixture as directed. Continue rolling until roller marks are eliminated and course has a density of at least 96 percent but not more than 100 percent of that attained in a laboratory specimen of the same mixture prepared in accordance with ASTM D 1559. During rolling, moisten wheels of the rollers enough to prevent adhesion of mixture to wheels, but excessive water is prohibited. Operation of rollers shall be by competent and experienced operators. Provide sufficient rollers for each spreading machine in operation on the job and to handle plant output. In places not accessible to the rollers, compact mixture thoroughly with hot hand tampers. Skin patching of an area after compaction is prohibited. Remove mixture that becomes mixed with foreign materials or is defective and replace with fresh mixture compacted to the density specified herein. Roller shall pass over unprotected edge of the course only when laying of course is to be discontinued for such length of time as to permit mixture to become cold.

G. Tolerances

1. Finished grade of asphaltic concrete shall be within 0.03 feet of indicated finish grade.
2. Finished surface shall not vary more than 1/8 inch when tested with a 10 foot straightedge.
3. The finished thickness shall not vary more than 1/4 inch from required thickness at any point and average thickness of depth measurements shall be at least the thickness indicated.

4. The finished surface shall be uniform in appearance and texture over the entire surface, including at joints. The entire surface shall be free of evidence of segregation, honeycombs and back scattering.
5. Areas not meeting the above requirements will be rejected until corrected by the Contractor.

H. Joints

1. Joints shall present the same texture and smoothness as other portions of the course, except permissible density at the joint may be up to 2 percent less than the specified course density.
Carefully make joints between old and new pavement or within new pavements in a manner to ensure a thorough and continuous bond between old and new sections of the course. Vertical contact surfaces of previously constructed sections that are coated with dust, sand, or other objectionable material shall be painted with a thin uniform coat of emulsion or other approved bituminous material just before placing fresh mixture.

2. Transverse Joints

a. Roller shall pass over unprotected end of freshly laid mixture only when laying of course is to be discontinued. Except when an approved bulkhead is used, cut back the edge of previously laid course to expose an even, vertical surface for the full thickness of the course. When required, rake fresh mixture against joints, thoroughly tamp with hot tampers, smooth with hot smoothers, and roll. Transverse joints in adjacent lanes shall be offset a minimum of 2 feet.

3. Longitudinal Joints

a. Space 6 inches apart. Do not allow joints to coincide with joints of existing pavement or previously placed courses. Spreader screed shall overlap previously placed lanes 2 to 3 inches and be of such height to permit compaction to produce a smooth dense joint. With a lute, push back mixture placed on the surface of previous lanes to the joint edge. Do not scatter mix. Remove and waste excess material. When edges of longitudinal joints are irregular, honeycombed, or poorly compacted, cut back unsatisfactory sections of joint and expose an even vertical surface for the full thickness of the course. When required, rake fresh mixture against joint, thoroughly tamp with hot tampers, smooth with hot smoothers, and roll while hot.

I. Protection

1. Do not permit traffic, including heavy equipment, on asphaltic concrete until surface temperature has cooled to at least 120 degrees F.

3.5 PROTECTION

A. Existing Pavement

1. Protect existing pavements to remain from damage. Movement of construction machinery and equipment over existing pavements during construction shall be at the Contractor's risk.
Existing pavements damaged by the contractor's operations shall repaired or replaced to their original condition at the contractor's expense.

B. Erosion Control

1. Protect existing streams, ditches, and storm drain inlets from water-borne soil by the means indicated on the contract drawings.

C. Existing Utilities

1. Location of the existing utilities indicated is approximate. The Contractor shall physically verify the location and elevation of the existing utilities indicated prior to starting construction. The Contractor shall contact the local utility location company or each applicable utility company as required for assistance in locating existing utilities.

D. Structures and Surfaces

1. Protect newly backfilled areas and adjacent structures, slopes, or grades from traffic, erosion settlement, or any other damage. Repair and reestablish damaged or eroded grades and slopes and restore surface construction prior to acceptance.

3.6 INSPECTION AND TESTING

A. Inspections

1. The Engineer will have the right to require that any portion of the work be done in his presence and if the work is covered up after such instruction, it shall be exposed by the Contractor for observation. However, if the Contractor notifies the Engineer that such work is scheduled and the Engineer fails to appear within 72 hours, the Contractor may proceed without him. All work done and materials furnished shall be subject to review by the Engineer or the Project

Representative, and all improper work shall be reconstructed, and all materials which do not conform to the requirements of the specifications shall be removed from the work upon notice being received from the Engineer for the rejection of such materials. The Engineer shall have the right to mark rejected materials so as to distinguish them as such.

2. The Contractor shall give the Project Engineer or Project Representative a minimum of 72 hours notice for all required observations or tests.

B. Testing

1. All testing shall be made at the Contractor's expense. Test locations shall be approved by the Engineer.
2. Test results shall be furnished to the Contractor, Engineer and Owner within 72 hours after field tests are taken.
3. The testing laboratory, Engineer and Owner shall be given a minimum of 72 hours notice for all tests. Testing Agencies - Testing shall be done by a testing laboratory which operates in accordance with ASTM E-329 (latest revision) and approved by the Engineer prior to engagement. The laboratory shall also conform to the testing requirements specified in section 401 of the South Carolina Department of Transportation Standard Specifications for Highway Construction. Mill certificates of tests on materials made by the manufacturers will be accepted provided the manufacturer maintains an adequate testing laboratory, makes regularly scheduled tests that are spot checked by an outside laboratory, and furnishes satisfactory certificates with the name of the one making the test. Agencies to be used shall be submitted to the Engineer for review prior to engagement.

4. Field testing

a. Independent Testing Laboratory shall prepare test reports that indicate test location, elevation data, and test results. The Owner, Engineer, and Contractor shall be provided copies of reports within 72 hours of the time the test was performed. In the event that any test performed fails to meet these specifications, the Owner, Engineer, and Contractor shall be notified immediately by Independent Testing Laboratory. The Owner reserves the right to employ an Independent Testing Laboratory and to direct any testing that it may deem necessary. The Contractor shall provide free access to the site for testing activities.

Asphaltic Concrete (Asphalt base course, Intermediate course and Surface Course):

1) Maximum density of compacted asphaltic concrete shall be determined in accordance with ASTM D 1188 or ASTM D 2726.

   a) One density test for each batch, but no less than one test for each 250 tons of asphaltic concrete produced or fraction thereof of asphalt produced.

2) Mix design compliance - Test asphaltic concrete produced for compliance with the approved mix design in accordance with the Marshall Method for Mix Design in the Asphalt Institute Manual Series No. 2 (MS-2).

   a) One analysis for each batch, but no less than one analysis for each 250 tons of asphaltic concrete produced or fraction thereof of asphalt produced.

3) In place density - 1 per 1000 square yards per course and per lift - in accordance with one of the following:

   a) ASTM D 2950
   b) Determine by taking 4" diameter cores obtained from intermediate course and surface course. Separate course by sawing. Determine in-place density of cores in accordance ASTM D 1188 or ASTM D 2726.

4) Grade - entire site. (50 feet grid maximum)

5) Straightedge - entire site (25 feet grid maximum)

C. Acceptance

1. In the event that a tested material does not meet or exceed the specified requirements, the Contractor shall perform additional testing as directed by the Engineer to adequately define the limits of the material not meeting the specifications. Materials shall be re-tested to the satisfaction of the Engineer until specified requirements are met.

2. All additional testing and work which is the result of a failed test shall be performed by the Contractor at no additional cost to the Owner.

END OF SECTION 32 12 16

SECTION 32 16 00 – SIDEWALKS, CURBS, AND GUTTER

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Concrete WORK shall consist of air entrained Portland cement constructed on a prepared subgrade in accordance with these SPECIFICATIONS. The completed WORK shall conform to the thicknesses and typical cross-sections shown on the DRAWINGS. The completed WORK shall conform to the lines and grades shown on the DRAWINGS or to those established by ENGINEER at the job site.

1.2 RELATED SECTIONS

A. The following is a list of SPECIFICATIONS which may be related to this section:

1. Section 01 57 19, Temporary Environmental Controls
2. Section 31 23 00, Excavation and Fill.
3. Section 31 23 19, Dewatering.
4. Section 31 23 33, Trenching and Backfilling.
5. Section 31 25 00, Erosion and Sedimentation Controls

1.3 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO):
    a. M6, Standard Specification for Fine Aggregate for Hydraulics Cement Concrete.
    b. M80, Standard Specification for Coarse Aggregate for Hydraulics Cement Concrete.
    c. M148, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
    d. M154, Standard Specification for Air-Entraining Admixtures for Concrete.

e. M171, Standard Specification for Sheet Materials for Curing Concrete.

f. M182, Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats.

g. M194M/M194, Standard Specification for Chemical Admixtures for Concrete.

h. T22, Standard Method of Test for Compressive Strength of Cylindrical Concrete Specimens.

i. T23, Standard Method of Test for Making and Curing Concrete Test Specimens in the Field.

j. T26, Standard Method of Test for Quality of Water to Be Used in Concrete.

k. T27, Sieve Analysis of Fine and Coarse Aggregates

l. T96, Standard Method of Test for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

m. T11, Standard Method of Test for Clay Lumps and Friable Particles in Aggregate.

n. T119M/T119, Standard Method of Test for Slump of Hydraulic Cement Concrete.

o. T121M/T121, Standard Method of Test for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete.

p. T141, Standard Method of Test for Sampling Freshly Mixed Concrete.

q. T152, Standard Method of Test for Air Content of Freshly Mixed Concrete by the Pressure Method.

r. T176, Standard Method of Test for Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test.

s. T199, Standard Method of Test for Air Content of Freshly Mixed Concrete by the Chace Indicator.

2. ASTM International (ASTM):

a. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.

b. C920, Standard Specification for Elastomeric Joint Sealants.

3. South Carolina Department of Transportation (SCDOT):

a. Section 720, Concrete Curb, Gutter, Curb and Gutter, Sidewalk, Driveway and Median.

b. Appendices A-4 and A-5, Gradation of Fine and Coarse Aggregates.

1.4 SUBMITTALS

A. CONTRACTOR shall cooperate with ENGINEER in obtaining and providing samples of all specified materials.

B. CONTRACTOR shall submit certified laboratory test certificates for all items
required in this section.

C. Contractor shall submit mix design for concrete in writing to ENGINEER for approval prior to placement of concrete.

D. CONTRACTOR shall submit batch tickets for each load of concrete. Tickets shall show weight of all materials and additives used in each batch.

PART 2 PRODUCTS

2.1 MATERIALS

A. Concrete Conformance:

1. Concrete shall conform to the following requirements:

Structural Concrete Table					
Aggregate Type	Minimum Cement Content (lbs./CY)	Other Cementitious Material (lbs./CY)	Min. 28 Day Mix Design (psi)	Percent Fine to Coarse Aggregate Ratio	Max. Water to Cementitious Material Ratio
Class 2500 (Non Structural)					
Crushed stone	494	--	2500	36:64	0.54
Gravel	494	--	2500	35:65	0.52
Marine Limestone	494	--	2500	40:60	0.56

2. This material shall consist of a mixture of coarse and fine aggregates, Portland cement, water and other materials or admixtures as required. The type of cement shall be Type I, II, or I/II unless sulfate conditions dictate otherwise. If sulfate conditions exist, Type V cement shall be used.

B. Concrete Aggregates: The grading and composition requirements for coarse and fine aggregates for concrete shall conform to the following tables.

Gradation of Coarse Aggregates Percentage by Weight Passing Sieves Having Square Openings										
Sieve Designation	Aggregate No.									
	CR-14	5	56	57	67	6M	8M	78	789	89M
2-inch	100	--	--	--	--	--	--	--	--	--
1½-inch	95 - 100	100	100	100	--	--	--	--	--	--
1-inch	70 - 100	90 - 100	90 - 100	95 - 100	100	100	--	--	--	--
¾-inch	--	20 - 55	40 - 85	--	90 - 100	90 - 100	100	100	100	--
½-inch	35 - 65	0 - 10	10 - 40	25 - 60	--	--	95 - 100	90 - 100	95 - 100	100
⅜-inch	--	0 - 5	0 - 15	--	20 - 55	0 - 20	75 - 100	40 - 75	80 - 100	98 - 100
No. 4	10 - 40	--	0 - 5	0 - 10	0 - 10	0 - 5	10 - 35	5 - 25	20 - 50	20 - 70
No. 8	--	--	--	0 - 5	0 - 5	--	--	--	--	2 - 20
No. 16	--	--	--	--	--	--	0 - 5	0 - 5	0 - 6	--
No. 100	--	--	--	--	--	--	0 - 2	--	0 - 2	0 - 3

Gradation of Fine Aggregates				
Percentage by Weight Passing Sieves Having Square Openings				
Sieve Designation	Aggregate No.			
	FA-10	FA-10M	FA-12	FA-13
½-inch	--	--	--	--
⅜-inch	100	100	100	100
No. 4	96 - 100	95 - 100	90 - 100	90 -100
No. 8	75 - 100	84 - 100	--	--
No. 16	55 - 98	45 - 95	50 - 86	40 - 80
No. 30	25 - 75	25 - 75	--	--
No. 50	5 - 30	8 - 35	2 - 20	0 - 10
No. 100	0 - 9	0.5 - 20	0 - 5	0 - 3
No. 200	0 - 3	0 – 10*	--	--

* Dust of fracture essentially free from clay or shale, final job site testing only.

C. Coarse Aggregate for Concrete: Coarse aggregates shall conform to the requirements of AASHTO M80, except that the percentage of wear shall not exceed forty-five (45) when tested in accordance with AASHTO T96. Coarse aggregate shall conform to the grading in above table.

D. Fine Aggregate for Concrete: Fine aggregates shall meet South Carolina Department of Transportation, Section 701 requirements and gradation as shown above. Fine aggregate for concrete shall conform to the requirements of AASHTO M6. The amount of deleterious substances removable by elutriation shall not exceed three percent (3%) by dry weight of fine aggregate when tested in accordance with AASHTO T11, unless otherwise specified. The minimum Sand Equivalent, as tested in accordance with AASHTO T176 shall be eighty (80), unless otherwise specified. The Fineness

Modules shall not be less than two and five-tenths (2.50) nor greater than three and five-tenths (3.50), unless otherwise approved.

E. Fly Ash and Water: Upon approval based on a satisfactory trial mix, CONTRACTOR shall have the option of substituting approved fly ash for Portland cement, up to a maximum of twenty percent (20%) by weight. The total weight of cement and fly ash shall not be less than the specified mix design.

1. Fly ash for concrete shall conform to the requirements of ASTM C618, Class C or Class F. All chemical requirements of ASTM C618 Table 1-A shall apply with the exception of footnote A.

2. Class C fly ash will not be permitted where sulfate resistant cement is required.

3. CONTRACTOR shall submit certified laboratory test results for the fly ash. Test results that do not meet the physical and chemical requirements may result in the suspension of the use of fly ash until the corrections necessary have been taken to ensure that the material meets the SPECIFICATIONS.

F. Water used in mixing or curing shall be clean and free of oil, salt, acid, alkali, sugar, vegetable, or other substance injurious to the finished product. Water shall be tested in accordance with, and shall meet the suggested requirements of AASHTO T26. Water known to be of potable quality may be used without test. Where the source of water is relatively shallow, the intake shall be enclosed so as to exclude silt, mud, grass, or other foreign materials.

G. Concrete Curing Materials and Admixtures:

1. Curing Materials: Curing materials shall conform to the following requirements as specified:

a. Burlap Cloth made from Jute or Kenaf: AASHTO M182.

b. Liquid Membrane-Forming Compounds Curing Concrete: AASHTO M148.

c. Sheet Materials for Curing Concrete: AASHTO M171.

d. Straw shall not be used for curing unless approved by ENGINEER.

2. Air-Entraining Admixture: Air-entraining admixtures shall conform to the requirements of AASHTO M154. Admixtures which have been frozen will be rejected. No chloride containing additives shall be permitted.

3. Chemical Admixtures: Chemical admixtures for concrete shall conform to the requirements of AASHTO M194M/M194. Admixtures which have been frozen will be rejected.

4. Joint Fillers: The joint fillers shall meet the requirements of ASTM C920.

PART 3 EXECUTION

3.1 SUBGRADE PREPARATION

A. The subgrade shall be excavated or filled to the required grades and lines. All soft, yielding, or otherwise unsuitable material shall be removed and replaced with suitable material with ENGINEER's approval. Filled sections shall be compacted and compaction shall extend a minimum of six (6) inches outside the form lines.

B. The moisture content of the subgrade shall be brought within +/- two percent (2%) of optimum moisture content and compacted to ninety-five percent (95%) of the maximum standard Proctor density (ASTM D698) for subgrade materials classified as A-4 through A-7 or ninety five percent (95%) of modified proctor density for materials classified as A-1 through A-3.

3.2 CONCRETE PLACEMENT

A. General:

1. Concrete transported in truck mixers or truck agitators shall be delivered to the site of the WORK and completely discharged within a period of ninety (90) minutes after the cement comes in contact with the mixing water or with the combined aggregates containing free moisture in excess of two percent (2%) by weight.

2. The concrete shall be placed either by an approved slip form/extrusion machine, by the formed method, or by a combination of these methods.

3. The subgrade shall be conditioned to provide a uniformly moist surface when concrete is placed.

B. Machine Placement: The slip form/extrusion machine shall be so designed to place, spread, consolidate, screed, and finish the concrete in one (1) complete pass in such a manner that a minimum of hand finishing will be necessary to provide a dense and homogenous concrete section. The machine shall shape, vibrate, and/or extrude the concrete for the full width and depth of the concrete section being placed. It shall be operated with as nearly a continuous forward movement as possible. All operations of mixing, delivery, and spreading concrete shall be so coordinated as to provide uniform progress, with stopping and starting of the machine held to a minimum.

C. Formed Method:

1. The vertical face of previously sawed and adjacent asphalt pavement may NOT be used as a forming surface. CONTRACTOR shall use forms on front and back of all curb and gutter, sidewalks and crosspans.

2. The forms shall be of metal or other suitable material that is straight and free from warp, having sufficient strength to resist the pressure of the concrete without displacement and sufficient tightness to prevent the leakage of mortar. Flexible or rigid forms of proper curvature may be used for curves having a radius of one hundred (100) feet or less. Division plates shall be metal. Where directed by ENGINEER, CONTRACTOR shall use a thin metal back form to preserve landscaping, sprinklers, etc. Form shall be straight and rigid and shall be approved by ENGINEER prior to use on PROJECT.

3. The front and back forms shall extend for the full depth of the concrete. All of the forms shall be braced and staked so that they remain in both horizontal and vertical alignment until their removal. No wooden stakes will be allowed. They shall be cleaned and coated with an approved form-release agent before concrete is placed against them. The concrete shall be deposited into the

forms without segregation and then it shall be tamped and spaded or mechanically vibrated for thorough consolidation. Low roll or mountable curbs may be formed without the use of a face form by using a straight edge and template to form the curb face. When used, face forms shall be removed as soon as possible to permit finishing. Front and back forms shall be removed without damage to the concrete after it has set.

4. Should the removal of adjacent asphalt pavement be required beyond that shown in the asphalt patch detail to properly correct failed concrete sections, CONTRACTOR shall remove and replace said asphalt pavement to such an extent as to provide a smooth repair. ENGINEER shall be notified prior to commencing any additional asphalt removal.

3.3 FINISHING

A. The plastic concrete shall be finished smooth by means of a wood float and then it shall be given final surface texture using a light broom or burlap drag. Concrete that is adjacent to forms and formed joints shall be edged with a suitable edging tool to the dimensions shown on the DRAWINGS.

3.4 JOINTING

A. Contraction Joints:

1. Contraction and construction joints shall be placed at the standard spacing of ten (10) feet in curb, gutter, sidewalks, crosspans, trickle channel, etc. A minimum spacing of five (5) feet shall be allowed for repairs.

2. Transverse weakened-plane contraction joints shall be constructed at right angles to the curb line at intervals not exceeding ten (10) feet for curb and gutter or five (5) feet for sidewalk. Joint depth shall average at least one-fourth (1/4) of the cross-section of the concrete.

3. Contraction joints may be sawed, hand-formed, or made by one-eighth inch (1/8") thick division plates in the formwork. Sawing shall be done early after the concrete has set to prevent the formation of uncontrolled cracking. The joints may be hand-formed either by (1) using a

narrow or triangular jointing tool or a thin metal blade to impress a plane of weakness into the plastic concrete, or (2) inserting one-eighth inch (1/8") thick steel strips into the plastic concrete temporarily. Steel strips shall be withdrawn before final finishing of the concrete. Where division plates are used to make contraction joints, the plates shall be removed after the concrete has set and while the forms are still in place.

B. Expansion Joints:

1. Expansion joints shall be constructed at a maximum interval of 40 inches and at all points of curvature. Expansion joints shall also be at right angles to the curb line at immovable structures and at points of curvature for short radius curves. Filler material for expansion joints shall conform to requirements of the requirements of ASTM C920 and shall be furnished in a single one-half inch (1/2") thick piece for the full depth and width of the joint.

2. Expansion joints in a slip-formed curb or curb-and-gutter shall be constructed with an appropriate hand tool by raking or sawing through partially set concrete for the full depth and width of the section. The cut shall be only wide enough to permit a snug fit for the joint filler. After the filler is placed, open areas adjacent to the filler shall be filled with concrete and then troweled and edged. CONTRACTOR may choose to place the filler and pour the concrete around it.

3. Alternately, an expansion joint may be installed by removing a short section of freshly extruded curb-and-gutter immediately, installing temporary holding forms, placing the expansion joint filler, and replacing and reconsolidating the concrete that was removed. Contaminated concrete shall be discarded.

4. Construction joints may be either butt or expansion-type joints. Curbs or combined curbs-and-gutters constructed adjacent to existing concrete shall have the same type of joints as in the existing concrete, with similar spacing; however, contraction joint spacing shall not exceed ten (10) feet.

3.5 PROTECTION

A. CONTRACTOR shall always have materials available to protect the surface of the plastic concrete against rain. These materials shall consist of waterproof paper or plastic sheeting. For slip-form construction, materials such as wood planks or forms to protect the edges shall also be required. Concrete damaged by rain shall be required to be removed and replaced at CONTRACTOR's expense.

B. Concrete being placed in cold weather during which the temperature may be expected to drop below thirty-five degrees Fahrenheit (35°F), shall be suitably protected to keep the concrete from freezing until it is at least ten (10) days old. Concrete injured by frost action shall be required to be removed and replaced at CONTRACTOR's expense.

C. CONTRACTOR shall be responsible for correcting any vandalism or defacement (graffiti) that occurs on the concrete prior to final acceptance.

3.6 CURING

A. Concrete shall be cured for at least seven (7) days after placement to protect against loss of moisture, rapid temperature change, and mechanical injury prior to any overlay or reconstruction work. Moist burlap, waterproof paper, white polyethylene sheeting, white liquid membrane compound, or a combination thereof may be used as the curing material. Membrane curing shall not be permitted in frost-affected areas when the concrete will be exposed to deicing chemicals within thirty (30) days after completion of the curing period.

3.7 BACKFILLING

A. The spaces in front and back of curbs shall be refilled with suitable material to the required elevations after the concrete has set sufficiently. The fill material shall be thoroughly tamped in layers.

3.8 TOLERANCE

A. Forms shall not deviate from true line by more than one-quarter (1/4) inch at any point.

B. Mixed concrete shall be not less than fifty degrees Fahrenheit (50°F), nor more than eighty degrees Fahrenheit (80°F) at the time of placement in forms, unless otherwise directed.

C. If air temperature is thirty-five degrees Fahrenheit (35°F) or less at the time of placing, ENGINEER shall require water and/or aggregate heated to not less than seventy degrees Fahrenheit (70°F), or more than one-hundred fifty degrees Fahrenheit (150°F).

D. Finished joints shall not deviate more than one-quarter (1/4) inch in the horizontal alignment from a straight line.

E. Any localized humps and or depressions greater than one-quarter (1/4) inch shall require removal and replacement of the WORK in question at CONTRACTORS expense

F. No ponding of water greater than three-eighths (3/8) inch shall be allowed.

G. Combination curb, gutter and walk and/or vertical curb and gutter flowline depth shall not vary from adopted standards by more than +/- one-half (1/2) inch, measured vertically from the top of curb to the gutter invert.

H. Pedestrian walks shall have a slope of two percent (2.0%) slope toward the roadway.

I. Heave or settlement of sidewalk, relative to separate curb pour, greater than one-half (1/2) inch shall be cause for corrective action. This provision shall not apply to transverse sidewalk joints.

3.9 QUALITY CONTROL

A. Testing: Refer to section SCDOT specification section 701.2.12.4.2.4 Acceptance of Concrete.

B. Repair:

1. Prior to backfilling and after forms are removed, honeycombed, defective or damaged areas of concrete shall be repaired.

Repairs shall be made within seven(7) days after the forms are removed.

2. At the time of final acceptance inspection, the repair of all cracks shall be completed.

   a. Cracks that are less than one-quarter (1/4) inch wide, exhibit no horizontal or vertical shifting, and do not meet the conditions in 2, 3, and 4, below may, at the discretion of the OWNER, be sealed by routing approximately three-quarter (3/4) inch to one (1) inch deep by one-quarter (1/4) inch wide and filling with Sikaflex 1-A or equivalent.

   b. Any crack that extends through a joint shall require removal and replacement of the entire cracked area.

   c. Any longitudinal cracked section of concrete shall require complete removal and replacement of that section between joints.

   d. Repair action for hairline cracks as determined in 1, above, may be waived at the discretion of OWNER. For the purpose of this section, a hairline crack is one that is reasonably immeasurable and without separation as determined by ENGINEER.

3.10 CLEAN-UP

A. The surface of the concrete shall be thoroughly cleaned upon completion of the WORK and prior to the substantial completion walk through, and the site left in a neat and orderly condition.

END OF SECTION 32 16 00

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SECTION 32 17 23 – PAVEMENT MARKINGS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Traffic lines, legends and markings on asphalt and concrete surfaces.
   2. Waterborne Traffic Paint.
   3. Thermoplastic Pavement Markings.
   4. Glass beads.

B. Related Sections:
   1. Section 32 12 16 - Asphalt Paving.
   2. Section 32 13 13 - Concrete Paving.

1.2 REFERENCES

A. American Association of State Highway and Transportation Officials:
   1. AASHTO M247 - Standard Specification for Glass Beads Used in Traffic Paint.

B. SCDOT Standard Specifications:
   1. Standard Specifications for Highway Construction, 2015, published by the South Carolina Department of Transportation.

1.3 PERFORMANCE REQUIREMENTS

A. Paint Adhesion: Adhere to road surface forming smooth continuous film one minute after application.

B. Paint Drying: Tack free by touch so as not to require coning or other traffic control devices to prevent transfer by vehicle tires within 10 minutes after application.

1.4 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Product Data: Submit paint formulation for each type of paint and glass beads if required.

C. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

D. Manufacturer's Installation Instructions: Submit instructions for application temperatures, eradication requirements, application rate, line thickness, and application of glass beads if required.

1.5 QUALITY ASSURANCE

A. Perform Work in accordance with Division 600 of SCDOT Standard Specifications.

B. Maintain one copy of document on site.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum 5 years experience.

B. Applicator: Company specializing in performing work of this section with minimum 5 years experience.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Section 01 60 00 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

B. Invert containers several days prior to use when paint has been stored more than two months. Minimize exposure to air when transferring paint. Seal drums and tanks when not in use.

C. Where glass beads are required, store glass beads in cool, dry place. Protect from contamination by foreign substances.

1.8 ENVIRONMENTAL REQUIREMENTS

A. Section 01 60 00 - Product Requirements: Environmental conditions affecting products on site.

B. Do not apply materials when surface and ambient temperatures are outside temperature ranges required by paint product manufacturer or:
   1. Waterborne Paint: Apply when ambient air temperature and surface temperature is minimum 40 degrees F and rising and a maximum of 160 degrees F.
   2. Thermoplastic: Do not apply until ambient air temperature and temperature of the pavement is 50 degrees F or higher.

C. Do not apply materials during rain or snow when relative humidity is outside humidity ranges or moisture content of surfaces exceed those required by paint product manufacturer.

D. Volatile Organic Content (VOC). Do not exceed State or Environmental Protection Agency maximum VOC on traffic paint.

PART 2 PRODUCTS

2.1 PAINTED PAVEMENT MARKINGS

A. Manufactures:
1. Ennis Paint Co., (ennispaint.com).
2. Franklin Paint Company (franklinpaint.com).
3. EZ-Liner Industries (ezliner.com).
4. TAPCO, Inc. (tapconet.com).
5. Pervo Paint Company (pervo.com).
6. Substitutions: Equal per Section 01 60 00 – Product Requirements.

B. Furnish materials in accordance with Division 600 of SCDOT Standard Specifications.

C. Waterborne Paint: Ready mixed, fast dry waterborne traffic paints, lead-free, non-toxic, suitable for roadway or parking lots.

D. Thermoplastic: Alkyd based ready mixed, fast dry, lead free, non toxic, for roadways.

E. Glass Beads: AASHTO M247, Type 1, coated to enhance embedment and adherence with paint.

2.2 EQUIPMENT

A. Roadway Application for Continuous Longitudinal Lines: Use equipment with following capabilities.
1. Dual nozzle paint gun to simultaneously apply parallel lines of indicated width in solid or broken patterns or various combinations of those patterns.
2. Pressurized bead-gun to automatically dispense glass beads onto painted surface, at required application rate.
3. Measuring device to automatically and continuously measure length of each line placed, to nearest foot.
4. Device to heat paint to manufacturer’s temperature recommendation for fast dry and thermoplastic applications.

B. Machine Calibration: Calibrate machines to meet specified tolerances.

C. Other Equipment: For application of crosswalks, intersections, stop lines, legends and other miscellaneous items by walk behind stripers, hand spray or stencil trucks, apply with equipment meeting requirements of this section. Do not use hand brushes or rollers. Optionally apply glass beads by hand.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 30 00 - Administrative Requirements: Verification of existing conditions before starting work.

B. Do not apply paint to concrete surfaces until concrete has cured for 28 days.

3.2 PREPARATION

A. Maintenance and Protection of Traffic:
1. Provide short term traffic control in accordance with Section 01 50 00 - Temporary Facilities and Controls.
2. Prevent traffic from interrupting or driving on newly applied markings before markings dry.
3. Maintain roadway travel lanes between 7:00 a.m. to 9:00 a.m. and between 4:00 p.m. and 6:00 p.m.
4. Maintain access to existing businesses and other properties requiring access.

B. Surface Preparation.
1. Clean and dry paved surface prior to painting.
2. Blow or sweep surface free of dirt, debris, oil, grease, or gasoline.
3. Spot location of final pavement markings as specified and as indicated on Drawings by applying pavement spots 25 feet on center.
4. Notify Engineer after placing pavement spots and minimum three days prior to applying traffic lines.

3.3 EXISTING WORK

A. Remove existing markings in an acceptable manner. Do not remove existing pavement markings by painting over with black paint. Remove by methods that will cause least damage to pavement structure or pavement surface. Satisfactorily repair any pavement or surface damage caused by removal methods.

B. Clean and repair existing or remaining lines and legends.

3.4 APPLICATION

A. Agitate paint for 1-15 minutes prior to application to ensure even distribution of paint pigment.

B. Dispense paint at temperature recommended by manufacturer to wet-film thickness of 15 mils.

C. Dispense thermoplastic at temperature recommended by manufacture to thickness of:
   1. 120 mils for center lines, skip lines, transverse markings, and legends.
   2. 90 mils for edge lines diagonals and arrow symbols.

D. Apply glass beads at rate of 1 to 3 pounds per gallon of paint.

E. Apply markings to indicated dimensions at indicated locations.

F. Prevent splattering and over spray when applying markings.

G. Unless material is track free at end of paint application convoy, use traffic cones to protect markings from traffic until track free.

H. When vehicle crosses a marking and tracks it or when splattering or overspray occurs, eradicate affected marking and resultant tracking and apply new markings.

I. Collect and legally dispose of residues from painting operations.

3.5 APPLICATION TOLERANCES

A. Section 01 40 00 - Quality Requirements: Tolerances.

B. Maximum Variation from Wet Film Thickness: 1 mil.

C. Maximum Variation from Wet Paint Line Width: Plus or minus 1/8 inch.

D. Maintain cycle length for skip lines at tolerance of plus or minus 6 inches per 40 feet and line length or plus or minus 3 inches per 10 feet.

E. Maximum Variation from Specified Application Temperature: Plus or minus 5 degrees F.

3.6 FIELD QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Field inspecting, testing, adjusting, and balancing.

B. Inspect for incorrect location, insufficient thickness, line width, coverage, retention, uncured or discolored material, and insufficient bonding.

C. Repair lines and markings which after application and curing do not meet following criteria:

1. Incorrect Location: Remove and replace incorrectly placed patterns.

2. Insufficient Thickness, Line Width, Paint Coverage, Retention or Glass Bead Coverage (where required): Prepare defective material by acceptably grinding or blast cleaning to remove substantial amount of beads and to roughen marking surface. Remove loose particles and debris. Apply new markings on cleaned surface in accordance with this Section.

3. Uncured or Discolored Material, Insufficient Bonding: Remove defective markings in accordance with this Section and clean pavement surface one foot beyond affected area. Apply new markings on cleaned surface in accordance with this Section.

D. Replace failed or defective markings in entire section of defective markings within 30 days after notification when any of the following exists:
1. Marking is discolored or exhibits pigment loss and is determined to be unacceptable by visual comparison with beaded color plates.
2. If glass beads are used, the average retro-reflectivity is less than 375 mcd/m2/1x for white pavement markings and 250 mcd/m2/1x for yellow pavement markings.

E. When eradication of existing paint lines is necessary, eradicate by shot blast or water blast method. Do not gouge or groove pavement more than 1/16 inch during removal. Limit area of removal to area of marking plus 1 inch on all sides. Prevent damage to transverse and longitudinal joint sealers and repair any damage according to requirements in Section 32 12 16 or Section 32 13 13.

F. Maintain daily log showing work complete, results of inspections or tests, pavement and air temperatures, relative humidity, presence of any moisture on pavement, and any material or equipment problems. Make legible entries in log in ink, sign, and submit by end of each work day. Enter environmental data into log prior to starting work each day and at two additional times during day.

3.7 PROTECTION OF FINISHED WORK

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for protecting finished Work.

B. Protect painted pavement markings from vehicular and pedestrian traffic until paint is dry and track free. Follow manufacturer's recommendations or use minimum of 30 minutes. Consider barrier cones as satisfactory protection for materials requiring more than two minutes dry time.

3.8 SCHEDULES

A. Pavement Markings:

Items	Location
4 inch white paint	Parking lot lines
4 inch yellow paint	Parking lot lane lines
24 inch white paint	Stop line
4 inch yellow paint	Roadway center lines
4 inch white paint	Roadway edge lines
8 inch skip white paint	Roundabout circulating lane edge at approaches
8 inch solid white paint	Crosswalk edge lines
4 inch solid white paint	Exit plaza merge striping

END OF SECTION 32 17 23

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SECTION 328400 IRRIGATION SYSTEM

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Work to be done includes furnishing all of the materials, labor, equipment and services to provide a complete, automatic landscape irrigation system as indicated on the Drawings, in these Specifications or both.

B. The mechanical point of connection for the irrigation system shall be to an existing irrigation water supply located in the terminal basement. The system is designed for a maximum flow of 16 gallons per minute at a minimum of 60-psi dynamic pressure at the point of connection to the existing supply. Contractor shall test available flow and pressure prior to starting work and report any deficiencies to the Owner's Representative immediately.

C. The electrical point of connection for the irrigation system shall be to the existing irrigation controller power supply located in the terminal basement. Controller to be hard wired to power source – pig tails will not be accepted. All wiring within the basement shall be installed in electrical conduit.

D. The Drawings and Specifications shall be interpreted together and are intended to complement each other. The Contractor shall provide parts required by the Drawings and omitted in the Specifications, or vice versa, as if they were included in both. If the Contractor notices any discrepancies or has a question of intent, the Contractor shall notify the Irrigation Consultant and his decision shall be final and binding.

E. All necessary changes to the Drawings to avoid obstacles or to conform to the final landscape layout shall be made by the Contractor with approval by the Irrigation Consultant.

F. Work shall be done in a professional, workman like manner to the full intent of the Drawings and Specifications. The Contractor shall dispose of all waste generated by the construction of the irrigation system on a daily basis.

1.03 PRECONSTRUCTION SUBMITTALS

A. Product Data: For each type of product required, include rated capacities, operating characteristics and furnished specialties and accessories. Where multiple models are listed on a manufacturer's product data, clearly indicate the model being submitted.

B. Qualification Data:

1. Irrigation Contractor shall have a minimum of five (5) years of experience installing systems of similar size and complexity.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Manual: The Irrigation Contractor shall provide three (3) binders labeled OPERATION AND MAINTENANCE INSTRUCTIONS FOR THE GSP AIRSIDE GARDEN IRRIGATION SYSTEM. The following information shall be included in the manual:

1. Owner's manuals indicating adjustment and maintenance for all components in the irrigation system
2. Copies of the Approved product submittals
3. One copy of the irrigation system Record Drawing
4. Winterization and Spring start-up procedures
5. Warranty information
6. Irrigation Contractor's contact information

1.05 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. Sprinklers and Nozzles: Equal to 1 percent of amount installed for each type and size indicated, but no fewer than 5 units of each.
2. Drip-Tubing: Equal to 1 percent of total length installed for each type and size indicated, but not less than 100 feet.
3. Valves: 1 of each type (manual, automatic) and size indicated.
4. Quick Coupling Valve Keys: Equal to 1 key for every five quick coupling valves used on the project. Each key shall include a ¾-inch hose swivel.

1.06 DELIVERY, STORAGE, AND HANDLING

A. All materials are to be new and without flaws.

B. Maintain piping through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture. Piping shall not be stored directly on bare soil. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

C. Only store materials on site that are to be used for the construction of the system

PART 2 - PRODUCTS

2.01 GENERAL

A. All materials to be utilized in this system shall be new and without flaws or defects and of quality and performance as specified and meeting the requirements of the system. All excess material at the completion of the installation are the property of the Contractor and shall be removed from the site.

B. No material substitutions from the products described in these Specifications and shown on the Drawings shall be made without prior approval and acceptance from the Irrigation Consultant.

2.02 PVC IRRIGATION PIPE

A. All pipe 2-1/2 inch and smaller shall be PVC, Schedule 40, Type 1120, Solvent-Weld PVC, conforming to ASTM No. D2241.

B. Pipe shall be as manufactured by Cresline, Texas United Pipe, JM or equal.

2.03 WIRE CONDUIT

A. Conduit for above and below ground wiring shall be Schedule 80 PVC electrical conduit, size as indicated on the details. Conduit shall be installed for all wire under non-soil areas and where indicated on the Drawings.

2.04 PVC PIPE SLEEVES

A. Sleeves shall be installed for all irrigation pipe and wire under non-soil areas and where indicated on the Drawings. Minimum sleeve size shall be three (3”) inch Schedule 80 PVC.

2.05 PVC PIPE FITTINGS

A. Fittings for solvent weld PVC pipe shall be Schedule 40 solvent weld PVC fittings. Threaded fittings shall be Schedule 80 PVC.

B. PVC solvent shall be NSF approved, for Type I and Type II PVC pipe, and Schedule 40 fittings. Cement is to meet ASTM D2564 and FF493 for potable water pipes. PVC solvent cement shall be used in conjunction with the appropriate primer. Primer shall be purple primer complying with ASTM-F656.

C. Fittings for solvent weld PVC pipe shall be as manufactured by Dura, Lasco, Spears or equal.

2.06 VALVE BOXES

A. All valve boxes shall be manufactured from unformed resin with a tensile strength of 3,000-4,000 psi conforming to ASTM D638.

B. Valve boxes for single electric valves, isolation valves, quick coupling valves and wire splices shall be 10-inch round valve boxes.

C. Valve boxes for dual electric valves shall be 12-inch standard rectangular valve boxes.

D. Valve boxes for drip control valves with filter and pressure regulator shall be 12-inch standard rectangular valve boxes.

E. Valve boxes for drip flushing valves and air/vacuum relief valves shall be 6-inch round valve boxes.

F. All valve box covers shall have a Tee-shaped lid construction and capable of withstanding lawn tractor traffic.

G. Valve box extensions shall be provided as required.

H. Valve boxes shall be as manufactured by Pentek, NDS Pro Series, Carson Specification Grade or approved equal.

2.07 QUICK COUPLING VALVES

A. The valve body shall be of cast brass construction with a Working pressure of 125 psi. The valve seat disc plunger body shall be spring loaded so that the valve is normally closed under all conditions when the key is not inserted.

B. The top of the valve body receiving the key shall be equipped with a single slot and smooth face to allow the key to open and close the valve slowly with a one-half turn. The quick coupling valve shall be equipped with a locking vinyl cover.

C. The valve body construction shall be such that the coupler seal washer may be removed from the top for cleaning or replacement without disassembling any other parts of the valve.

D. Quick coupling valves shall be installed on three-quarter (3/4") inch prefabricated PVC triple elbow swing joint. Swing joint shall be a minimum twelve (12") inches in length. Installation shall be as per detail.

E. Keys shall be single lug with 3 three-quarter (3/4") inch male thread at the top.

F. Quick coupling valves shall be as manufactured by Rain Bird model 3RC or approved equal.

2.08 ELECTRIC CONTROL VALVES

A. Electric control valves shall be molded valves with 24-volt solenoid, diaphragm type, fiberglass or reinforced nylon body plastic valves with manual flow control, manual bleed screw and 200 psi pressure rating. Valves shall be globe configuration.

B. Electric control valves shall be as manufactured by Rain Bird model PEB or approved equal.

2.09 MASTER VALVE

A. Electric control master valve shall be 24-volt solenoid, diaphragm type, brass valve with manual flow control, manual bleed screw and 200 psi pressure rating. Valve shall be globe configuration.

B. Electric control master valve shall be as manufactured by Rain Bird model 100-EFB-CP or approved equal.

2.10 ISOLATION VALVES

A. Isolation gate valves 2½-inches and smaller shall be of bronze construction, US Manufacture, 600 WOG with steel cross handle and 200 psi rating as manufactured by NIBCO, Apollo, Watts or approved equal.

2.11 WIRE

A. All wire shall be single-strand, solid copper, 600v, direct burial (UF) and shall meet all state and local codes for this service. Individual wires must be used for each zone valve. Wire colors and sizes shall be as indicated below:

Wire	Color	Size
Common	White	14AWG
Lawn Zone Control	Red	14AWG
Landscape Zone Control	Blue	14AWG
Spare	Gray	14AWG

B. In ground wire connections shall be rated at 600 volts and UL listed under UL486D. Wire connections shall include gel filled tubes that compresses the wire insulation when closed to provide strain relief on the wire connection inside the tube. All wire splices shall be made in valve boxes, at controller, or at valves. Wire connectors shall be 3M DBR/Y or approved equal.

C. Wire type and method of installation shall be in accordance with local codes for NEC Class II circuits of 30-volt A.C. or less.

2.12 SMALL ROTARY SPRINKLERS

A. The sprinkler shall be of the gear-driven, rotary type, capable of covering a 25-45 foot radius at 45 PSI with a discharge rate of 1.0-8.0 GPM. The sprinkler shall have radius adjustment capabilities by means of a stainless-steel nozzle retainer/radius adjustment screw. The sprinkler shall have an in-turret flow shut-off feature that will enable the user to stop the water flow through an individual sprinkler head.

B. The sprinkler shall be both full-circle and adjustable part-circle operation in a single unit. The sprinkler shall be minutely adjustable from 50° to 360°. It shall be adjustable in all phases of installation (i.e., before installation, after installation while static, and after installation while in operation). The sprinkler shall be equipped with a self-adjusting stator to ensure constant rotation speed regardless of nozzle installed.

C. The sprinkler shall have a non-strippable drive mechanism that allows the nozzle turret to be turned during operation, without damage. It shall also have an automatic arc return feature that returns the nozzle turret to its proper orientation if it is turned outside its intended arc of coverage.

D. The sprinkler shall have a minimum of 4-inch pop-up stroke from the cap to the rotating nozzle turret. The sprinkler shall have a rubber cover firmly attached to the top of the sprinkler riser. The sprinkler shall be equipped with a drain check valve to prevent low head drainage, and be capable of checking up to 10 feet in elevation change. The sprinkler shall have a 3/4-inch Female National Pipe Thread (FNPT) inlet. The sprinkler shall be serviceable after installation in the field by unscrewing the body cap, removing the riser assembly, and extracting the inlet filter screen.

E. The body and riser of the sprinkler shall be constructed of corrosion resistant, impact resistant, heavy-duty A.B.S. It shall have a stainless steel spring for positive retraction of the riser when irrigation is complete.

F. Mount small rotary sprinklers on an 18” maximum length of ½” polyethylene tubing. Tubing to withstand 400 psi burst test and shall have a wall thickness of 0.1”. Fittings for tubing shall be compatible and made by the same manufacturer.

G. Sprinklers shall be manufactured by Rain Bird model 5004+PC(FC)SAM or approved equal.

2.13 AUTOMATIC CONTROLLER

A. The controller shall have four independent programs with minimum four start times per program. Any two programs shall have the capability of running concurrently. Watering times shall be available from 1 minute to 12 hours in 1-minute increments per station.

B. Controller shall have seasonal adjust as well as cycle and soak features.

C. Controller shall include a lockable weather proof enclosure with internal transformer. Controller shall have a station capacity to include one station per electric control valve plus a minimum of two spare stations.

D. Controller shall be able to react to automatically learn station flow rates, react to flows outside of programmed parameters (high or low flow) and manage the number of stations operating simultaneously automatically to maximize the water supply capacity.

E. Controller shall have a weather module that automatically receives weather data and adjusts the irrigation system operation accordingly.

F. Controller shall be as manufactured by Rain Bird model ESP16LXMEF with ET Manager Cartridge or approved equal.

2.14 FLOW METER

A. Flow meter shall be 1-inch in size mounted in a brass tee. Flow meter shall be removable from the tee and held in place with a retaining nut. Flow meter shall have a rated working pressure of 150psi and a recommended flow range of 0.25–12fps.

B. Flow meter shall have an accuracy better than ±1% within recommended flow range and repeatability better than ±0.3% within recommended flow range.

C. Flow meter impeller shall be high density polyethylene, shaft shall be tungsten carbide and have a BUNA N o-ring.

D. Flow meter shall be as manufactured by Rain Bird model FS100B or approved equal.

2.15 AUTOMATIC RAIN SENSOR

A. The rain sensor shall be plastic in construction and have adjustable interrupt settings from 1/8” to 3/4”. Sensor shall hard wire directly to the controller. Sensor shall have ½” male threads for mounting to a conduit. All above ground sensor wiring to be installed in schedule 80 PVC electrical conduit.

B. Sensor shall be as manufactured by Rain Bird model RSD-CEx or approved equal.

2.16 DRIP TUBING

A. Drip tubing shall have in-line, pressure compensating emitters with integral check valves. Emitter shall be spaced 12-inches on center along the tubing. Emitter shall have a flow rate of 0.6gph.

B. Drip tubing shall be as manufactured by Netafim model TLCV6-12, Hunter Industries model PLD- 06, Rain Bird model XFCV-6-12 or approved equal.

2.17 DRIP FLUSHING VALVES

A. Line flushing valves shall be installed on drip zone exhaust headers and shall automatically flush approximately 1 gallon of water and debris at the start of zone operation and then close. Valve shall have ½-inch male threads.

B. Line flushing valves shall be as manufactured by Netafim model TL050MFV-1 or approved equal.

2.18 AIR/VACUUM RELIEF VALVES

A. Air/vacuum relief valves shall be installed at the high points within a drip zone. The valve shall allow air into the drip tubing to prevent the development of a vacuum within the tubing. The valve shall also release air from the tubing during zone operation.

B. Air/vacuum relief valves shall be as manufactured by Netafim model TLAVRV, Rain Bird model ARV050 or approved equal.

2.19 DRIP ZONE CONTROL KITS

A. Electric control valves shall be molded valves with 24-volt solenoid, diaphragm type, fiberglass or reinforced nylon body plastic valves with manual flow control, manual bleed screw and 200 psi pressure rating. Valves shall be globe configuration.

B. Pressure regulators for drip zones shall be capable of handling the entire flow of the drip zone either individually or manifolded. Regulator shall regulate the downstream pressure to 45-psi.

C. Filters shall have minimum 140-mesh equivalent filtration and have either stainless steel screens or disks. Filter element shall be removable for cleaning.

D. Drip zone control kits shall be as manufactures by Rain Bird model XCZ-PRB, Hunter Industries model ICZ, or approved equal.

PART 3 - EXECUTION

3.01 GENERAL

A. The Consultant shall make frequent observations of the Contractor's work while such work is in progress. The Consultant shall bring to the attention of the Contractor any work which does not meet the specifications of the contract and the Contractor shall correct such work as brought to his attention.

B. Staking of sprinkler locations shall be done by the Contractor and approved by the Consultant. Location shall be according to the plans provided with field modifications to adjust for local conditions and actual plant locations, both existing and proposed. Coordinate with other trades (landscaping and other site Work trades). The Contractor shall be responsible for full and complete coverage of all irrigated areas and shall make any necessary minor adjustments. The Irrigation Contractor shall coordinate with the Landscape Contractor to ensure that the irrigation system conforms to the landscape layout. Major changes shall be reviewed with the Consultant prior to proceeding. The Contractor shall denote all changes on the Record Drawings in accordance with Contract Documents.

C. At all times, protect existing irrigation, landscaping, paving, structures, walls, footings, etc. from damage. Any inadvertent damage to the Work of another trade shall be reported and repaired at once.

3.02 PIPE AND FITTINGS INSTALLATION

A. The Contractor shall have all utilities located prior to beginning trenching. The Contractor shall exercise reasonable care to avoid causing damage to any and all underground utilities and structures. It is the Contractor's responsibility to locate and to protect all utilities. Any damage to utilities shall be corrected and paid for by the Contractor.

B. All excavation shall be unclassified and shall include all materials encountered except materials which cannot be excavated by normal mechanical excavation means. Such exceptions shall be brought to the attention of the Consultant and an adjustment in price shall be agreed upon before excavation of these areas proceeds. Such price adjustments and agreement shall include responsibility for disposal of the unsuitable materials removed from the trench and the acquiring of additional backfill materials.

C. On existing sodded areas, sod shall be removed, preserved, and replaced once backfilling is accomplished.

D. If trenching is necessitated through existing asphalt roadways, the Contractor shall saw cut asphalt to the width of the trench prior to trenching unless noted otherwise on the plan. Removal of cut asphalt and replacement of all asphalt shall be the responsibility of the Contractor. No trenching shall be done in existing asphalt or concrete paving without prior approval from the Consultant.

E. Using proper width trencher chain, excavate a straight and true trench to a depth of 2-inches below pipe invert elevation.

F. Loam encountered within the limits of trench excavation for irrigation mains and branch lines shall be carefully removed to the lines and depths as shown on the Drawings and stockpiled for subsequent replacement in the upper 6 inches of the trench from which it is excavated. Such removal and replacement of the quantities of loam shall be considered incidental to the irrigation system and no additional compensation will be allowed.

G. Pipe shall be laid on undisturbed trench bottom provided suitable base is available with no rock larger than 1 inch or sharp edges; if not, excavate to 2 inch below pipe invert and provide sand base or 95% compacted soil upon which to lay pipe.

H. Backfilling shall be accomplished as follows: the first 10-inch of backfill material shall contain no foreign matter and no rock larger than 1 inch in diameter. Carefully place material around pipe and wire and tamp in place. Remainder of backfill shall be placed in (6”) six inch maximum lifts and tamped to compaction with mechanical equipment matching adjacent undisturbed area. Frozen material shall not be used for backfill.

I. Make all solvent-weld joints in strict accordance with manufacturer's recommendations, making certain not to apply an excess of primer or solvent, and wiping off excess solvent from each connection. Allow connections to set minimum 24 hours before pulling or pressure is applied to the system. Provide for expansion and contraction as recommended.

J. Mainline pipe shall have minimum 24 inches of COVER (excavate to invert as required by pipe size). Lateral pipe shall have minimum 18 inches of COVER (excavate to invert as required by pipe size).

K. Cut plastic pipe with handsaw or pipe-cutting tool, removing all burrs at cut ends. All pipe cuts are to be square and true. Bevel cut end, as required, to conform to Manufacturer's Specifications.

L. Every precaution shall be taken to prevent foreign material from entering the pipe while it is being placed in the trench. At times when installation of the piping is not in progress, the open end(s) of the pipe shall be closed by a watertight plug or other means. All piping, which cannot temporarily be joined, shall be sealed to make as watertight as possible. Pipe not to be installed that day shall not be laid out. Should water enter the trench during or after installation of the piping, no additional piping may be installed or back filled until all water is removed from the trench. Pipe shall not be installed when water is in the trench, when precipitation is occurring, or when the ambient temperature is at 35 degrees F or below. PVC pipe shall be snaked in the trench to accommodate for expansion and contraction due to changes in temperature.

M. In installing irrigation pipe the Contractor shall route the pipe as necessary to prevent damage to tree roots. Where trenching must occur near trees, the Contractor shall provide proper root pruning and sealing methods to all roots 1 inch and larger.

N. Throughout the guarantee period it will be the responsibility of the Contractor to refill any trenches that have settled due to incomplete compaction.

O. All PVC may be installed by standard trenching techniques. Plowing or pulling in of pipe will be allowed provided the proper installation depth can be maintained.

P. Lateral pipes and fittings shall be installed in accordance with the manufacturer's recommendations, including the snaking-in of the PVC pipe to accommodate for expansion and contraction due to changes in temperature.

3.03 ELECTRICAL WIRE CONDUIT INSTALLATION

A. Electrical conduit shall be installed for all above ground wiring to controller and rain sensor and for wiring installation below non-soil areas.

3.04 PIPE SLEEVING INSTALLATION

A. Contractor shall be responsible to coordinate installation of required sleeves beneath pavement. Sleeves shall have a minimum cover of 24-inches (excavate to invert as required). Sleeves are to be provided for all piping installed below non-soil areas.

3.05 ISOLATION VALVE INSTALLATION

A. Install isolation valves on mainline per detail where indicated on the Drawings. Install specified valve box over each mainline isolation valve.

3.06 VALVE BOX INSTALLATION

A. Furnish and install a valve access box for each electric valve, quick coupling valve, isolation valve, air/vacuum relief valve, line flushing valve and wire splice.

B. The valve box lid shall be set flush with the adjacent grade.

3.07 QUICK COUPLING VALVE INSTALLATION

A. Provide quick coupling valves where indicated on the Drawings.

B. Quick coupling valves shall be installed on one (1”) inch prefabricated PVC triple elbow swing joint with stabilizer. Swing joint shall be a minimum twelve (12”) inches in length. Installation shall be as per detail.

3.08 24 VOLT CONTROL VALVE INSTALLATION

A. Control valves shall be set plumb with adjusting handle and all bolts, screws and wiring accessible through the valve box opening.

B. Adjust zone valve operation after installation using flow control device on valve.

3.09 WIRING INSTALLATION

A. Wiring shall be installed along with the mainline. Multiple wire bundles shall be laid beside, and at the same invert as, the irrigation lines. Sufficient slack for expansion and contraction shall be maintained and wiring shall at no point be installed tightly. Provide an additional 8 inches to 12 inches slack at all changes of direction. Wiring in valve boxes shall be a sufficient length to allow the valve solenoid, splice, and all connections to be brought a minimum of two feet above grade for servicing. This additional slack shall be coiled for neatness in the valve box. Each valve shall have a separate wire back to the controller.

B. All wire shall be laid in trenches and shall be carefully back-filled to avoid any damage to the wire insulation or wire conductors themselves. In areas of unsuitable material, the trench shall have a 2 inch layer of sand or stone dust on the bottom before the wires are laid into the trench and back- filled. The wires shall have a minimum of 12 inches of cover when installed in a separate trench from the irrigation piping. Wire not to be installed that day shall not be laid out.

C. An expansion curl shall be provided within 6 inches of each wire connection to a solenoid and at least every 100 feet of wire length on runs more than 100 feet in length. Expansion curls can be formed by wrapping five (5) turns of wire around a 1-inch diameter or larger pipe, then withdrawing the pipe.

D. Provide control wiring for 24-volt service in accordance with the Drawings and state and local codes. All in-ground wire connections shall be made with wire nuts and a waterproof connection. All splices shall be made in valve boxes (wire runs requiring splices between valve locations shall be provided in splice box). Splice locations shall be shown on the Record Drawings.

E. Contractor shall provide a complete wiring diagram showing wire routing for the connections between the controller and valves. See section one for the inclusion of wiring diagram in operation and maintenance manuals.

3.10 CONTROLLER INSTALLATION

A. Install controller where indicated on the drawings. Coordinate location with electrical contractor to ensure proper location of the electrical circuit and wire controller to 120-volt electrical supply.

B. Wire valves and sensors to controller and set proper program.

C. Keys shall be turned over to Owner's Representative.

3.11 SPRINKLER INSTALLATION

A. Mount small rotary sprinklers on an 18” maximum length of ½” polyethylene tubing. Tubing to withstand 400 psi burst test and shall have a wall thickness of 0.1”. Fittings for tubing shall be compatible and made by the same manufacturer.

B. Staking of sprinkler locations shall be done by the Contractor and approved by the Owner's Representative. Location shall be according to plans provided with field modifications to adjust to local conditions and actual plant locations, both existing and proposed. The Contractor shall be responsible for full and complete coverage of all irrigated areas and shall make any necessary minor adjustments.

3.12 DRIP TUBING

A. Drip tubing in planting beds shall be installed in rows 18-inches on center. Supply and exhaust manifolds are to be provided at the drip zone connect to the valve and at the ends connecting all tubing rows together.

B. Drip tubing tree rings shall be installed in sizes as shown on the details based on the tree's mature size. The inner ring shall be isolatable using an in-line shut off valve allowing the ring to be removed as the tree matures to prevent girdling.

C. Tubing shall be staked every 5 feet to prevent movement.

D. Tubing shall be installed below the mulch at a maximum depth of 4-inches below finished grade. No tubing shall be visible.

3.13 LINE FLUSHING VALVE

A. Drip line flushing valves shall be installed on the drip zone exhaust headers in a 6-inch round valve boxes. A 10-inch diameter by 12-inch deep gravel sump shall be provided beneath the valve box.

3.14 AIR/VACUUM RELIEF VALVE

A. Drip air/vacuum relief valves shall be installed at the high points in the zone in a 6-inch round valve box.

3.15 TESTING AND SYSTEM

A. Testing System: Upon completion of the irrigation system and after sufficient time has been allowed for solvent weld joints to cure, the entire system shall be tested for proper operation. All air will be flushed from the system and the Contractor will check all components for proper operation.

B. Balancing and Adjustment: The Contractor shall balance and adjust the various components of the sprinkler system so the overall operation of the system is most efficient. This includes a synchronization of the controllers, adjustments to pressure regulators, pressure relief valves, part circle sprinkler heads, and individual station adjustments on the controllers.

C. Operational Testing: Perform operational testing after hydrostatic testing, backfill is in place, and sprinkler heads are adjusted to final position. Demonstrate to Owner that the completed system meets coverage requirements and that automatic controls function properly.

D. Final Grades at Heads: After completion of grassing, planting and mulching and settlement with establishment of the final grades, carefully adjust all irrigation equipment so it will be flush with or not more than 1/4" above grade.

E. Notice of Substantial Completion:

F. When the Contractor is satisfied the system is operating properly, and all work and clean-up is completed, then he shall issue the notice of substantial completion to the Owner no less than ten

(10) working days prior to requested review. The notice of completion shall include the request for final inspection on which date and time will be given.

G. Final Inspection with Consultant: The Consultant will respond to the notice of completion by the Contractor and shall appear at an agreed upon time for the final inspection. The Consultant shall note any inconsistencies on the plans or specifications and a written copy of corrections shall be given to the Contractor.

H. Guarantees: The Work included under this contract shall be guaranteed by the Contractor against all defects and malfunctions due to faulty workmanship or defective material for a period of one year from the date of substantial completion as deemed by the Owner. Upon being informed by the Owner of any defects or malfunctions, the Contractor shall make all necessary repairs and/or replacements within 48 hours maximum at no additional cost to the Owner. The Owner may make emergency repairs, when necessary, without relieving the Contractor of his guarantee obligation. The Contractor shall be obligated to repair any settling of backfilled trenches, which may occur during the guarantee period. The Contractor is also obligated to restore any and all damaged plantings, paving, or improvements due to trench settlement or repairs within the year period.

3.16 CLEANING AND ADJUSTING

A. Adjust sprinkler heads, valve boxes, and quick coupling valves to grade as required to avoid damage by mowing operations.

B. Continue sprinkler coverage adjustment as required by settlement, etc., throughout the guarantee period.

C. Each control zone shall be operated for a minimum of 5 minutes and all heads checked for consistency of delivering water. Adjustments shall be made to sprinklers that are not consistent to the point that they match the manufacturer's standards. All sprinklers, valves, timing devices or other mechanical or electrical components, which fail to meet these standards, shall be rejected, replaced and tested until they meet the manufacturer's standards.

D. Upon completion of all installation Work, Contractor shall remove all leftover materials and equipment from the site in a safe and legal manner.

3.17 ACCEPTANCE AND OPERATION BY OWNER’S REPRESENTATIVE

A. The Contractor shall provide and keep up to date a complete set of record drawings which shall be corrected daily to show changes in sprinkler locations, controller locations, wire sizes and locations, piping locations, pipe sizes, and any deviations from the original irrigation design drawing as provided to him. All isolation valve locations, backflow prevention, water meters, and quick couplers shall be shown with actual measurements to reference points so they may be located easily in the field.

B. Upon completion of the work, the Contractor shall furnish the Owner with a complete set of record drawings showing the irrigation system as installed.

C. The Contractor shall furnish, in addition to the Record Drawings and operational manuals, copies of all available specification sheets and catalog sheets to the Owner's personnel responsible for the operation of the irrigation system. The Contractor shall guarantee all parts and labor for a minimum period of one (1) year from date of substantial completion.

END OF SECTION 32 84 00

SECTION 329200 - 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. Sprigging.
5. Planting soil and amendments.
6. Erosion-control materials (turf related only)
7. Maintenance.

1.3 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 Grass Seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.

1. Certification of each seed mixture for turfgrass sod. Include identification of source and name and telephone number of supplier.

C. Qualification Data: For qualified landscape Installer.

D. Product Certificates: For soil amendments and fertilizers, from manufacturer.

E. Material Test Reports: Soil analysis report for standardized ASTM D 5268 topsoil existing in-place surface soil.

F. Sod Installation Schedule: Provide schedule of installation dates for sod. Do not install dormant sod without prior approval of Architect.

G. Minutes of preinstallation conference.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape Installer whose work has resulted in successful [turf]establishment.

1. Experience: Five years' experience in [turf][and][meadow] installation in addition to requirements in Division 01 Section "Quality Requirements."
2. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.

3. Maintenance Proximity: Not more than two hours' normal travel time from Installer's place of business to Project site.
4. Pesticide Applicator: State licensed, commercial.

B. 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.

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 turf growth.

    a. Based on the test results, state recommendations for soil treatments and soil amendments to be incorporated. State recommendations in weight per 1000 sq. ft. or volume per cu. yd. 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. Preinstallation Conference: Conduct conference at Project site.

E. Authorities Having Jurisdiction: Conform to requirements of all authorities having jurisdiction.

1. Where conflicts exist between the requirements of the Contract Documents and those of authorities having jurisdiction, the higher quality or more restrictive requirement shall apply.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, as applicable.

B. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver sod in time for planting within 24 hours of harvesting. Protect sod from breakage and drying.

C. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Accompany each delivery of bulk fertilizers, lime, and soil amendments with appropriate certificates.

1.6 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, base course, or setting beds.

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.

1.7 MAINTENANCE SERVICE

A. Initial 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 Final Completion of project.

PART 2 - PRODUCTS

2.1 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.

B. Seed Species: State-certified seed of grass species as follows:

1. Seed: as indicated on Plant Schedule.

2.2 TURFGRASS SOD

A. Turfgrass Sod: Certified Number 1 Quality/Premium, including limitations on thatch, weeds, diseases, nematodes, and insects, complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture, strongly rooted, and capable of vigorous growth and development when planted.

1. Turfgrass Species: as indicated on Plant Schedule.
2. Sod shall be delivered to the project site within twenty four (24) hours after harvest at the nursery, and shall be sheltered from the sun and wind until planted by the Contractor.
3. Contractor shall lay sod within thirty six (36) hours after harvest. Sod shall not be laid where the roots have dried due to exposure from the sun and wind, or has thinned for these or other reasons.

2.3 INORGANIC SOIL AMENDMENTS

A. Provide inorganic soil amendments in quantities and proportions recommended by soil analysis report.

B. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
1. Class: O, with a minimum of 95 percent passing through No. 8 sieve and a minimum of 55 percent passing through No. 60 sieve.
2. Provide lime in form of ground dolomitic limestone.

C. Sulfur: Granular, biodegradable, containing a minimum of 90 percent sulfur, and with a minimum of 99 percent passing through No. 6 sieve and a maximum of 10 percent passing through No. 40 sieve.

D. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.

E. Aluminum Sulfate: Commercial grade, unadulterated.

F. Perlite: Horticultural perlite, soil amendment grade.

G. Agricultural Gypsum: Minimum 90 percent calcium sulfate, finely ground with 90 percent passing through No. 50 sieve.

H. Sand: Clean, washed, natural or manufactured, and free of toxic materials.

I. Diatomaceous Earth: Calcined, 90 percent silica, with approximately 140 percent water absorption capacity by weight.

J. Zeolites: Mineral clinoptilolite with at least 60 percent water absorption by weight.

2.4 ORGANIC SOIL AMENDMENTS

A. Provide organic soil amendments in quantities and proportions recommended by soil analysis report.

B. 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 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.

C. Sphagnum Peat: Partially decomposed sphagnum peat moss, finely divided or of granular texture, with a pH range of 3.4 to 4.8.

D. Wood Derivatives: Decomposed, nitrogen-treated sawdust, ground bark, or wood waste; of uniform texture and free of chips, stones, sticks, soil, or toxic materials.

1. In lieu of decomposed wood derivatives, mix partially decomposed wood derivatives with ammonium nitrate at a minimum rate of 0.15 lb/cu. ft. of loose sawdust or ground bark, or with ammonium sulfate at a minimum rate of 0.25 lb/cu. ft. of loose sawdust or ground bark.

E. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, and material harmful to plant growth.

2.5 FERTILIZERS

A. Provide fertilizers in quantities and proportions recommended by soil analysis report.

B. Bonemeal: Commercial, raw or steamed, finely ground; a minimum of 4 percent nitrogen and 20 percent phosphoric acid.

C. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.

D. 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: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

E. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:

1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

2.6 PLANTING SOILS

A.

A. At Contractor's option, provide one or more of the following planting soils. All soils used for planting shall be prepared as necessary using soil amendments and fertilizers in the quantities recommended in the soil analysis report to produce satisfactory planting soil suitable for healthy, viable plants.

1. Planting Soil: ASTM D 5268 topsoil, with pH range of 5.5 to 7, a minimum of 6 percent organic material content; free of stones 1 inch or larger in any dimension and other extraneous materials harmful to plant growth. Mix ASTM D 5268 topsoil with soil amendments and fertilizers in the quantities recommended in the soil analysis report to produce planting soil.
2. Planting Soil: Existing, in-place surface soil. Verify suitability of existing surface soil to produce viable planting soil. Remove stones, roots, plants, sod, clods, clay lumps, pockets of coarse sand, concrete slurry, concrete layers or chunks, cement, plaster, building debris, and other extraneous materials harmful to plant growth. Mix surface soil with soil amendments and fertilizers in the quantities recommended in the soil analysis report to produce planting soil.
3. Planting Soil: Imported topsoil or manufactured topsoil from off-site sources. Obtain topsoil displaced from naturally well-drained construction or mining sites where topsoil occurs at least 4 inches deep; do not obtain from agricultural land, bogs, or marshes.

    a. Additional Properties of Imported Topsoil or Manufactured Topsoil: Screened and free of stones 1 inch or larger in any dimension; free of roots, plants, sod, clods, clay lumps, pockets of coarse sand, paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials harmful to plant growth; free of obnoxious weeds and invasive plants including quackgrass, Johnsongrass, poison ivy, nutsedge, nimblewill, Canada thistle, bindweed, bentgrass, wild garlic, ground ivy, perennial sorrel, and bromegrass; not infested with nematodes; grubs; or other pests, pest eggs, or other undesirable organisms and disease-causing plant pathogens; friable and with sufficient structure to give good tilth and aeration. Continuous, air-filled pore space content on a volume/volume basis shall be at least 15 percent when moisture is present at field capacity. Soil shall have a field capacity of at least 15 percent on a dry weight basis.
    b. Mix imported topsoil or manufactured topsoil with soil amendments and fertilizers in the quantities recommended in the soil analysis report to produce planting soil.

2.7 MULCHES

A. 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.

B. Nonasphaltic Tackifier: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application; nontoxic and free of plant-growth or germination inhibitors.

2.8 PESTICIDES AND HERBICIDES

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 (ECB): Biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh. Include manufacturer's recommended steel wire staples, 6 inches long.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Propex Geosynthetics, Landlok S1.
b. East Coast Erosion Blankets, ECS-1.
c. North American Green, S75.

B. Bonded Fiber Matrix (BFM): Biodegradable, hydraulically applied, flexible erosion control blanket composed of long strand, thermally processed wood fibers and an organic, hydro-colloid tackifier. Material shall require no more than 48 hrs. cure time to reach full effectiveness.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Profile Products,LLC, Hydro-Blanket.
b. Mat, Inc., Soil Guard.
c. USG Corp., Enviro-Shield.

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 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. Remove stones larger than 1 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. Thoroughly blend planting soil off-site before spreading or 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.
    b. Mix lime with dry soil before mixing fertilizer.

3. Spread planting soil to the depth indicated or to a min. depth of 8 inches, 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 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 6 inches. Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top 4 inches 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 1 inch 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 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 TURF REINFORCEMENT MAT (TRM)

A. Prepare area as specified in "Turf Area Preparation" Article.

B. For turf reinforcement mat, install planting soil in two lifts, with second lift equal to thickness and on top of the mat.

C. Install mat and fasten as instructed by material manufacturer.

D. Fill cells of turf reinforcement mat with planting soil and compact before planting.

E. 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 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 dry weight, and seed component is deposited at not less than the specified seed-sowing rate.

B. Protect seeded areas with erosion-control blankets where shown on Drawings; install and anchor according to manufacturer's written instructions.

3.6 BONDED FIBER MATRIX

A. Prepare area as specified in "Turf Area Preparation" Article.

B. Confirm that precipitation is not forecasted for at least 48 hours following the completion of installation.

C. Strictly comply with manufacturer’s instructions for required equipment.

1. Use approved mechanically agitated hydraulic seeding/mulching machine with fan-type nozzle with 50 degree tip.

D. Strictly comply with manufacturer’s instructions for installation procedures.

1. Apply BFM in two coats, per manufacturer's instructions, from opposing directions to achieve the most uniform soil coverages.
2. Mix and apply first coat with seed, soil amendments, and a small amount of BFM for visual meterings.
3. Mix and apply second coat of BFM at manufacturer's instructed mixing ratio for the equipment used.

E. Apply at the rate of [3000 lbs/ac][3,500 lbs/ac].

3.7 FLEXIBLE GROWTH MEDIUM

A. Prepare area as specified in "Turf Area Preparation" Article.

B. Confirm that precipitation is not forecasted during the period expected to be required for installation.

C. Strictly comply with manufacturer's instructions for required equipment.

1. Use approved mechanically agitated hydraulic seeding/mulching machine with fan-type nozzle with 50 degree tip.

D. Strictly comply with manufacturer's instructions for installation procedures.

1. Apply BFM in two coats, per manufacturer's instructions, from opposing directions to achieve the most uniform soil coverages.
2. Mix and apply first coat with seed, soil amendments, and a small amount of FGM for visual meterings.
3. Mix and apply second coat of FGM at manufacturer's instructed mixing ratio for the equipment used.

E. Apply at the rate of [3000 lbs/ac][3,500 lbs/ac][4,000lbs/ac].

3.8 SODDING

A. Lay sod within 36 hours of harvesting. Do not lay sod if ground is frozen or muddy.

1. Do not lay dormant sod without prior approval of Architect.

B. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to subgrade or sod during installation. Tamp and roll lightly to ensure contact with subgrade, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.

1. Lay sod across angle of slopes exceeding 1:3.
2. Anchor sod on slopes exceeding 1:4 with steel staples spaced as instructed by sod manufacturer but not less than 2 anchors per sod strip to prevent slippage.

C. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches below sod.

3.9 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 remulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.

1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
2. 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 utilize irrigation system to keep turf uniformly moist to a depth of 4 inches.

1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
2. Water turf with fine spray at a minimum rate of 1 inch per week unless rainfall precipitation is adequate.

C. Mow turf as soon as top growth is tall enough to cut. 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 bermudagrass to a height of 1/2 to 1 inch.
2. Mow carpetgrass, centipedegrass, perennial ryegrass, and zoysiagrass to a height of 1 to 2 inches.
3. Mow Kentucky bluegrass, buffalograss, annual ryegrass, chewings, and red fescue to a height of 1-1/2 to 2 inches.
4. Mow bahiagrass, turf-type tall fescue, and St. Augustinegrass to a height of 2 to 3 inches.

D. Turf Postfertilization: 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. to turf area.

3.10 SATISFACTORY TURF

A. Turf installations shall meet the following criteria as determined by Architect:

1. Satisfactory Seeded Turf: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. and bare spots not exceeding 6 by 6 inches.
2. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.
3. Satisfactory Sprigged Turf: At end of maintenance period, the required number of sprigs has been established as well-rooted, viable plants, and areas between sprigs are free of weeds and other undesirable vegetation.

B. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.

3.11 PESTICIDE AND HERBICIDE APPLICATION

A. Apply pesticides and other chemical products and biological control agents in accordance with requirements of authorities having jurisdiction and manufacturer's written instructions. 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.

3.12 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 329200

SECTION 329300 - 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 soil and amendments
3. Tree stabilization.
4. Landscape edgings.
5. Weed control barriers
6. Mulch.
7. Maintenance.

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. Balled and Potted Stock: Plants dug with firm, natural balls of earth in which they are grown and placed, unbroken, in a container. Ball size is not less than diameter and depth recommended by ANSI Z60.1 for type and size of plant required.

D. Bare-Root Stock: Plants with a well-branched, fibrous-root system developed by transplanting or root pruning, with soil or growing medium removed, and with not less than minimum root spread according to ANSI Z60.1 for type and size of plant required.

E. 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.

F. Duff Layer: The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.

G. Fabric Bag-Grown Stock: Healthy, vigorous, well-rooted plants established and grown in-ground in a porous fabric bag with well-established root system reaching sides of fabric bag. Fabric bag size is not less than diameter, depth, and volume required by ANSI Z60.1 for type and size of plant.

H. Finish Grade: Elevation of finished surface of planting soil.

I. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.

J. 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.

K. 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.

L. Planting Area: Areas to be planted.

M. 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.

N. 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.

O. 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.

P. Stem Girdling Roots: Roots that encircle the stems (trunks) of trees below the soil surface.

Q. 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.

R. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.

S. 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 true size and condition of the typical plant to be furnished. Include a scale rod or other measuring device in each photograph. For species where more than 20 plants are required, include a minimum of three photographs showing the average plant, 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.

B. Samples for Verification: For each of the following:

1. Trees and Shrubs: Three samples of each variety and size. Maintain approved samples on-site as a standard for comparison.
2. Organic/Compost Mulch: 1-quart volume of each organic mulch required; in sealed plastic bags labeled with composition of materials by percentage of weight and source of mulch. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of color, texture, and organic makeup.
3. Mineral Mulch: 2 lb of each mineral mulch required, in sealed plastic bags labeled with source of mulch. Sample shall be typical of the lot of material to be delivered and installed on the site; provide an accurate indication of color, texture, and makeup of the material.
4. Weed Control Barrier: 12 by 12 inches.
5. Edging Materials and Accessories: Manufacturer's standard size, to verify color selected.
6. Tree Grates and Accessories: Manufacturer's standard size, to verify design and color selected.
7. Root Barrier: Width of panel by 12 inches.

C. 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.

D. Product Certificates: For each type of manufactured product, from manufacturer, and complying with the following:

1. Manufacturer's certified analysis of standard products.
2. Analysis of other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.

E. Material Test Reports: For standardized ASTM D 5268 topsoil, existing in-place surface soil and imported or manufactured topsoil.

F. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of plants during a calendar year. Submit before start of required maintenance periods.

G. Warranty: Sample of special warranty.

H. Minutes of preinstallation conference.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape Installer whose work has resulted in successful establishment of plants.

1. Experience: Five years' experience in landscape installation in addition to requirements in Division 01 Section "Quality Requirements."
2. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
3. 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 areas, designated CLT-Exterior.
b. Certified Ornamental Landscape Professional, designated COLP.

4. Pesticide Applicator: State licensed, commercial.

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. or volume per cu. yd. 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.

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 above the root flare for trees up to 4-inch caliper size, and 12 inches above the root flare for larger sizes.
2. Other Plants: Measure with stems, petioles, and foliage in their normal position.

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 seven days in advance of delivery to site.

G. Preinstallation Conference: Conduct conference at Project site.

H. Authorities Having Jurisdiction: Conform to requirements of all authorities having jurisdiction.

1. Where conflicts exist between the requirements of the Contract Documents and those of authorities having jurisdiction, the higher quality or more restrictive requirement shall apply.

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, lime, and soil amendments with appropriate certificates.

C. Deliver bare-root stock plants freshly dug. Immediately after digging up bare-root stock, pack root system in wet straw, hay, or other suitable material to keep root system moist until planting.

D. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.

E. Handle planting stock by root ball.

F. Store bulbs, corms, and tubers in a dry place at 60 to 65 deg F until planting.

G. Deliver plants after preparations for planting have been completed, and install immediately. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.

1. Heel-in bare-root stock. Soak roots that are in dry condition in water for two hours. Reject dried-out plants.
2. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
3. Do not remove container-grown stock from containers before time of planting.
4. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly-wet condition.

1.7 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.

1. Notify Architect no fewer than two days in advance of proposed interruption of each service or utility.
2. Do not proceed with interruption of services or utilities without Architect's written permission.

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 and warranty requirements.

C. 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, except for defects resulting from abuse, lack of adequate maintenance, or neglect by Owner, or incidents that are beyond Contractor's control.
b. Structural failures including plantings falling or blowing over.
c. Faulty performance of tree stabilization and edgings].
d. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

2. Warranty Periods from Date of Final Completion:

a. Trees, Shrubs, Vines, and Ornamental Grasses: 12 months.
b. Ground Covers, Biennials, Perennials, and Other Plants: 12 months.
c. Annuals: Three months.

3. Include the following remedial actions as a minimum:

a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.

1.9 MAINTENANCE SERVICE

A. Initial Maintenance Service for 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 plantings are acceptably healthy and well established but for not less than maintenance period below.

1. Maintenance Period: Until date of Final Completion.

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 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 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.

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 each plant of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for the plant 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 INORGANIC SOIL AMENDMENTS

A. Provide inorganic soil amendments in quantities and proportions recommended by soil analysis report.

B. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:

1. Class: O, with a minimum of 95 percent passing through No. 8 sieve and a minimum of 55 percent passing through No. 60 sieve.
2. Provide lime in form of ground dolomitic limestone.

C. Sulfur: Granular, biodegradable, and containing a minimum of 90 percent sulfur, with a minimum of 99 percent passing through No. 6 sieve and a maximum of 10 percent passing through No. 40 sieve.

D. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.

E. Aluminum Sulfate: Commercial grade, unadulterated.

F. Perlite: Horticultural perlite, soil amendment grade.

G. Agricultural Gypsum: Minimum 90 percent calcium sulfate, finely ground with 90 percent passing through No. 50 sieve.

H. Sand: Clean, washed, natural or manufactured, and free of toxic materials.

I. Diatomaceous Earth: Calcined, 90 percent silica, with approximately 140 percent water absorption capacity by weight.

J. Zeolites: Mineral clinoptilolite with at least 60 percent water absorption by weight.

2.3 ORGANIC SOIL AMENDMENTS

A. Provide organic soil amendments in quantities and proportions recommended by soil analysis report.

B. 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 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.

C. Sphagnum Peat: Partially decomposed sphagnum peat moss, finely divided or granular texture, with a pH range of 3.4 to 4.8.

D. Wood Derivatives: Decomposed, nitrogen-treated sawdust, ground bark, or wood waste; of uniform texture and free of chips, stones, sticks, soil, or toxic materials.

1. In lieu of decomposed wood derivatives, mix partially decomposed wood derivatives with ammonium nitrate at a minimum rate of 0.15 lb/cu. ft. of loose sawdust or ground bark, or with ammonium sulfate at a minimum rate of 0.25 lb/cu. ft. of loose sawdust or ground bark.

E. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, debris, and material harmful to plant growth.

2.4 FERTILIZERS

A. Provide fertilizers in quantities and proportions recommended by soil analysis report.

B. Bonemeal: Commercial, raw or steamed, finely ground; a minimum of 4 percent nitrogen and 20 percent phosphoric acid.

C. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.

D. 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: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

E. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:

1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

F. Planting Tablets: Tightly compressed chip type, long-lasting, slow-release, commercial-grade planting fertilizer in tablet form. Tablets shall break down with soil bacteria, converting nutrients into a form that can be absorbed by plant roots.

1. Nutrient Composition: 20 percent nitrogen, 10 percent phosphorous, and 5 percent potassium, by weight plus micronutrients.

G. Chelated Iron: Commercial-grade FeEDDHA for dicots and woody plants, and commercial-grade FeDTPA for ornamental grasses and monocots.

2.5 PLANTING SOILS

A. At Contractor’s option, provide one or more of the following planting soils. All soils used for planting shall be prepared as necessary using soil amendments and fertilizers in the quantities recommended in the soil analysis report to produce satisfactory planting soil suitable for healthy, viable plants.

1. Planting Soil: ASTM D 5268 topsoil, with pH range of 5.5 to 7, a minimum of 6 percent organic material content; free of stones 1 inch or larger in any dimension and other extraneous materials harmful to plant growth. Mix ASTM D 5268 topsoil with soil amendments and fertilizers in the quantities recommended in the soil analysis report to produce planting soil.
2. Planting Soil: Existing, in-place surface soil. Verify suitability of existing surface soil to produce viable planting soil. Remove stones, roots, plants, sod, clods, clay lumps, pockets of coarse sand, concrete slurry, concrete layers or chunks, cement, plaster, building debris, and other extraneous materials harmful to plant growth. Mix surface soil

with soil amendments and fertilizers in the quantities recommended in the soil analysis report to produce planting soil.

3. Planting Soil: Imported topsoil or manufactured topsoil from off-site sources. Obtain topsoil displaced from naturally well-drained construction or mining sites where topsoil occurs at least 4 inches deep; do not obtain from agricultural land, bogs, or marshes.

    a. Additional Properties of Imported Topsoil or Manufactured Topsoil: Screened and free of stones 1 inch or larger in any dimension; free of roots, plants, sod, clods, clay lumps, pockets of coarse sand, paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials harmful to plant growth; free of obnoxious weeds and invasive plants including quackgrass, Johnsongrass, poison ivy, nutsedge, nimblewill, Canada thistle, bindweed, bentgrass, wild garlic, ground ivy, perennial sorrel, and bromegrass; not infested with nematodes; grubs; or other pests, pest eggs, or other undesirable organisms and disease-causing plant pathogens; friable and with sufficient structure to give good tilth and aeration. Continuous, air-filled pore space content on a volume/volume basis shall be at least 15 percent when moisture is present at field capacity. Soil shall have a field capacity of at least 15 percent on a dry weight basis.
    b. Mix imported topsoil or manufactured topsoil with soil amendments and fertilizers in the quantities recommended in the soil analysis report to produce planting soil.

2.6 MULCHES

A. Organic Mulch: Free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:

    1. Type: as indicated on Plant Schedule.
    2. Size Range for chipped or shredded mulch (where applicable): 3 inches maximum, 1/2 inch minimum.
    3. Color: Natural.

B. Mineral Mulch: Hard, durable stone, washed free of loam, sand, clay, and other foreign substances, of following type, size range, and color:

    1. Type: as indicated on Plant Schedule.
    2. Size Range: as indicated on Plant Schedule.
    3. Color: as indicated on Plant Schedule.

2.7 PESTICIDES AND HERBICIDES

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.

2.8 TREE STABILIZATION MATERIALS

A. Stakes and Guys:

1. Upright and Guy Stakes: Rough-sawn, sound, new wood, free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal by length indicated, pointed at one end.
2. Guys and Tie Wires: ASTM A 641/A 641M, Class 1, galvanized-steel wire, two-strand, twisted, 0.106 inch in diameter.
3. Tree-Tie Webbing: UV-resistant polypropylene or nylon webbing with brass grommets.

    a. Products: Subject to compliance with requirements, provide one of the following (or approved equal):

        1) GCS, Inc.; TreeStrap.

4. Flags: Standard surveyor's plastic flagging tape, white, 6 inches long.
5. Proprietary Staking Devices: Proprietary stake and adjustable tie systems to secure each new planting by plant stem; sized as indicated and per manufacturer's written recommendations.

    a. Products: Subject to compliance with requirements, provide one of the following:

        1) T-Mate-O, LLC; Tree Mate O System.
        2) J.R. Partners, Inc.; R2 Stake, Mega Stake, or Grate Stake System as applicable.

B. Root-Ball Stabilization Materials:

1. Proprietary Root-Ball Stabilization Devices: Proprietary at- or below-grade stabilization systems to secure each new planting by root ball; sized per manufacturer's written recommendations unless otherwise indicated.

    a. Products: Subject to compliance with requirements, provide one of the following (or approved equal):

        1) Border Concepts, Inc.; Tomahawk Tree Stabilizers.
        2) Foresight Products, LLC; Duckbill Rootball Fixing System.
        3) Tree Staple, Inc.; Tree Staples.

2.9 LANDSCAPE EDGINGS

A. Steel Edging: Standard commercial-steel edging, rolled edge, fabricated in sections of standard lengths, with loops stamped from or welded to face of sections to receive stakes.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Border Concepts, Inc.
    b. Collier Metal Specialties, Inc.
    c. Russell, J. D. Company (The).
    d. Sure-Loc Edging Corporation.

2. Edging Size: 3/16 inch wide by 4 inches deep.
3. Stakes: Tapered steel, a minimum of 15 inches long.
4. Accessories: Standard tapered ends, corners, and splicers.

5. Finish: Enamel paint.
6. Paint Color: as specified by Architect from manufacturer's full range.

2.10 MISCELLANEOUS PRODUCTS

A. Wood Pressure-Preservative Treatment: AWPA C2, 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.

B. Root Barrier: Black, molded, modular panels manufactured with 50 percent recycled polyethylene plastic with ultraviolet inhibitors, 85 mils thick, with vertical root deflecting ribs protruding 3/4 inch out from panel, and each panel [18 inches] [24 inches] wide.

C. Antidesiccant: Water-insoluble emulsion, permeable moisture retarder, film forming, for trees and shrubs. Deliver in original, sealed, and fully labeled containers and mix according to manufacturer's written instructions.

D. Burlap: Non-synthetic, biodegradable.

E. Planter Drainage Gravel: Naturally or artificially graded mixture of crushed gravel or stone, in accordance with the gradation requirements for Coarse Aggregate #789 as defined by the South Carolina Department of Transportation Standard Specifications for Highway Construction.

1. Material shall be free of shale, clay, friable material, debris, waste, frozen materials, vegetation, organic material, or other deleterious matter.

F. Planter Filter Fabric: Nonwoven geotextile manufactured for separation applications and made of polypropylene, polyolefin, or polyester fibers or combination of them.

G. Mycorrhizal Fungi: Dry, granular inoculant containing at least 5300 spores per lb of vesicular-arbuscular mycorrhizal fungi and 95 million spores per lb of ectomycorrhizal fungi, 33 percent hydrogel, and a maximum of 5.5 percent inert material.

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. Apply antidesiccant to trees and shrubs using power spray to provide an adequate film over trunks (before wrapping), branches, stems, twigs, and foliage to protect during digging, handling, and transportation.

1. If deciduous trees or shrubs are moved in full leaf, spray with antidesiccant at nursery before moving and again two weeks after planting.

E. Wrap trees and shrubs with burlap fabric over trunks, branches, stems, twigs, and foliage to protect from wind and other damage during digging, handling, and transportation.

3.3 PLANTING AREA ESTABLISHMENT

A. Loosen subgrade of planting areas to a minimum depth of 12 inches. Remove stones larger than 1 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. Thoroughly blend planting soil off-site before spreading or 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.
    b. Mix lime with dry soil before mixing fertilizer.

3. Spread planting soil to a depth of 8 inches 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 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.

D. Application of Mycorrhizal Fungi: At time of planting, broadcast dry product uniformly over prepared soil at application rate instructed by manufacturer.

3.4 EXCAVATION FOR TREES AND SHRUBS

A. Planting Pits and Trenches: Excavate circular planting pits with sides sloping inward at a 60-degree angle. Excavations with vertical sides shall be avoided. 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 root ball diameter.
2. Excavate at least 12 inches 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 overnight and when unattended by Installer's personnel.

B. Subsoil and topsoil removed from excavations may be used as planting soil for individually planted trees that are not located within a prepared plant bed.

C. Obstructions: Notify Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.

1. Hardpan Layer: Drill 6-inch- diameter holes, 24 inches apart, into free-draining strata or to a depth of 10 feet, 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.

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 2 inches above adjacent finish grades.

1. Use excavated soil for backfill.
2. After placing some backfill around root ball to stabilize plant, carefully cut and remove burlap, rope, and wire baskets from tops of root balls and from sides, but do not remove

from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.

3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
4. Place planting tablets in each planting pit when pit is approximately one-half filled; in amounts recommended in soil reports from soil-testing laboratory. Place tablets beside the root ball about 1 inch from root tips; do not place tablets in bottom of the hole.
5. 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 above adjacent finish grades.

1. Use excavated soil for backfill.
2. Carefully remove root ball from container without damaging root ball or plant.
3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
4. Place planting tablets in each planting pit when pit is approximately one-half filled; in amounts recommended in soil reports from soil-testing laboratory. Place tablets beside the root ball about 1 inch from root tips; do not place tablets in bottom of the hole.
5. Continue backfilling process. Water again after placing and tamping final layer of soil.

E. Set fabric bag-grown stock plumb and in center of planting pit or trench with root flare 1 inch above adjacent finish grades.

1. Use excavated soil for backfill.
2. Carefully remove root ball from fabric bag without damaging root ball or plant. Do not use planting stock if root ball is cracked or broken before or during planting operation.
3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
4. Place planting tablets in each planting pit when pit is approximately one-half filled; in amounts recommended in soil reports from soil-testing laboratory. Place tablets beside the root ball about 1 inch from root tips; do not place tablets in bottom of the hole.
5. Continue backfilling process. Water again after placing and tamping final layer of soil.

F. Set and support bare-root stock in center of planting pit or trench with root flare 2 inches above adjacent finish grade.

1. Use excavated soil for backfill.
2. Spread roots without tangling or turning toward surface, and carefully work backfill around roots by hand. Puddle with water until backfill layers are completely saturated. Plumb before backfilling, and maintain plumb while working backfill around roots and placing layers above roots.
3. Place planting tablets in each planting pit when pit is approximately one-half filled; in amounts recommended in soil reports from soil-testing laboratory. Place tablets beside soil-covered roots about 1 inch from root tips; do not place tablets in bottom of the hole or touching the roots.
4. Continue backfilling process. Water again after placing and tamping final layer of soil.

G. When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.

3.6 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 TREE, SHRUB, AND VINE PRUNING

A. Prune, thin, and shape trees, shrubs, and vines according to standard professional horticultural and arboricultural practices. Unless otherwise indicated by Architect, do not cut tree leaders; remove only injured, dying, or dead branches from trees and shrubs; and prune to retain natural character.

B. Do not apply pruning paint to wounds.

3.8 TREE STABILIZATION

A. Install trunk stabilization as follows unless otherwise indicated:

1. Upright Staking and Tying: Stake trees of 4-inch or larger caliper and all trees in windy locations. Use a minimum of two stakes of length required to penetrate at least 18 inches below bottom of backfilled excavation and to extend one-third of trunk height above grade. Set vertical stakes and space to avoid penetrating root balls or root masses.
2. Use three stakes for each tree. Space stakes equally around trees.
3. Support trees with two strands of tie wire, connected to the brass grommets of tree-tie webbing at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.

    a. Attach flags to each guy wire, 30 inches above finish grade.

4. Proprietary Staking and Guying Device: Install staking and guying system sized and positioned as recommended by manufacturer unless otherwise indicated and according to manufacturer's written instructions.

B. Root-Ball Stabilization: Install at- or below-grade stabilization system to secure each new planting by the root ball unless otherwise indicated.

1. Proprietary Root-Ball Stabilization Device: Install root-ball stabilization system sized and positioned as recommended by manufacturer unless otherwise indicated and according to manufacturer's written instructions.

3.9 PLANTING IN PLANTERS

A. Place a layer of drainage gravel at least 4 inches thick in bottom of planter. Cover bottom with filter fabric and wrap filter fabric 4 inches up on all sides. Duct tape along the entire top edge of the filter fabric, to secure the filter fabric against the sides during the soil-filling process.

B. Fill planter with planting soil. Place soil in lightly compacted layers to an elevation of 1-1/2 inches below top of planter, allowing natural settlement.

3.10 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 <Insert drawing designation> 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.

3.11 PLANTING AREA MULCHING

A. Mulch backfilled surfaces of planting areas and other areas indicated.

1. Trees and Tree-like Shrubs in Turf Areas: Apply mulch ring of 3-inch average thickness, with 30-inch radius around trunks or stems. Do not place mulch within 3 inches of trunks or stems.
2. Mulch in Planting Areas: Apply 3-inch average thickness of mulch as indicated on Drawings. Extend at least 12 inches beyond edge of individual planting pit or trench and over whole surface of planting area, and finish level with adjacent finish grades. Do not place mulch within 3 inches of trunks or stems.

3.12 EDGING INSTALLATION

A. Steel Edging: Install steel edging where indicated according to manufacturer's written instructions. Anchor with steel stakes spaced according to manufacturer's written instructions, driven below top elevation of edging.

B. Shovel-Cut Edging: Separate mulched areas from turf areas with a 45-degree, 4- to 6-inch-deep, shovel-cut edge as shown on Drawings.

3.13 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 past 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.

3.14 PESTICIDE AND HERBICIDE 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.

3.15 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.

3.16 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 329300

SECTION 331100 - WATER DISTRIBUTION SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

1. 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 water-distribution piping and related components outside the building for water service and fire-service mains.

B. The Section includes general requirements that will apply to all water systems. In addition, the operating utility (the authority having jurisdiction) has numerous specific requirements for materials and execution that are too varied to cover in this specification.

1. For this Project, the operating utility is Greenville Spartanburg Airport.
2. Materials and execution requirements that are not covered in this Section shall comply with the requirements of the operating utility.
3. Materials and execution requirements that are covered, but are in conflict with the requirements of the operating utility, shall comply with the higher quality or more restrictive requirement.

1.3 DEFINITIONS

A. CTS: Copper Tubing Size.

B. DIP: Ductile iron pipe.

C. EPDM: Ethylene propylene diene terpolymer rubber.

D. HDPE: High density polyethylene pipe.

E. LLDPE: Linear, low-density polyethylene plastic.

F. NPS: Nominal pipe size.

G. PE: Polyethylene plastic.

H. PVC: Polyvinyl chloride plastic.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

1. Ductile iron pipe.
2. Polyvinyl chloride pipe.

3. Tees, elbows, reducers and similar fittings.
4. Special fittings for expansion and deflection.
5. Joint restraint.
6. Valves and valve boxes.
7. Tapping sleeve assemblies.
8. Fire hydrants.
9. Flushing (blowoff) hydrants and boxes.
10. Yard hydrants.
11. Fire department connections.
12. Backflow preventers.
13. Pressure reducing valves
14. Relief valves
15. Service connection piping and fittings
16. Corrosion-protection piping encasement.
17. Protective enclosures.

B. Shop Drawings: Detail precast concrete vault assemblies and indicate dimensions, method of field assembly, and components.

C. Installer Qualifications: For high density polyethylene pipe installations, provide names and documentation of completed training by manufacturer's authorized representative for installers, fusion welders and joint inspectors.

D. Field quality-control test reports.

E. Bacteriological test reports.

F. Record Drawings: Include the following, as required by authorities having jurisdiction, for use by Owner's surveyor in preparing record drawings:

1. Location of water mains from centerline of road or curb. Contractor shall coordinate with Owners surveyor to allow for location of water main prior to backfilling.
2. Location of fire hydrants, valves, tees, elbows, reducers, and other fittings.
3. Location and elevation of any other below ground appurtenances.
4. Designation, size and length of water lines between fittings.
5. Location and depth below finished grade of service connections.

G. Minutes of preinstallation conference.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Comply with requirements of utility company supplying water. Include tapping of water mains and backflow prevention.
2. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.
3. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.

B. Preinstallation Conference: Conduct conference to comply with requirements in Division 01 Section "Project Management and Coordination."

1. Review methods and procedures related to water system installation including, but not limited to, the following:

    a. Review requirements of the operating utility.
    b. Review site conditions and preparatory work.
    c. Review requirements for protecting work.
    d. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
    e. Review inspection schedule and procedures required to monitor and document quality assurance.

C. Piping materials shall bear label, stamp, or other markings of specified testing agency.

D. Comply with ASTM F 645 for selection, design, and installation of thermoplastic (PVC and HDPE) water piping.

E. Comply with FMG's "Approval Guide" or UL's "Fire Protection Equipment Directory" for fire-service-main products.

F. NFPA Compliance: Comply with NFPA 24 for materials, installations, tests, flushing, and valve and hydrant supervision for fire-service-main piping for fire suppression.

G. NSF Compliance: Comply with NSF 61 for materials for water-service piping and specialties for domestic water.

H. Lead Free Requirement: Section 1417 of the Federal Safe Drinking Water Act has mandated that "Any pipe, solder, or flux used after June 19, 1986, in the installation or repair of public water systems and plumbing used for drinking water must be "Lead Free". The act defines "Lead Free" as less than 0.2-percent lead in solder and flux and less than 8.0-percent lead in pipes and fittings.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Preparation for Transport: Prepare valves, including fire hydrants, according to the following:

1. Ensure that valves are dry and internally protected against rust and corrosion.
2. Protect valves against damage to threaded ends and flange faces.
3. Set valves in best position for handling. Set valves closed to prevent rattling.

B. During Storage: Use precautions for valves, including fire hydrants, according to the following:

1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
2. Protect from weather. Store indoors and maintain temperature higher than ambient dew-point temperature. Support off the ground or pavement in watertight enclosures when outdoor storage is necessary.

C. Handling: Use sling to handle valves and fire hydrants if size requires handling by crane or lift. Rig valves to avoid damage to exposed parts. Do not use hand wheels or stems as lifting or rigging points.

D. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.

E. Protect stored piping from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.

F. Protect flanges, fittings, and specialties from moisture and dirt.

G. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

1.7 PROJECT CONDITIONS

A. Interruption of Existing Water-Distribution Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water-distribution service according to requirements indicated:

1. Notify Architect, Owner, and Utility having jurisdiction no fewer than two days in advance of proposed interruption of service.
2. Do not proceed with interruption of water-distribution service without Architect's written permission.

1.8 COORDINATION

A. Where required, coordinate connection to water main with utility company.

PART 2 - PRODUCTS

2.1 STANDARDS OF OPERATING UTILITY

A. See paragraph 1.2.B above for information regarding materials standards of the operating utility.

2.2 DUCTILE-IRON PIPE (DIP)

A. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end unless mechanical joint or flanged ends are indicated on Drawings or required by operating utility.

1. Gaskets: AWWA C111, rubber. Use only non-toxic lubricants approved by the manufacturer and that will not support microbiological growth. Vegetable shortening shall not be used.
2. Pressure class: Class 350 for NPS 3 to NPS 12; Class 250 for NPS 14 and larger.
3. Cement mortar lining: AWWA C 104, standard thickness.
4. Laying length: 18 feet-0 inches to 20 feet-0 inches.
5. Pipe size: No metric sized pipe shall be permitted.
6. Testing: All pipe lengths shall be tested to 500 psi working pressure prior to shipping.
7. Marking: Clearly mark each joint of pipe at convenient intervals, as follows:

a. Manufacturer’s name.
b. Nominal pipe size.
c. Letters “DI” or “Ductile”.
d. Weight.
e. Pressure Class.

8. Products: Subject to compliance with requirements, provide products by one of the following:

    a. American-Cast Iron Pipe Co.
    b. Griffin Pipe Co.
    c. McWane Cast Iron Pipe Co..
    d. U.S. Pipe Co.

B. Flanged Joints: where indicated on Drawings or where required by operating utility and in accordance with standards of operating utility.

C. Mechanical Joints: where indicated on Drawings or where required by operating utility and in accordance with standards of operating utility.

2.3 POLYVINYL CHLORIDE PLASTIC PIPE (PVC)

A. PVC, AWWA Pipe: AWWA C900 (4" thru 12" NPS) or AWWA C905 (14" and larger NPS), Class 235, with bell end with gasket, and with spigot end.

1. Gaskets: ASTM F 477, rubber. Use only non-toxic lubricants approved by the manufacturer and that will not support microbiological growth. Vegetable shortening shall not be used.
2. Joints: ASTM D 3139.
3. Laying length: 18 feet-0 inches to 20 feet-0 inches
4. Pipe size: comply with outside diameter dimensions of DIP.
5. Standard dimension ratio: SDR 18.
6. Pipe color: blue.
7. Comply with UL 1285 for fire-service mains if indicated.
8. The use of solvent weld joints is prohibited.
9. Marking: Clearly mark each joint of pipe at convenient intervals, as follows:

    a. Manufacturer's name.
    b. Nominal pipe size.
    c. Pressure class.
    d. Material designation.
    e. National Sanitation Foundation (NSF) seal.

2.4 HIGH DENSITY POLYETHYLENE PIPE(HDPE)

A. HDPE, AWWA Pipe: AWWA C906, DR No. 7, 9, or 11; with PE compound number required to give working pressure rating not less than 160 psig.

1. Joints: Thermal butt fused, saddle fused, or socket fused in accordance with manufacturer's instructions.

2. Marking: Clearly mark each joint of pipe at convenient intervals, as follows:

    a. Manufacturer's name.
    b. Nominal pipe size.
    c. Pressure class.
    d. Material designation.
    e. National Sanitation Foundation (NSF) seal.

3. Products: Subject to compliance with requirements, provide products by one of the following:

    a. Performance Pipe (Chevron Phillips Chemical Company, LLC)
    b. J-M Manufacturing Co.
    c. WL Plastics Co.
    d. KWH Pipe Ltd.

2.5 FITTINGS (NPS 3 AND LARGER)

A. Mechanical-Joint, Ductile-Iron Fittings: For NPS 3 and larger, AWWA C110, ductile-iron standard pattern or AWWA C153, ductile-iron compact pattern. For NPS 2 and smaller see “Service Connections” article below.

1. Glands and Gaskets: AWWA C111, ductile-iron glands, rubber gaskets. Use only non-toxic lubricants approved by the manufacturer and that will not support microbiological growth. Vegetable shortening shall not be used.
2. Nuts and Bolts: 316 Stainless Steel, material shall be marked on nuts and bolts.
3. Material: Cast iron fittings are not permitted.
4. Pressure class: Class 250.
5. Fitting size: Metric sized fittings are not permitted.
6. Cement mortar lining: AWWA C 104, standard thickness.

7. Products: Subject to compliance with requirements, provide products by one of the following:

    a. American-Cast Iron Pipe Co.
    b. Griffin Pipe Co.
    c. McWane Cast Iron Pipe Co..
    d. U.S. Pipe Co.

2.6 SPECIAL PIPE FITTINGS FOR DEFLECTION AND EXPANSION

A. Ductile-Iron Flexible Expansion Joints: Compound fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include 2 gasketed ball-joint sections and 1 or more gasketed sleeve sections, rated for 250-psig minimum working pressure and for offset and expansion indicated.

1. Manufacturers:

    a. EBAA Iron Sales, Inc.
    b. Romac Industries, Inc.
    c. Star Pipe Products.

2. Thrust Restraint: Cast-in-place concrete thrust blocks or equivalent restraint system to be approved by Architect.

2.7 RESTRAINTED JOINTS

A. Push-on (DIP only) or mechanical joint type joint restraint where indicated on Drawings or where required by operating utility and in accordance with standards of operating utility.

1. Push-on Gaskets: AWWA C 111, for use on DIP only, approved for use on the pipe on which it is installed. Use only non-toxic lubricants approved by the manufacturer and that will not support microbiological growth. Vegetable shortening shall not be used.
2. Mechanical Joint Glands, Gaskets and Bolts: AWWA C 111, the gland, gasket and bolts shall be part of an integral system by the same manufacturer and approved for use on the pipe on which it is installed. Installation shall require only standard mechanical joint assembly techniques. Bolts shall be 316 Stainless Steel. Use only non-toxic lubricants approved by the manufacturer and that will not support microbiological growth. Vegetable shortening shall not be used.
3. DIP Pressure Rating: 350 psi.
4. PVC Pressure Rating: rated at a 2:1 safety factor for the pipe on which it is installed.
5. Products: Subject to compliance with requirements, provide products by one of the following:

    a. American-Cast Iron Pipe Co.
    b. Griffin Pipe Co.
    c. McWane Cast Iron Pipe Co..
    d. U.S. Pipe Co.
    e. Ebba Iron Inc.
    f. Ford Meter Box Co.
    g. Sigma Corporation.

2.8 VALVES (NPS 3 AND LARGER)

A. General:

1. For NPS 2 and smaller: see “Service Connections” article below.
2. Available Manufacturers: Subject to compliance with these requirements and the standards of operating utility, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. American AVK Co.; Valves & Fittings Div.
    b. American Cast Iron Pipe Co.; American Flow Control Div.
    c. Crane Co.; Crane Valve Group.
    d. East Jordan Iron Works, Inc.
    e. McWane, Inc.; Clow Valve Co. Div. (Oskaloosa).
    f. McWane, Inc.; Kennedy Valve Div.
    g. McWane, Inc.; M & H Valve Company Div.
    h. McWane, Inc.; Tyler Pipe Div.; Utilities Div.
    i. Mueller Co.; Water Products Div.
    j. U.S. Pipe and Foundry Company.

3. Opening direction: As required by operating utility.
4. Operating system: 2” square operating nut for below grade installation, wheel for above grade or vault installations.
5. Exterior Nuts and Bolts: 316 stainless steel
6. Interior Coating: Complying with AWWA C550.

B. AWWA, Gate Valves:

1. Nonrising-Stem, Resilient-Seated Gate Valves:

    a. Description: For NPS 3 to NPS 12, gray- or ductile-iron body and bonnet; with bronze or ductile-iron gate, resilient seats, bronze stem, and stem nut.

1) Standard: AWWA C509.
2) Minimum Pressure Rating: 250 psig.
3) End Connections: AWWA C 111, mechanical joint.

C. UL/FMG, Gate Valves:

1. UL/FMG, Nonrising-Stem Gate Valves:

a. Description: Gray- or ductile-body and bonnet with flange for indicator post, bronze seating material, and inside screw.

1) Standards: UL 262 and FMG approved.
2) Minimum Pressure Rating: 175 psig.
3) End Connections: Flanged or mechanical joint as required.

b. Indicator Posts: UL 789, FMG-approved, vertical-type, cast-iron body with operating wrench, extension rod, and adjustable cast-iron barrel of length required for depth of burial of valve.

2. OS&Y, Rising-Stem Gate Valves:

a. Description: Iron body and bonnet and bronze seating material.

1) Standards: UL 262 and FMG approved.
2) Minimum Pressure Rating: 175 psig.
3) End Connections: Flanged.

D. AWWA Butterfly Valves:

1. Description: For NPS 14 and larger, resilient synthetic rubber seated.

a. Standard: AWWA C504.
b. Body: Cast or ductile iron.
c. End Connections: Flanged (ANSI B16.1) or mechanical joint (AWWA C111). as required by operating utility.
d. Pressure Rating: 150 psig.

E. Tapping-Sleeve Assemblies:

1. Description: Sleeve and valve compatible with drilling machine.

a. Standard: MSS SP-60.
b. Tapping Sleeve: Ductile-iron or stainless-steel, two-piece bolted sleeve with flanged outlet for new branch connection. Include sleeve matching size and type of pipe material being tapped and with recessed flange for branch valve.
c. Pressure Rating: 250 psig.
d. Tapping Valve: AWWA C 509, cast or ductile-iron, nonrising-stem, resilient-seated gate valve.
e. Valve End Connections: Flanged (ANSI B16.1) for end mating tapping-sleeve flange and mechanical joint (AWWA C111) for opposite end.

2.9 VALVE ACCESSORIES (NPS 3 AND LARGER)

A. Valve Boxes:

1. Material: Cast or ductile-iron, suitable for heavy traffic use and conforming to ASTM A-48, Class 20.

    a. Available Manufacturers: Subject to compliance with these requirements and the standards of operating utility, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

        1) East Jordan Iron Works
        2) Tyler Pipe
        3) Bingham and Taylor.

    b. Model: as required by the operating utility.
    c. Elevation Adjustment: as required by operating utility.
    d. Inside Shaft Diameter: 5-1/4 inches.
    e. Coating: Asphaltic, not less than 1 mil thick.
    f. Cover: Heavy cast iron with the word WATER cast in raised letters.
    g. Base: Enlarged to enclose and protect valve operating nut without actually being in contact with pipe or valve.

B. Valve Box Protection Rings:

1. Material: Reinforced, precast 3,000 psi concrete.

    a. Inside diameter: 9-1/4 inches.
    b. Outside Diameter: 27 inches.
    c. Thickness" 5 inches at inner diameter with top tapering to 2 inches at outer diameter.
    d. Reinforcing: Two #3 rebar, one at 21 inch diameter and one at 24 inch diameter.
    e. Min. Weight: 110 lbs.

2.10 FIRE HYDRANTS

A. Dry-Barrel Fire Hydrants:

1. Available Manufacturers: Subject to compliance with these requirements and the standards of authorities having jurisdiction, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. American AVK Co.; Valves & Fittings Div.
    b. American Cast Iron Pipe Co.; American Flow Control Div.
    c. American Cast Iron Pipe Co.; Waterous Co. Subsidiary.
    d. American Foundry Group, Inc.
    e. East Jordan Iron Works, Inc.
    f. McWane, Inc.; Clow Valve Co. Div. (Oskaloosa).
    g. McWane, Inc.; Kennedy Valve Div.
    h. McWane, Inc.; M & H Valve Company Div.
    i. Mueller Co.; Water Products Div.
    j. Troy Valve; a division of Penn-Troy Manufacturing, Inc.
    k. U.S. Pipe and Foundry Company.

2. Description: Freestanding, with one NPS 4-1/2 and two NPS 2-1/2 outlets, 5-1/4-inch main valve, drain valve, and NPS 6 mechanical-joint inlet. Include interior coating according to AWWA C550. Hydrant shall have cast-iron body, compression-type valve opening against pressure and closing with pressure.

a. Standard: AWWA C502.
b. Pressure Rating: 150 psig minimum.
c. Outlet Threads: NFPA 1963, with external hose thread used by local fire department. Include cast-iron caps with steel chains.
d. Operating and Cap Nuts: Pentagon, 1-1/2 inches point to flat.
e. Direction of Opening: as required by authorities having jurisdiction.
f. Exterior Finish: Paint type and colors as required by authorities having jurisdiction.

2.11 FLUSHING HYDRANTS (BLOWOFFS)

A. Post-Type Flushing Hydrants:

1. Available Manufacturers: Subject to compliance with these requirements and the standards of operating utility, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. GIL Industries, Inc.
b. Kupferle Foundry Co. (The).
c. Mueller Co.; Water Products Div.
d. M&H Valve Co.

2. Description: Nonfreeze and drainable, of length required for shutoff valve installation below frost line.

a. Pressure Rating: 150 psig minimum.
b. Outlet: One, with horizontal discharge.
c. Hose Thread: NPS 2-1/2, with NFPA 1963 external hose thread for use by local fire department, and with cast-iron cap with brass chain.
d. Barrel: Cast-iron or steel pipe with breakaway feature.
e. Valve: Bronze body with bronze-ball or plunger closure, and automatic draining.
f. Security: Locking device for padlock.
g. Exterior Finish: Paint type and colors as required by authorities having jurisdiction.
h. Inlet: NPS 2 minimum.
i. Operating Wrench: One for each unit.

B. Ground-Type Flushing Hydrants:

1. Available Manufacturers: Subject to compliance with these requirements and the standards of operating utility, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. GIL Industries, Inc.
b. Kupferle Foundry Co. (The).
c. Mueller Co.; Water Products Div.
d. M&H Valve Co.

2. Description: Nonfreeze and drainable, of length required for shutoff valve installation below frost line.

a. Pressure Rating: 150 psig minimum.
b. Outlet: One, with angle discharge.
c. Hose Thread: NPS 2-1/2 with NFPA 1963 external hose thread for use by local fire department, and with cast-iron cap with brass chain.
d. Barrel: Cast-iron or steel pipe.

e. Valve: Bronze body with bronze-ball or plunger closure, and automatic draining.
f. Inlet: NPS 2 minimum.
g. Hydrant Box: Cast iron with cover, for ground mounting.
h. Operating Wrench: One for each unit.

2.12 YARD HYDRANTS

A. Available Manufacturers: Subject to compliance with these requirements and the standards of operating utility, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Zurn Plumbing Products Group
2. Kupferle Foundry Co. (The).
3. Woodford Manufacturing Co.

B. Description: Nonfreeze and automatic draining, with integral backflow prevention device.

1. Pressure Rating: 125 psig minimum.
2. Length: Sufficient to provide 30 inch installation height with depth of bury to position drain port below frost line.
3. Outlet: Brass ¾ inch male hose thread.
4. Casing: 1-1/4 inch galvanized steel pipe.
5. Operating Handle: Cast Iron.
6. Inlet: Female pipe thread, 3/4 inch minimum.
7. Operating Rod: 3/8 inch diameter brass or galvanized steel.

2.13 FIRE DEPARTMENT CONNECTIONS

A. Fire Department Connections:

1. Available Manufacturers: Subject to compliance with these requirements and the standards of authorities having jurisdiction, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Elkhart Brass Mfg. Co., Inc.
b. Fire End & Croker Corporation.
c. Guardian Fire Equipment, Inc.
d. Kidde Fire Fighting.
e. Potter Roemer.
f. Reliable Automatic Sprinkler Co., Inc.

2. Description: Freestanding, with cast-bronze body, thread inlets according to NFPA 1963 and matching local fire department hose threads, and threaded bottom outlet. Include lugged caps, gaskets, and chains; lugged swivel connection and drop clapper for each hose-connection inlet; 18-inch- high brass sleeve; and round escutcheon plate.

a. Standard: UL 405.
b. Connection Size and Number: As required by local fire department.
c. Inlet Alignment: Inline, horizontal
d. Finish Including Sleeve: Polished bronze
e. Escutcheon Plate Marking: "FDC”.

2.14 WATER METERS

A. See paragraph 1.2.C above regarding water meters.

2.15 BACKFLOW PREVENTERS

A. Double-Check, Backflow-Prevention Assemblies:

1. Available Manufacturers: Subject to compliance with these requirements and the standards of authorities having jurisdiction, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Ames Fire & Waterworks; a division of Watts Regulator Co.
b. Conbraco Industries, Inc.
c. FEBCO; SPX Valves & Controls.
d. Flomatic Corporation.
e. Watts Water Technologies, Inc.
f. Zurn Plumbing Products Group; Wilkins Water Control Products Div.

2. Standards: AWWA C510 and any other requirements of authorities having jurisdiction.
3. Operation: Continuous-pressure applications, unless otherwise indicated.
4. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.
5. Size: as indicated on Drawings.
6. Body: Cast iron with interior lining complying with AWWA C550.
7. End Connections: Flanged.
8. Configuration: Designed for horizontal, straight through flow.

B. Reduced-Pressure-Principle Backflow Preventers:

1. Available Manufacturers: Subject to compliance with these requirements and the standards of authorities having jurisdiction, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Ames Fire & Waterworks; a division of Watts Regulator Co.
b. Conbraco Industries, Inc.
c. FEBCO; SPX Valves & Controls.
d. Flomatic Corporation.
e. Watts Water Technologies, Inc.
f. Zurn Plumbing Products Group; Wilkins Water Control Products Div.

2. Standard: AWWA C511 and any other requirements of authorities having jurisdiction.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
5. Size: as indicated on Drawings.
6. Body: Cast iron with interior lining complying with AWWA C550.
7. End Connections: Flanged.
8. Configuration: Designed for horizontal, straight through flow.

C. Reduced-Pressure-Detector, Fire-Protection Backflow Preventer Assemblies:

1. Available Manufacturers: Subject to compliance with these requirements and the standards of authorities having jurisdiction, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Ames Fire & Waterworks; a division of Watts Regulator Co.
b. Conbraco Industries, Inc.
c. FEBCO; SPX Valves & Controls.
d. Watts Water Technologies, Inc.
e. Zurn Plumbing Products Group; Wilkins Water Control Products Div.

2. Standards: ASSE 1047 and UL listed or FMG approved.
3. Operation: Continuous-pressure applications.
4. Size: as indicated on Drawings.
5. Body: Cast iron with interior lining complying with AWWA C550.
6. End Connections: Flanged.
7. Configuration: Designed for horizontal, straight through flow.

2.16 CONCRETE VAULTS

A. Description: Precast, reinforced-concrete vault, designed for A-16 load designation according to ASTM C 857 and made according to ASTM C 858.

1. Access Hatch: of type and configuration required by operating utility.

a. Size: Sufficient to allow easy removal of equipment housed by vault.
b. Material: Aluminum.
c. Load Rating:

1) 300 psf for hatches not subjected to traffic.
2) AASHTO H-20 for hatches in traffic areas.

d. Available Manufacturers: Subject to compliance with these requirements and the standards of operating utility, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1) Bilco Co.
2) US Foundry, Inc.
3) Halliday Products, Inc.

2. Drain: ASME A112.6.3, cast-iron floor drain with outlet of size indicated. Include body anchor flange, light-duty cast-iron grate, bottom outlet, and integral or field-installed bronze ball or clapper-type backwater valve.

2.17 PRESSURE-REDUCING VALVES

A. Water Control Valves:

1. Available Manufacturers: Subject to compliance with these requirements and the standards of operating utility, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. CLA-VAL Automatic Control Valves.
b. Flomatic Corporation.
c. OCV Control Valves.
d. Watts Regulator Co.; Ames Fluid Control Systems.
e. Watts Regulator Co.; Watts ACV Division.
f. Zurn Plumbing Products Group; Wilkins Water Control Products Div.

2. Description: Pilot-operation, diaphragm-type, single-seated main water control valve with AWWA C550 interior epoxy coating. Include small pilot control valve, restrictor device, specialty fittings, and sensor piping.

    a. Pressure Rating: Initial pressure of 150 psig minimum.
    b. Main Valve Body: Cast- or ductile-iron body with AWWA C550 interior epoxy coating; or stainless-steel body.

        1) Size: as indicated on Drawings.
        2) Pattern: valve design as required by operating utility.
        3) Trim: Stainless steel.

    c. Design Flow Rate: <Insert gpm.>
    d. Design Inlet Pressure: <Insert psig.>
    e. Design Outlet Pressure Setting: <Insert psig.>
    f. End Connections: Flanged.

2.18 RELIEF VALVES

A. Air-Release Valves:

1. Available Manufacturers: Subject to compliance with these requirements and the standards of operating utility, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Crispin-Multiplex Manufacturing Co.
    b. GA Industries, Inc.
    c. Val-Matic Valve & Manufacturing Corp.

2. Description: Hydromechanical device to automatically release accumulated air.

    a. Standard: AWWA C512.
    b. Pressure Rating: 300 psig.
    c. Body Material: Cast iron.
    d. Trim Material: Stainless steel[, brass, or bronze].
    e. Water Inlet Size: <Insert NPS.>
    f. Air Outlet Size: <Insert NPS.>
    g. Orifice Size: <Insert inch.>
    h. Design Air-Release Capacity: <Insert cfm> at <Insert psig> pipeline pressure.

B. Air/Vacuum Valves:

1. Available Manufacturers: Subject to compliance with these requirements and the standards of operating utility, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Crispin-Multiplex Manufacturing Co.
    b. GA Industries, Inc.
    c. Val-Matic Valve & Manufacturing Corp.

2. Description: Direct-acting, float-operated, hydromechanical device with large orifice to automatically release accumulated air or to admit air during filling of piping.

    a. Standard: AWWA C512.

b. Pressure Rating: 300 psig.
c. Body Material: Cast iron.
d. Trim Material: Stainless steel[, brass, or bronze].
e. Inlet and Outlet Size: <Insert NPS.>
f. Orifice Size: <Insert inch.>
g. Design Air Capacity: <Insert cfm> at <Insert psig> differential pressure.

2.19 SERVICE CONNECTIONS (NPS 3 AND SMALLER)

A. Copper Tubing and Fittings

1. Soft Copper Tube: ASTM B 88, Type K, water tube, annealed temper.

a. Copper, Pressure-Seal Fittings: wrought-copper fitting with EPDM O-ring seal in each end.
b. Copper, Solder-Joint Fittings: Only acceptable where other connections will not work. ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint pressure type. Furnish only wrought-copper fittings if indicated.

B. Polyethylene (PE) Tubing: AWWA C901, material type PE-3408/3608.

1. Copper tubing size (CTS), rated for min. working pressure of 160 psi.
2. Marking: Clearly mark each joint of pipe at convenient intervals, as follows:

a. Manufacturer's name.
b. Nominal pipe size.
c. Material type.
d. Pressure rating.
e. National Sanitation Foundation (NSF) seal.

C. PVC Pipe: Schedule 40 in accordance with ASTM D 1785, with solvent cement joints in accordance with ASTM D 2564 and fitting in accordance with ASTM D 2466.

1. Marking: Clearly mark each joint of pipe at convenient intervals, as follows:

a. Manufacturer's name.
b. Nominal pipe size.
c. Pressure class.
d. Material designation.
e. National Sanitation Foundation (NSF) seal.

D. Tapping Saddles and Sleeves: in accordance with standards of operating utility.

E. Corporation Stops: in accordance with standards of operating utility.

F. Curb Stops: in accordance with standards of operating utility.

G. Meter Boxes: in accordance with standards of operating utility.

H. Water Meters: see paragraph 1.2.C regarding water meters.

I. Miscellaneous Fittings: in accordance with standards of operating utility.

2.20 CORROSION-PROTECTION PIPING ENCASEMENT

A. Encasement for Underground Metal Pipe, Fittings and Appurtenances:

1. Standards: ASTM A 674 or AWWA C105.
2. Form: Tube.
3. Material: LLDPE film of 0.008-inch minimum thickness.
4. Color: Blue.

2.21 PIPE DETECTION MATERIALS

A. Detectable Warning Tape: specified in Section titled “Earth Moving”.

B. Locator Wire In addition to warning tape where required by operating utility. Specified in Section titled “Earth Moving”.

2.22 PROTECTIVE ENCLOSURES

A. Freeze-Protection Enclosures:

1. Available Manufacturers: Subject to compliance with these requirements, the standards of authorities having jurisdiction, and approval by the Architect, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. DekoRRa Products.
b. G&C Enclosures.
c. Hot Box, Inc.
d. HydroCowl, Inc.
e. Watts Water Technologies, Inc.

2. Description: Insulated enclosure designed to protect aboveground water piping, equipment, or specialties from freezing and damage, with heat source to maintain minimum internal temperature of 40 deg F when external temperatures reach as low as minus 34 deg F.

a. Standard: ASSE 1060.
b. Class I: For pressure or atmospheric vacuum breaker equipment or devices. Include drain opening in housing.

1) Housing: Reinforced aluminum or fiberglass construction.

a) Size: Of dimensions indicated, but not less than those required for access and service of protected unit.
b) Drain opening for units with drain connection.
c) Access doors with locking devices.
d) Insulation inside housing.
e) Anchoring devices for attaching housing to concrete base.

2) Electric heating cable or heater with self-limiting temperature control.

B. Weather-Resistant Enclosures:

1. Available Manufacturers: Subject to compliance with these requirements, the standards of authorities having jurisdiction, and approval by the Architect, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. DekoRRa Products.
    b. G&C Enclosures.
    c. Hot Box, Inc.
    d. HydroCowl, Inc.
    e. Watts Water Technologies, Inc.

2. Description: Uninsulated enclosure designed to protect aboveground water piping, equipment, or specialties from weather and damage.

    a. Standard: ASSE 1060.
    b. Class II: For pressure or atmospheric vacuum breaker equipment or devices. Include drain opening in housing.

        1) Housing: Reinforced aluminum or fiberglass construction.

            a) Size: Of dimensions indicated, but not less than those required for access and service of protected unit.
            b) Drain opening for units with drain connection.
            c) Access doors with locking devices.
            d) Insulation inside housing.
            e) Anchoring devices for attaching housing to concrete base.

C. Enclosure Bases:

1. Description: 4 inch minimum thickness precast concrete, of dimensions required to extend at least 6 inches beyond edges of enclosure housings. Include openings for piping.

PART 3 - EXECUTION

3.1 STANDARDS OF OPERATING UTILITY

A. See paragraph 1.2.B above for information regarding execution standards of the operating utility.

3.2 EARTHWORK

A. Refer to Section titled "Earth Moving" for excavating, trenching, and backfilling.

B. Refer to Section titled "Earth Moving" for installation requirements of pipe detection materials.

3.3 PIPING APPLICATIONS

A. General: Use pipe, fittings, and joining methods for piping systems according to the following applications.

1. Transition couplings and special fittings with pressure ratings at least equal to piping pressure rating may be used, unless otherwise indicated.
2. Do not use flanges or unions for underground piping.
3. Flanges, unions, and special fittings may be used, instead of joints indicated, on aboveground piping and piping in vaults.
4. Restrained joints shall be provided where required by the operating utility and where indicated on Drawings.
5. Underground Water Main Piping NPS 3 and larger shall be the following, subject to approval by the operating utility and as indicated on the Drawings:
    a. Ductile-iron, push-on-joint pipe with ductile-iron, mechanical-joint fittings and gasketed joints.
    b. PVC, push-on-joint pipe with ductile-iron, mechanical-joint fittings and gasketed joints.
    c. HDPE pipe with ductile-iron, mechanical-joint fittings, and thermal fused joints.

B. Above Ground and Vault Water Main Piping NPS 3 and larger shall be ductile-iron, mechanical or flanged joint pipe and ductile-iron-pipe appurtenances; and gasketed, restrained joints.

C. Underground Water-Service Piping NPS 3/4 to NPS 2 shall be the following, subject to approval by the operating utility:

1. Soft copper tubing with copper, pressure-seal fittings and pressure-sealed joints. Wrought-copper, solder-joint fittings only where other connections will not work.
2. PE tubing with molded PE compression band fittings and heat-fusion joints.

3.4 VALVE APPLICATIONS

A. General Application: Use mechanical-joint-end valves for NPS 3 and larger underground installation. Use flanged-end valves for installation above ground or in vaults. Use UL/FMG, nonrising-stem gate valves for installation with indicator posts. Use corporation stops and curb stops with ends compatible with piping, for NPS 2 and smaller installation.

B. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Underground Valves for Water Mains: NPS 3 and Larger: AWWA, cast-iron, nonrising-stem, resilient-seated gate valves with valve box.
2. Underground Valves for Fire Protection Lines: NPS 3 and Larger, for Indicator Posts: UL/FMG, cast-iron, nonrising-stem gate valves with indicator post.
3. Use the following for valves in vaults and above ground:
    a. Gate Valves for Water Mains: NPS 3 and Larger: AWWA, cast iron, OS&Y rising stem, resilient seated.
    b. Gate Valves for Fire Protection Lines: NPS 3 and Larger: UL/FMG, cast iron, OS&Y rising stem.
4. Pressure-Reducing Valves: Use for water-service piping in vaults and above ground to control water pressure.
5. Relief Valves: Use for water-service piping in vaults and above ground.
    a. Air-Release Valves: To release accumulated air.
    b. Air/Vacuum Valves: To release or admit large volume of air during filling of piping.
    c. Combination Air Valves: To release or admit air.

3.5 PIPING INSTALLATION

A. Water-Main Connection: Arrange with utility company for tap of size and in location indicated in water main.

B. Water-Main Connection: [Tap][Install new tee in] water main according to requirements of water utility company and of size and in location indicated.
   1. Make connections larger than NPS 2 with tapping machine according to the following:
      a. Install tapping sleeve and tapping valve according to MSS SP-60.
      b. Install tapping sleeve on pipe to be tapped. Position flanged outlet for tapping valve.
      c. Install tapping valve onto tapping sleeve. Comply with MSS SP-60. Install valve with stem pointing up and with valve box.
      d. Use tapping machine compatible with valve and tapping sleeve; cut hole in main. Extract bit and close valve. Remove tapping machine.
      e. Slightly open valve briefly to flush out filings. Close valve and connect water-piping.
   2. Make connections NPS 2 and smaller with drilling machine according to the following:
      a. Install service-saddle assemblies and corporation stops in size, quantity, and arrangement required by operating utility.
      b. Install service-saddle assemblies on water-service pipe to be tapped. Position outlets for corporation stops.
      c. Install corporation stops into service-saddle assemblies.
      d. Use drilling machine compatible with service-saddle assemblies and corporation stops. Drill hole in main. Extract bit and close corporation stop.
      e. Remove drilling machine.
      f. Slightly open stop briefly to flush out filings. Close stop and connect water-service piping.
      g. Install manifold for multiple taps in water main.
      h. Install curb valve in water-service piping with head pointing up and with service box.

C. Install ductile-iron pipe according to AWWA C600, AWWA M41 and the standards of the operating utility.
   1. Install PE corrosion-protection encasement according to ASTM A 674 or AWWA C105.

D. Install PVC, AWWA pipe according to ASTM F 645, AWWA M23 and the standards of the operating utility.

E. Install HDPE, AWWA pipe according to AWWA M 55, PPI Handbook of Polyethylene Pipe and the standards of the operating utility.

F. Install PE tubing according to ASTM D 2774, ASTM F 645 and the standards of the operating utility.

G. Install copper tubing according to CDA's "Copper Tube Handbook" and the standards of the operating utility.

H. Install Schedule 40 PVC according to ASTM D 2774, ASTM F 645 and the standards of the operating utility.

I. Install fire-service-main piping according to NFPA 24 and standards of authorities having jurisdiction

1. For DIP, install PE corrosion-protection encasement according to ASTM A 674 or AWWA C105.

J. Bury piping with depth of cover over top at least 36 inches, with top at least 12 inches below level of maximum frost penetration, and according to the following:

1. Under Driveways and Streets: With at least 36 inches cover over top.
2. Under Railroad Tracks: With at least 48 inches cover over top.
3. In Loose Gravelly Soil and Rock: With at least 12 inches additional cover.

K. Install piping by tunneling or jacking, or combination of both, under streets and other obstructions that cannot be disturbed.

L. Install underground piping with restrained joints at horizontal and vertical changes in direction, at locations indicated on Drawings and where required by the operating utility. Use restrained-joint piping, thrust blocks, anchors, tie-rods and clamps, and other supports as accepted by the operating utility.

3.6 JOINT CONSTRUCTION

A. Make pipe joints according to the following (as applicable):

1. Ductile-Iron Piping, Gasketed Joints for Water Main Piping : AWWA C600, AWWA C111 AWWA M41 and standards of authorities having jurisdiction.
2. Ductile-Iron Piping, Gasketed Joints for Fire-Service-Main Piping: UL 194 and standards of authorities having jurisdiction.
3. PVC Piping Gasketed Joints: Use joining materials according to AWWA C900. Construct joints with elastomeric seals and lubricant according to ASTM D 2774 or ASTM D 3139, pipe manufacturer's written instructions and standards of authorities having jurisdiction.
4. HDPE Piping: Thermally butt fuse joints according to ASTM D 2657 and PPI Handbook of Polyethylene Pipe.

    a. Butt fusion joining of dissimilar SDR pipe sections is prohibited.
    b. Installers and joining inspectors shall be trained by manufacturer’s authorized representative.
    c. Fusion welding equipment shall be of a make and model approved by the manufacturer and shall operate in accordance with original equipment specifications.
    d. Join to other pipe materials by means of flanged connections or mechanical joint couplings designed for joining HDPE pipe to the other pipe material.

5. Copper-Tubing, Pressure-Sealed Joints: Use procedure recommended by copper, pressure-seal-fitting manufacturer.
6. PE Tubing, Pressure-Sealed Joints: Use brass fittings and fasteners according to fitting manufacturer's written instructions.
7. Schedule 40 PVC Piping: in accordance with ASTM D 2564 and standards of authorities having jurisdiction.
8. Dissimilar Materials Piping Joints: Use adapters compatible with both piping materials, with correct OD, and with system working pressure at least equal to pipe. Install according to fitting manufacturer's written instructions

3.7 ANCHORAGE INSTALLATION

A. Anchorage, General: Install water system piping with restrained joints at horizontal and vertical changes in direction, at locations indicated on Drawings, and where required by the operating utility. Subject to acceptance by the operating utility, anchorages and restrained-joint types that may be used include the following:

1. Concrete thrust blocks.
2. Set-screw mechanical retainer glands.
3. Bolted flanged joints.
4. Heat-fused joints.
5. Pipe clamps and tie rods.

B. Install anchorages for tees, plugs and caps, bends, crosses, valves, and hydrant branches. Include anchorages for the following piping systems:

1. Gasketed-Joint, Ductile-Iron, Water- Piping: According to AWWA C600 and the standards of the operating utility.
2. Gasketed-Joint, PVC Water- Piping: According to AWWA M23 and the standards of the operating utility.
3. Thermally Fused Joint, HDPE Water Piping with Mechanical Joint Fittings: According to AWWA M55 and the standards of the operating utility.
4. Fire-Service-Main Piping: According to NFPA 24 and the standards of jurisdictions having authority.

C. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

3.8 VALVE INSTALLATION

A. AWWA Gate Valves: Comply with AWWA C600, AWWA M44 and standards of the operating utility. Install each underground valve with stem pointing up and with valve box.

B. AWWA Valves Other Than Gate Valves: Comply with AWWA C600, AWWA M44 and standards of the operating utility.

C. UL/FMG, Gate Valves: Comply with NFPA 24 and standards of authorities having jurisdiction. Install each underground valve and valves in vaults with stem pointing up and with vertical cast-iron indicator post.

D. UL/FMG, Valves Other Than Gate Valves: Comply with NFPA 24 and standards of the authorities having jurisdiction.

E. Corporation and Curb Stops: Install according to the manufacturer’s written instructions and to the standards of the operating utility with head pointed up and with service box.

F. Pressure-Reducing Valves: Install in vault or above ground between shutoff valves.[Install full-size valved bypass.]

G. Relief Valves: Comply with AWWA C512. Install aboveground with shutoff valve on inlet.

3.9 FIRE HYDRANT INSTALLATION

A. General: Install each fire hydrant with separate and adjoining gate valve in supply pipe, anchor with restrained joints or thrust blocks to standards of operating utility, and support in upright position.

B. AWWA Fire Hydrants: Comply with AWWA M17, standards of operating utility, and standards of authorities having jurisdiction.

3.10 FLUSHING HYDRANT (BLOWOFF) INSTALLATION

A. Install post-type flushing hydrants with valve below frost line and provide for drainage. Support in upright position. Include separate gate valve or curb valve and restrained joints in supply piping.

B. Install ground-type flushing hydrants with valve below frost line and provide for drainage. Install hydrant box flush with grade. Include separate gate valve or curb valve and restrained joints in supply piping.

3.11 YARD HYDRANT INSTALLATION

A. Install in accordance with manufacturer's written instructions and standards of operating utility.

B. Install straight and plumb and positioned such that the drain port is located below frost line.

3.12 FIRE DEPARTMENT CONNECTION INSTALLATION

A. Install in accordance with manufacturer's written instructions and standards of operating utility.

B. Install straight and plumb and positioned such that the drain port is located below frost line.

C. Install ball drip valves at each check valve for fire department connection to mains.

D. Install protective pipe bollards [on two sides of] [on three sides of] each fire department connection.

3.13 WATER METER INSTALLATION

A. Install utility provided water meters, piping, and specialties according to standards of the operating utility.

B. Water Meters: Install water meters, NPS 3 and larger, in meter vaults. Include shutoff valves on water meter inlets and outlets and valved bypass around meters. Support meters, valves, and piping on brick or concrete piers.

3.14 ROUGHING-IN FOR WATER METERS

A. Rough-in piping and specialties, according to standards of the operating utility, ready to receive water meter installation by utility.

3.15 WATER METER BOX INSTALLATION

A. Install meter boxes according to the manufacturer's written instructions and the standards of the operating utility.

B. Install water meter boxes in paved areas flush with surface.

C. Install water meter boxes in grass or earth areas with top 2 inches above surface.

3.16 BACKFLOW PREVENTER INSTALLATION

A. Install backflow preventers of type, size, and capacity indicated. Include valves and test cocks. Install according to requirements of plumbing health department and authorities having jurisdiction.

B. Do not install backflow preventers that have relief drain in vault, or in other spaces subject to flooding, without adequate provisions for drainage.

C. Do not install bypass piping around backflow preventers.

D. Support NPS 2-1/2 and larger backflow preventers, valves, and piping near floor and on brick or concrete piers.

3.17 CONCRETE VAULT INSTALLATION

A. Install precast concrete vaults according to ASTM C 891, the standards of the operating utility, and the standards of the authorities have jurisdiction.

B. Install access hatch according to the manufacturer's written instructions, the standards of the operating utility, and the standards of the authorities have jurisdiction.

3.18 PROTECTIVE ENCLOSURE INSTALLATION

A. Install protective enclosures according to the manufacturer's written instructions and the standards of the operating utility.

B. Install concrete base level and with top approximately 2 inches above grade.

C. Install protective enclosure over valves and equipment.

D. Anchor protective enclosure to concrete base.

3.19 SERVICE CONNECTION INSTALLATION

A. Extend water-service piping and connect to water meter and building-water-piping systems at outside face of building wall in locations and pipe sizes indicated.

1. Terminate water-service piping at building wall until building-water-piping systems are installed. Terminate piping with caps, plugs, or flanges as required for piping material. Make connections to building-water-piping systems when those systems are installed.

3.20 PIPE DETECTION MATERIALS INSTALLATION

A. Install continuous underground detectable warning tape and locator wire, where required by operating utility. during backfilling of trench for underground water-distribution piping. Locate below finished grade, directly over piping and according to standards of operating utility. Pipe detection materials are specified in Section titled "Earth Moving."

3.21 FIELD QUALITY CONTROL

A. Hydrostatic Test: Conduct test according to AWWA C 600 or C 605, as applicable, and the standards of the authorities having jurisdiction.

1. Pre-testing: The Contractor shall conduct his on pre-tests and confirm that the system is capable of passing prior to requesting the Architect's presence to witness the test.

    a. Conduct pre-tests only after all installation is complete including joint restraint. Concrete thrust blocks shall have been in place long enough to have hardened sufficiently. Fill pipeline 24 hours before testing and apply test pressure to stabilize system. Use only potable water.
    b. Leaks shall be immediately repaired and the test shall be repeated until acceptable results are obtained.
    c. The Contractor shall notify the Architect at least 48 hours before the scheduled time of the official test. Passing test performed without the Architect present will be rejected. The Contractor will be required to retest, with the Architect present, without additional compensation.

2. Test Procedures: The line shall be slowly filled with water and all air expelled through air valves or other means. A suitable test pump, water meter and potable water source, furnished by the Contractor, shall be connected to the line by means of a tap (or other suitable means) in the line and the proper test pressure slowly applied to the line. The test pressure shall be maintained for at least two hours.

    a. Test at not less than 150 psi or one-and-one-half times working pressure, whichever is larger, for two hours. If pressure falls more than 5 psi during the test, the pump shall be reactivated and the pressure restored to the starting pressure as often as necessary. At the end of two hours, the pressure shall be restored to the starting pressure a final time and the total quantity of water used (leakage) to maintain the pressure for two hours shall be read.
    b. Open and close each valve within the system several times during the test period.
    c. Service connections, if present, shall be subjected to the hydrostatic test concurrently with the main lines.

3. Allowable Leakage: Allowable leakage shall be determined by the following formula:

    a. $L = 0.000007SD\sqrt{P}$
    b. Where:
    c. L = allowable leakage in gallons per hour.
    d. S = the total length of the pipe tested in feet.
    e. D = the nominal diameter of the pipe in inches.
    f. P = the average test pressure in psi gauge.

B. Preliminary Inspection: Make arrangements with Architect to conduct preliminary final inspection.

1. Pre-inspection: The Contractor shall conduct his own pre-inspection and confirm that the system is capable of passing prior to requesting the Architect's presence to witness the preliminary inspection.

    a. Repair or remove and replace components where test results or pre-inspections indicate that they do not comply with specified requirements.

2. Preliminary Inspection: The Contractor shall notify the Architect at least 48 hours before the scheduled time of the preliminary inspection.

    a. Preliminary inspection shall include but shall not necessarily be limited to the following (as applicable):

        1) A visual inspection of fire hydrants: Requirements include: verification that hydrant is plumb and at correct elevation, verification that caps are in place and operational, verification that hydrant is operational and that no apparent leakage exists, verification that gate valve is in place and operational, verification that hydrant finish is adequate, verification that hydrant location is correct.
        2) A visual inspection of valves: Requirements include: verification that valves are operational, verification that valve boxes are centered, plumb, at correct elevation, and properly backfilled, verification that valve indicates that water line is at adequate depth, verification that valve location is correct, verification that valve protection rings are properly installed, and verification that any valve appurtenances are properly installed and functioning.
        3) A visual inspection of connections to existing water system: Requirements include: verification of adequacy of connection work, verification that leakage does not exist, verification that connection valve is off, verification that safeguards are in place to prevent contamination of existing system by backflow from the new system.
        4) A visual inspection of water meters, backflow preventers and other appurtenances to confirm proper installation.

    b. Repair or remove and replace components where test results or preliminary final inspections indicate that they do not comply with specified requirements.
    c. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

C. Final Inspection: Upon successful completion of the preliminary inspection and after any required documentation has been received and approved by the authorities having jurisdiction, the Contractor, Architect, representatives of the authorities having jurisdiction shall conduct a final inspection of the system.

    a. The Contractor shall notify the Architect at least 48 hours before the desired time of the pre-inspection. The Architect shall endeavor to schedule attendance by representatives of the authorities having jurisdiction at the desired time; however, the Architect provides no guarantee of availability at that time. If unavailable, the Architect will schedule the representative at the soonest reasonable time. Final inspections will not be held without the attendance of both the Architect and a representative of the authorities having jurisdiction.
    b. Final inspection shall include but shall not necessarily be limited to the items listed for the pre-inspection.
    c. Repair or remove and replace components where test results or final inspections indicate that they do not comply with specified requirements.

d. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

D. Reports of Inspection Activities.

1. Where required, the Architect will provide final required documentation to authorities having jurisdiction for the purpose of obtaining a Permit to Operate. Promptly provide any documents required from Contractor. Once Permit to Operate is received, Architect will notify Contractor. Make final connections, when necessary, and place system in operation. Do NOT place system in operation before notification by Architect that Permit to Operate has been received.

3.22 DISINFECTION AND BACTERIOLOGICAL TESTING

A. Clean and disinfect water-distribution piping as follows:

1. Purge and disinfect according to AWWA C 651 and standards of authorities having jurisdiction.

a. Purge new water-distribution piping systems and parts of existing systems that have been altered, extended, or repaired before use.

1) Provide adequate openings to ensure that required flushing velocities are met.
2) Where applicable. provide protective measures as required to ensure that flushing waters do not damage property or cause erosion or flooding.

b. Fill lines to be disinfected with water/chlorine solution containing at least 50 ppm of chlorine; isolate and allow to stand for at least 24 hours.
c. At end of retention time, perform concentration testing of solution at the extreme end of the lines to be disinfected. Solution shall contain not less than 25 ppm of chlorine. If residual chlorine is less than 25 ppm, repeat procedure.
d. Once an acceptable residual chlorine count is obtained, flush system with clean, potable water until no chlorine remains in water coming from the system.

B. Bacteriological Testing:

1. Perform bacteriological testing according to AWWA C 651 and the standards of the authorities having jurisdiction.

a. Using methods acceptable to the Architect and authorities having jurisdiction, take two successive samples, at each dead-end line and at points deemed representative of the water in the newly constructed mains, at a period of at least 24 hours apart.
1) A test for residual chlorine content must be performed within 15 minutes of the time that the sample is drawn. Residual chlorine must be below the level required by AWWA C 651 and the authorities having jurisdiction.
b. Perform tests, at an independent laboratory certified by the authorities having jurisdiction, for coliform growth, non-coliform growth and residual chlorine.
c. Should the test values exceed the maximum acceptable values permitted by the authorities having jurisdiction, repeat disinfection, flushing and testing until acceptable values are obtained (with the exception of residual chlorine, in which case the samples are considered invalid and system must be only be flushed and retested).

d. Prepare reports of purging, disinfecting, and testing activities, including water sample chain of custody and copies of passing bacteriological tests, and provide to Architect.
   1) No more than 30 days can have passed between the time that the first passing sample is drawn and the time the corresponding bacteriological test results are submitted, along with all other required water system closeout documents, to the authorities having jurisdiction.
e. After passing samples are obtained, make arrangements for follow-up samples to be taken by the authorities having jurisdiction.
f. As before, should the test values of the follow-up samples exceed maximum acceptable values, repeat disinfection, flushing and testing until acceptable values are obtained.

END OF SECTION 331100

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SECTION 333100 – GRAVITY FLOW SANITARY SEWERAGE SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

1. 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 gravity sanitary sewer piping and related components outside the building.

B. The Section includes general requirements that will apply to all gravity sanitary sewerage systems. In addition, the operating utility (the authority having jurisdiction) has numerous specific requirements for materials and execution that are too varied to cover in this specification.

1. For this Project, the operating utility is Greenville Spartanburg Airport.
2. Materials and execution requirements that are not covered in this Section shall comply with the requirements of the operating utility.
3. Materials and execution requirements that are covered, but are in conflict with the requirements of the operating utility, shall comply with the higher quality or more restrictive requirement.

C. Tap and Impact Fees will be paid directly to the utility by the Owner and payment of said fees shall not be included in the Contractor’s scope of services.

1.3 DEFINITIONS

A. DIP: Ductile iron pipe.

B. LLDPE: Linear, low-density polyethylene plastic.

C. NPS: Nominal pipe size.

D. PP: Polypropylene plastic.

E. PVC: Polyvinyl chloride plastic.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

1. Ductile iron pipe.
2. Polyvinyl chloride pipe.
3. Wyes, elbows, reducers and similar fittings.
4. Precast concrete manholes, frame and covers, and related components.

5. Cleanout caps and covers.
6. Nonpressure-type pipe couplings.
7. Restrained joint type pipe couplings.
8. Grease traps.
9. Special fittings for expansion and deflection.
10. Corrosion-protection piping encasement.

B. Field quality-control test reports.

C. Record Drawings: Include the following, as required by authorities having jurisdiction, for use by Owner's surveyor in preparing record drawings:
1. Designation, size and length of sewer lines between manholes or cleanouts.
2. Location and depth below finished grade of service connections to sewer main.
3. Location and elevation of any other below ground appurtenances.

D. Minutes of preinstallation conference.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Comply with requirements of the authorities having jurisdiction.
2. Comply with standards of operating utility for sanitary sewer-service piping, including materials, installation, and testing.

B. Preinstallation Conference: Conduct conference to comply with requirements in Division 01 Section "Project Management and Coordination."

1. Review methods and procedures related to sanitary sewerage installation including, but not limited to, the following:

a. Review requirements of the operating utility.
b. Review site conditions and preparatory work.
c. Review requirements for protecting work.
d. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
e. Review inspection schedule and procedures required to monitor and document quality assurance.

C. Piping materials shall bear label, stamp, or other markings of specified testing agency.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic materials in direct sunlight. Support to prevent sagging and bending.

B. Protect pipe, pipe fittings, and seals from dirt and damage.

C. Handle manholes and precast concrete structures, according to manufacturer's written rigging instructions.

1.7 PROJECT CONDITIONS

A. Interruption of Existing Sanitary Sewer Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary sanitary sewer service according to requirements indicated:

1. Notify Architect, Owner, and Utility having jurisdiction no fewer than two days in advance of proposed interruption of service.
2. Do not proceed with interruption of water-distribution service without Architect's written permission.

1.8 COORDINATION

A. Where required, coordinate connection to existing sewer lines with operating utility.

PART 2 - PRODUCTS

2.1 STANDARDS OF OPERATING UTILITY

A. See paragraph 1.2.B above for information regarding materials standards of the operating utility.

2.2 DUCTILE-IRON PIPE AND FITTINGS (DIP)

A. Push-on-Joint, Ductile-Iron Pipe: ASTM A 746, with push-on-joint bell and plain spigot ends.

1. Gaskets: AWWA C111, rubber. Use only lubricants approved by the manufacturer.
2. Fittings: AWWA C110 or AWWA C153.
3. Pressure class: Class 150 minimum or as required by agency having jurisdiction.
4. Interior Lining: Ceramic Epoxy (Protecto 401 or approved equal), 40 mil thickness.
5. Laying length: 18 feet-0 inches to 20 feet-0 inches.
6. Pipe size: No metric sized pipe shall be permitted.
7. Marking: Clearly mark each joint of pipe at convenient intervals, as follows:

    a. Manufacturer’s name.
    b. Nominal pipe size.
    c. Letters “DI” or “Ductile”.
    d. Weight.
    e. Pressure Class.

8. Products: Subject to compliance with requirements, provide products by one of the following:

    a. American-Cast Iron Pipe Co.
    b. Griffin Pipe Co.
    c. McWane Cast Iron Pipe Co..
    d. U.S. Pipe Co.

2.3 POLYVINYL CHLORIDE PLASTIC PIPE AND FITTINGS (PVC)

A. PVC Sewer Pipe (ASTM): ASTM D 3034, Class 150, with bell end with gasket, and with spigot end.

1. Gaskets: ASTM F 477, rubber. Use lubricants approved by the manufacturer.
2. Fittings: ASTM D 3034. Use of saddle type fittings is prohibited.
3. Joints: ASTM D 3212.
4. Laying length: 18 feet-0 inches to 20 feet-0 inches
5. Pipe size: comply with outside diameter dimensions of DIP.
6. Standard dimension ratio: SDR 26, unless otherwise indicated on Drawings. SDR 21 where indicated for greater depth and crossings of other utilities (AWWA C900 or DIP may alternately be indicated for these applications).
7. Pipe color: green.
8. The use of solvent weld joints is prohibited.
9. Marking: Clearly mark each joint of pipe at convenient intervals, as follows:

    a. Manufacturer's name.
    b. Nominal pipe size.
    c. Pressure class.
    d. Material designation.
    e. National Sanitation Foundation (NSF) seal.

B. PVC Sewer Pipe (AWWA): AWWA C900, Class 150, with bell end with gasket, and with spigot end.

1. Gaskets: ASTM F 477, rubber. Use only non-toxic lubricants approved by the manufacturer and that will not support microbiological growth. Vegetable shortening shall not be used.
2. Joints: ASTM D 3139.
3. Laying length: 18 feet-0 inches to 20 feet-0 inches
4. Pipe size: comply with outside diameter dimensions of DIP.
5. Standard dimension ratio: SDR 18.
6. Pipe color: green.
7. The use of solvent weld joints is prohibited.
8. Marking: Clearly mark each joint of pipe at convenient intervals, as follows:

    a. Manufacturer's name.
    b. Nominal pipe size.
    c. Pressure class.
    d. Material designation.

C. National Sanitation Foundation (NSF) seal.

D. PVC Sewer Pipe: AWWA C905, DR-18, with bell end with gasket, and with spigot end.

1. Gaskets: ASTM F 477, rubber. Use lubricants approved by the manufacturer.
2. Fittings: ASTM D 3034. Use of saddle type fittings is prohibited.
3. Joints: AWWA C111
4. Laying length: 18 feet-0 inches to 20 feet-0 inches
5. Pipe size: comply with outside diameter dimensions of DIP.
6. Standard dimension ratio: SDR 18, unless otherwise indicated on Drawings.
7. Pipe color: green.
8. The use of solvent weld joints is prohibited.
9. Marking: Clearly mark each joint of pipe at convenient intervals, as follows:

a. Manufacturer's name.
b. Nominal pipe size.
c. Pressure class.
d. Material designation.
e. National Sanitation Foundation (NSF) seal.
f.

2.4 MANHOLES

A. Standard Precast Concrete Manholes: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.

1. Diameter: 48 inches minimum or as required to accommodate pipe size, unless otherwise indicated.
2. Ballast: Increase thickness of precast concrete sections or add concrete to base section, as required to prevent flotation.
3. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section, and having separate base slab or base section with integral floor.
4. Inverts (channels and benches): See "Concrete" article below.
5. Riser Sections: 4-inch minimum thickness, and lengths to provide depth indicated.
6. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.
7. Joint Sealant: ASTM C 990, bitumen or butyl rubber.
8. Resilient Pipe Connectors: ASTM C 923, cast or fitted into manhole walls, for each pipe connection.
9. Steps: Individual ASTM A 615/A 615M, deformed, 1/2-inch steel reinforcing rods encased in ASTM D 4101, PP wide enough to allow worker to place both feet on 1 step and designed to prevent lateral slippage off of step. Cast or anchor steps into sidewalls at 12 to 16-inch intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches.
10. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and diameter matching manhole frame and cover. Include sealant recommended by ring manufacturer.
11. Protective Coating: For interior surfaces of lift station receiving manholes, manholes with force main connections, and the next manhole downstream apply Raven 405 by Raven Lining Systems or approved equal. 120 mil nominal thickness.
12. Manhole Frames and Covers: Ferrous; 24 inch ID by 7 to 9 inch riser with 4 inch minimum width flange and 26 inch diameter cover. Include indented top design with lettering cast into cover, using wording or design required by agency having authority. Where no specific wording or design is required by agency, wording equivalent to "SANITARY SEWER" shall be cast.

    a. Material: ASTM A 48, Class 35 gray iron, unless otherwise indicated.
    b. Protective Coating: Foundry-applied, SSPC-Paint 16, coal-tar, epoxy-polyamide paint; 10-mil minimum thickness applied to all surfaces, unless otherwise

B. Manhole Cover Inserts: Manufactured, plastic form, of size to fit between manhole frame and cover and designed to prevent stormwater inflow. Include handle for removal and gasket for gastight sealing.

1. Manufacturers:

    a. FRW Industries; a Syneco Systems, Inc. company.

b. Knutson Enterprises.
c. L.F. Manufacturing, Inc.
d. Parson Environmental Products, Inc.

2.5 FIELD INSTALLED PIPE TO MANHOLE CONNECTORS

A. Resilient Pipe Connectors: ASTM C 923, design specifically for field installation, for each pipe connection.

2.6 CLEANOUTS

A. PVC Cleanouts: PVC body with PVC threaded plug. Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping.

1. Manufacturers:

a. Canplas Inc.
b. IPS Corporation.
c. NDS Inc.
d. Plastic Oddities, Inc.
e. Sioux Chief Manufacturing Company, Inc.
f. Zurn Industries, Inc.; Zurn Light Commercial Specialty Plumbing Products.

B. Frame and Cover: Traffic grade cast-iron according to the standards of the authorities having jurisdiction, as indicated or, where not indicated, in accordance with the following:

1. Use medium-duty, top-loading classification cleanouts in landscaped and foot-traffic areas.
2. Use heavy-duty, top-loading classification cleanouts in vehicle-traffic service areas.
3. Use extra-heavy-duty, top-loading classification cleanouts in roads areas.

C. Concrete Collar: Where not located as a casting embedded in pavement, provide cast-in-place concrete collar as indicated on Drawings or, where not indicated 18 by 18 by 12 inchesdeep.

2.7 NONPRESSURE-TYPE PIPE COUPLINGS

A. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined, and stainless steel tension band and tightening mechanism on each end.

B. Sleeve Materials:

1. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

C. Unshielded Flexible Couplings: Elastomeric sleeve with stainless steel shear ring and stainless steel-metal tension band and tightening mechanism on each end.

1. Manufacturers:

a. Dallas Specialty & Mfg. Co.
b. Fernco Inc.

c. Logan Clay Products Company (The).
d. Mission Rubber Company; a division of MCP Industries, Inc.
e. NDS Inc.
f. Plastic Oddities, Inc.

D. Ring-Type Flexible Couplings: Elastomeric compression seal with dimensions to fit inside bell of larger pipe and for spigot of smaller pipe to fit inside ring.

1. Manufacturers:

a. Fernco Inc.
b. Logan Clay Products Company (The).
c. Mission Rubber Company; a division of MCP Industries, Inc.

2.8 RESTRAINTED JOINTS

A. Push-on (DIP only) or mechanical joint type joint restraint for DIP to PVC transitions and where indicated on Drawings or where required by operating utility and in accordance with standards of operating utility.

1. Push-on Gaskets: AWWA C 111, for use on DIP only, approved for use on the pipe on which it is installed. Use only non-toxic lubricants approved by the manufacturer and that will not support microbiological growth. Vegetable shortening shall not be used.
2. Mechanical Joint Glands, Gaskets and Bolts: AWWA C 111, the gland, gasket and bolts shall be part of an integral system by the same manufacturer and approved for use on the pipe on which it is installed. Installation shall require only standard mechanical joint assembly techniques. Bolts shall be 316 Stainless Steel. Use only non-toxic lubricants approved by the manufacturer and that will not support microbiological growth. Vegetable shortening shall not be used.
3. DIP Pressure Rating: 350 psi.
4. PVC Pressure Rating: rated at a 2:1 safety factor for the pipe on which it is installed.
5. Products: Subject to compliance with requirements, provide products by one of the following:

a. American-Cast Iron Pipe Co.
b. Griffin Pipe Co.
c. McWane Cast Iron Pipe Co..
d. U.S. Pipe Co.
e. Ebba Iron Inc.
f. Ford Meter Box Co.
g. Sigma Corporation.

2.9 SPECIAL PIPE FITTINGS FOR DEFLECTION AND EXPANSION

A. Ductile-Iron Flexible Expansion Joints: Compound fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include 2 gasketed ball-joint sections and 1 or more gasketed sleeve sections, rated for 250-psig minimum working pressure and for offset and expansion indicated.

1. Manufacturers:

a. EBAA Iron Sales, Inc.
b. Romac Industries, Inc.

c. Star Pipe Products.

2.10 GREASE TRAPS

A. Description: Precast, reinforced-concrete vault, designed for A-16 load designation according to ASTM C 857 and made according to ASTM C 858, with internal; grease trap configuration as indicated on Drawings.

1. Dimensions: as indicated on Drawings.
2. Ballast: Increase thickness of precast concrete sections or add concrete to base section, as required to prevent flotation.
3. Riser Sections: ASTM C 478, precast, reinforced concrete, 4-inch minimum thickness, and lengths to provide depth indicated.
4. Manhole Frames and Covers: Ferrous; 24 inch ID by 7 to 9 inch riser with 4 inch minimum width flange and 26 inch diameter cover. Include indented top design with lettering cast into cover, using wording or design required by agency having authority. Where no specific wording or design is required by agency, wording equivalent to "SANITARY SEWER" shall be cast.

    a. Material: ASTM A 48, Class 35 gray iron, unless otherwise indicated.
    b. Protective Coating: Foundry-applied, SSPC-Paint 16, coal-tar, epoxy-polyamide paint; 10-mil minimum thickness applied to all surfaces, unless otherwise

5. Internal Components: as indicated on Drawings.

2.11 CONCRETE

A. General: Class 3000 concrete in accordance with Section 701 of the South Carolina Department of Transportation Standard Specifications for Highway Construction.

B. Portland Cement Design Mix: 3000 psi minimum, with 0.45 maximum water-cementitious materials ratio.

1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
2. Reinforcement Bars: ASTM A 615/A 615M, Grade 60, deformed steel.

C. Manhole Channels and Benches: Field formed from concrete.

1. Channels: Concrete invert, formed to same width as connected piping, with height of vertical sides to three-fourths of pipe diameter. Form curved channels with smooth, uniform radius and slope.

    a. Invert Slope: Minimum of 1 percent or as required to provide uniform slope between invert elevations indicated on Drawings.

2. Benches: Concrete, sloped to drain into channel.

    a. Slope: 8 percent.

D. Ballast and Pipe Supports: Field formed from concrete.

1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
2. Reinforcement Bars: ASTM A 615/A 615M, Grade 60, deformed steel.

2.12 CORROSION-PROTECTION PIPING ENCASEMENT

A. Encasement for Underground Metal Pipe, Fittings and Appurtenances:

1. Standards: ASTM A 674 or AWWA C105.
2. Form: Tube.
3. Material: LLDPE film of 0.008-inch minimum thickness.
4. Color: Blue.

2.13 PIPE DETECTION MATERIALS

A. Detectable Warning Tape: specified in Section titled “Earth Moving”.

B. Locator Wire In addition to warning tape where required by operating utility. Specified in Section titled “Earth Moving”.

PART 3 - EXECUTION

3.1 STANDARDS OF OPERATING UTILITY

A. See paragraph 1.2.B above for information regarding execution standards of the operating utility.

3.2 EARTHWORK

A. Refer to Section titled "Earth Moving" for excavating, trenching, and backfilling.

B. Refer to Section titled "Earth Moving" for installation requirements of pipe detection materials.

3.3 PIPING APPLICATIONS

A. Flexible pipe couplings may be used in applications below, unless otherwise indicated.

1. Use nonpressure-type flexible couplings where required to join gravity-flow, nonpressure sewer piping of different material type or size, unless otherwise indicated. No other use of flexible couplings will be permitted.

a. Unshielded flexible couplings for same or minor difference OD pipes.
b. Unshielded, increaser/reducer-pattern, flexible couplings for pipes with different OD.
c. Ring-type flexible couplings for piping of different sizes where annular space between smaller piping's OD and larger piping's ID permits installation.

B. Special Pipe Fittings: Use for pipe expansion and deflection. Pipe couplings and special pipe fittings with pressure ratings at least equal to piping rating shall be used only where indicated on the Drawings.

C. Gravity-Flow, Nonpressure Sewer Piping: Use the following pipe materials as indicated on the Drawings.

1. Ductile-iron, gravity sewer pipe; ductile-iron standard or compact fittings; gaskets; and gasketed joints.
2. PVC sewer pipe and fittings, gaskets, and gasketed joints.

3.4 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate location and arrangement of underground sanitary sewerage piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for using lubricants, and other installation requirements.

C. Install manholes for changes in direction, unless fittings are indicated. Use fittings for service branch connections, unless direct tap into existing sewer is indicated.

D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

E. Tunneling: Install pipe under streets or other obstructions that cannot be disturbed by tunneling, jacking, or combination of both.

F. Install gravity-flow, nonpressure, sanitary sewerage piping according to the following:

1. Install piping pitched down in direction of flow, at the slope indicated or, where not indicated, at a minimum slope of 1/2 percent.
2. Install piping with 36-inch minimum cover unless otherwise indicated.
3. Install ductile-iron, gravity sewer piping according to ASTM A 746 and the standards of the operating utility.
4. Install ductile-iron and special fittings according to AWWA C600, AWWA M41 and the standards of the operating utility.
5. Install PVC sewer piping according to ASTM D 2321, ASTM F 1668 and the standards of the operating utility.

G. Install corrosion-protection piping encasement over ductile-iron pipe and fittings according to ASTM A 674 or AWWA C105 and the standards of the operating utility.

H. Clear interior of piping and manholes of dirt and superfluous material as work progresses. Maintain swab or drag in piping, and pull past each joint as it is completed. Place plug in end of incomplete piping at end of day and when work stops.

3.5 PIPE JOINT CONSTRUCTION

A. Join gravity-flow, nonpressure, sanitary sewerage piping according to the following:

1. Join ductile-iron, gravity sewer piping according to AWWA C600 for push-on joints and the standards of the operating utility.
2. Join ductile-iron and special fittings according to AWWA C600, AWWA M41 and the standards of the operating utility.

3. Join PVC sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric-gasket joints and the standards of the operating utility.
4. Join dissimilar pipe materials with [nonpressure-type, flexible][restrained joint] couplings in accordance with manufacturer's written instructions.

3.6 MANHOLE INSTALLATION

A. General: Install manholes complete with appurtenances and accessories indicated.

B. Install precast concrete manhole sections with sealants according to ASTM C 891.

C. Form continuous concrete channels and benches between inlets and outlet.

D. For manholes that occur in pavements, set tops of frames and covers flush with finished surface. Set tops 2 inches above finished surface elsewhere, unless otherwise indicated.

E. Install manhole cover inserts in frame and immediately below cover in accordance with manufacturer's written instructions.

3.7 CONCRETE PLACEMENT

A. Place cast-in-place concrete according to Sections 701, and 702 of the South Carolina Department of Transportation Standard Specifications for Highway Construction for measuring, mixing, transporting, and placing concrete.

3.8 CLEANOUT INSTALLATION

A. Install cleanouts and riser extension from sewer pipe to cleanout at grade. Use pipe fittings of same material as pipe at branches for cleanouts and PVC pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.

B. Install cast-iron frames and covers.

1. Use medium-duty, top-loading classification cleanouts in landscaped and foot-traffic areas.
2. Use heavy-duty, top-loading classification cleanouts in vehicle-traffic service areas.
3. Use extra-heavy-duty, top-loading classification cleanouts in roads areas.
4. Set cleanout frames and covers located in earthen areas in cast-in-place concrete collar, 18 by 18 by 12 inchesdeep. Set with tops 1 inch above surrounding earth grade
5. Set cleanout frames and covers in pavement with tops flush with pavement surface.

3.9 SERVICE CONNECTION INSTALLATION

A. Extend sanitary sewer-service piping and connect to building sanitary sewer system at outside face of building wall in locations and pipe sizes indicated.

1. Terminate sanitary sewer service piping at building wall until building sanitary sewer piping is installed. Terminate piping with caps, plugs, or flanges as required for piping material. Make connections to building sanitary sewer piping systems when those systems are installed.

3.10 CONNECTIONS TO EXISTING SANITARY SEWER

A. Where required by operating utility, connections to existing piping or manholes shall be made in the presence of an authorized inspector. Notify the Architect at least 48 hours before starting a connection.

B. Where indicated, construct new manhole over existing gravity main by cutting upper half of existing pipe after base of manhole is completed so as not to obstruct flow of the existing pipe.

C. Where indicated, make connections to existing piping using 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 concrete.

D. Where indicated, make connections to existing underground manholes as follows:

1. Core drill opening into existing manhole large enough to allow installation of resilient manhole connector.
2. Install resilient manhole connector in manhole opening accordance with manufacturer's written instructions.
3. Install pipe in resilient connector in accordance with manufacturer's written instructions.
4. Cut end of connection pipe passing through manhole wall to be flush with inside wall, unless otherwise indicated.
5. On outside of manhole wall, encase entering connection and pipe in 6 inches of concrete for minimum length of 12 inches to provide additional support of connector from connection to undisturbed ground.
6. On inside of manhole wall, encase outside of pipe to flush with face of wall with grout. Form smooth invert channel transition to existing invert or complete installation of internal drop piping as applicable.
7. Use epoxy-bonding compound as interface between new and existing concrete and piping materials.

E. Protect piping and manholes to prevent concrete or debris from entering while making connections. Remove debris or other extraneous material that may accumulate.

3.11 CLOSING ABANDONED SANITARY SEWERAGE SYSTEMS

A. Abandoned Piping: Close open ends of abandoned underground piping indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of abandoned piping have been closed:

1. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.

B. Abandoned Manholes: Excavate around manhole as required and use either procedure below:

1. Remove manhole and close open ends of remaining piping.
2. Remove top of manhole down to at least 36 inches below final grade. Fill to within 12 inches of top with stone, rubble, gravel, or compacted dirt. Fill to top with concrete.

C. Backfill to grade according to Section titled "Earth Moving."

3.12 PIPE DETECTION MATERIALS INSTALLATION

A. Install continuous underground detectable warning tape and locator wire, where required by operating utility. during backfilling of trench for underground sanitary sewerage piping. Locate below finished grade, directly over piping and according to standards of operating utility. Pipe detection materials are specified in Section titled "Earth Moving."

3.13 FIELD QUALITY CONTROL

A. During Installation: Inspect interior of piping, to determine whether line displacement or other damage has occurred, continuously during installation. Inspect after approximately 24 inches of backfill is in place, and again at completion of each section of piping between manholes.

1. Defects requiring correction include the following:

    a. Alignment: Less than full diameter of inside of pipe is visible between structures.
    b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 95 percent of piping diameter.
    c. Crushed, broken, cracked, or otherwise damaged piping or manholes.
    d. Infiltration: Water leakage into piping or manholes.
    e. Exfiltration: Water leakage from or around piping.

2. Replace defective piping and manholes using new materials, and repeat inspections until defects are within allowances specified.

B. Testing: The Contractor shall notify the Architect at least 48 hours before the scheduled time of the official tests. Passing test performed without the Architect present will be rejected. The Contractor will be required to retest, with the Architect present, without additional compensation

1. Pipe deflection test: Each section of piping will be tested for internal diametric deflection by the use of a 5% mandrel.

    a. The mandrel pull shall be performed according to the "Recommended Standards for Wastewater Facilities" by the Great Lakes - Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers (Ten State Standards)” and the standards of the operating utility.
    b. The Contractor shall not use any mechanical device for the mandrel pull.
    c. Deflections of greater than 5% shall be corrected.

2. Low Pressure Air Tests: Test gravity sewer piping according to UNI-B-6, and the standards of operating utility.

    a. Prior to performing test, system shall be backfilled to final grade and a waiting period, specified by the operating utility, shall have passed.
    b. All service connections shall be in place prior to testing.
    c. Leaks and loss in test pressure constitute defects that must be repaired.
    d. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

C. Preliminary Inspection: Make arrangements with Architect to conduct preliminary final inspection.

1. Pre-inspection: The Contractor shall conduct his own pre-inspection and confirm that the system is capable of passing prior to requesting the Architect's presence to witness the preliminary inspection.

    a. Repair or remove and replace components where test results or pre-inspections indicate that they do not comply with specified requirements.
    b. Remove all sand, dirt, brick, excess grout, and other foreign matter from manholes and piping. Material shall not be flushed into existing sewer lines

2. Preliminary Inspection: The Contractor shall notify the Architect at least 48 hours before the scheduled time of the preliminary inspection.

    a. Preliminary inspection shall include but shall not necessarily be limited to the following:

        1) A visual inspection of manholes. Requirements include: verification that manhole is plumb and at correct elevation; verification that frame and cover is properly installed, centered, grouted inside and out, and at proper elevation; verification that section joints are sealed watertight and properly grouted; verification that inverts and shelves are smooth, of correct slope, and properly formed; verification that steps are properly positioned, securely embedded, and undamaged; verification that drop manhole piping is properly installed and secure; verification that pipe openings are watertight, properly located, and properly grouted; verification that interior of manhole has been cleaned of dirt and construction debris and verification that grades in the vicinity of the manhole are properly established and well drained.
        2) A visual inspection of piping. Requirements include: verification that piping is clean and unobstructed; verification that piping is straight and not visually deflected from a circular cross-section (i.e.: full moon when flashed or lamped); verification that no infiltration or exfiltration is visually evident.
        3) Verification of proper elevations, slopes, and horizontal and vertical alignment (under no circumstances will a line be accepted which is below the minimum slope required by the authorities having jurisdiction for a given line size.

    b. Repair or remove and replace components where test results or preliminary inspections indicate that they do not comply with specified requirements.
    c. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

D. Final Inspection: Upon successful completion of the preliminary final inspection and after any required documentation has been received and approved by the authorities having jurisdiction, the Contractor, Architect, representatives of the authorities having jurisdiction shall conduct a final inspection of the system.

    a. The Contractor shall notify the Architect at least 48 hours before the desired time of the pre-inspection. The Architect shall endeavor to schedule attendance by representatives of the authorities having jurisdiction at the desired time; however, the Architect provides no guarantee of availability at that time. If unavailable, the Architect will schedule the representative at the soonest reasonable time. Final inspections will not be held without the attendance of both the Architect and a representative of the authorities having jurisdiction.
    b. Final inspection shall include but shall not necessarily be limited to the items listed for the pre-inspection.

c. Repair or remove and replace components where test results or final inspections indicate that they do not comply with specified requirements.
d. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

E. Video Documentation: Immediately after final approval of the completed system, complete a videotaped inspection of the completed piping system utilizing equipment made expressly for the purpose. Provide a written report, inspection logs, and a copy of the inspection videotape to the Architect.

F. Reports of Inspection Activities.

1. Where required, the Architect will provide final required documentation to authorities having jurisdiction for the purpose of obtaining a Permit to Operate. Promptly provide any documents required from Contractor. Once Permit to Operate is received, Architect will notify Contractor. Make final connections, when necessary, and place system in operation. Do NOT place system in operation before notification by Architect that Permit to Operate has been received.

END OF SECTION 333100

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SECTION 334100 - STORM DRAINAGE SYSTEM

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 gravity-flow, nonpressure storm drainage outside the building with the following components:

1. Special fittings for expansion and deflection.
2. Backwater valves.
3. Cleanouts.
4. Pipe culverts.
5. Drains.
6. Corrosion-protection piping encasement.
7. Drainage structures.
8. Channel drainage systems.
9. Outlet protection.
10. Storage and leaching chambers.
11. Manholes.
12. Stormwater oil and sediment separators.

1.3 DEFINITIONS

A. CMP: Corrugated Metal Pipe (Steel)

B. DIP: Ductile iron pipe

C. Drainage Structures: catch basins, curb inlets, junction boxes, weir inlets, pond outlet structures.

D. HDPE: High density polyethylene pipe

E. LLDPE: Linear low-density, polyethylene plastic.

F. NPS: Nominal pipe size

G. PE: Polyethylene plastic.

H. PP: Polypropylene plastic.

I. PVC: Polyvinyl chloride plastic.

J. SRCP: Reinforced Concrete Pipe (sealant joints)

K. GRCP: Reinforced Concrete Pipe (gasket joints)

1.4 PERFORMANCE REQUIREMENTS

A. Gravity-Flow, Nonpressure, Drainage-Piping Pressure Rating: Pipe joints shall be at least silt-tight, unless otherwise indicated.

1.5 SUBMITTALS

A. Product Data: For the following:

1. Special pipe fittings.
2. Backwater valves.
3. Cleanouts.
4. Pipe culverts.
5. Drains.
6. Corrosion protection piping encasement
7. Channel drainage systems.
8. Outlet protection

B. Shop Drawings: Include plans, elevations, sections, details, and frames and covers for the following:

1. Manholes.
2. Drainage structures.
3. Storage and leaching chambers.
4. Stormwater oil and sediment separators

C. Field quality-control test reports.

D. Minutes of preinstallation conference.

1.6 QUALITY ASSURANCE

A. Authorities Having Jurisdiction: Conform to requirements of all authorities having jurisdiction.

1. Where conflicts exist between the requirements of the Contract Documents and those of authorities having jurisdiction, the higher quality or more restrictive requirement shall apply.

a. For locations within areas of DOT jurisdiction, perform all work, testing, and inspections in accordance with applicable DOT standards and procedures.

B. Preinstallation Conference: Conduct conference to comply with requirements in Division 01 Section "Project Management and Coordination."

1. Review methods and procedures related to storm drainage installation including, but not limited to, the following:

a. Review requirements of the authorities having jurisdiction.

b. Review site conditions and preparatory work.
c. Review requirements for protecting work.
d. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
e. Review inspection schedule and procedures required to monitor and document quality assurance.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic materials in direct sunlight. Support to prevent sagging and bending.

B. Protect pipe, pipe fittings, and seals from dirt and damage.

C. Handle manholes, drainage structures and pipe culverts according to manufacturer's written rigging instructions.

1.8 PROJECT CONDITIONS

A. Interruption of Existing Storm Drainage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:

1. Notify Architect no fewer than two days in advance of proposed interruption of service.
2. Do not proceed with interruption of service without Architect's written permission.

PART 2 - PRODUCTS

2.1 DUCTILE-IRON PIPE AND FITTINGS (DIP)

A. Pipe: AWWA C151, for push-on joints.

B. Standard Fittings: AWWA C110, ductile or gray iron, for push-on joints.

C. Compact Fittings: AWWA C153, for push-on joints.

D. Gaskets: AWWA C111, rubber.

E. Corrosion Protection Encasement for Underground Metal Piping: ASTM A 674 or AWWA C105.

1. Form: Tube.
2. Material: LLDPE film of 0.008-inch minimum thickness.
3. Color: Black.

2.2 STEEL PIPE AND FITTINGS (CMP)

A. Corrugated-Steel Pipe and Fittings: ASTM A 760/A 760M, Type I with fittings of similar form and construction as pipe.

1. Silt-tight Joint Bands: Corrugated steel with O-ring seals.
2. Coating: Aluminum.

2.3 HIGH DENSITY POLYETHYLENE PIPE AND FITTINGS (HDPE)

A. Corrugated HDPE Drainage Pipe and Fittings NPS 10 and Smaller: AASHTO M 252M, Type S, with smooth waterway for coupling joints

1. Silt-tight Couplings: HDPE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with tube and fittings.

B. Corrugated HDPE Pipe and Fittings NPS 12 to NPS 48: AASHTO M 294M, Type S, with smooth waterway for coupling or integral bell and spigot joints.

1. Water-tight Couplings: Bell to bell HDPE couplers or integral bell and spigot joints with ASTM F 447, elastomeric seals that mate with pipe and fittings.
2. Finished joint system shall meet the requirements of ASTM D 3212.

C. Corrugated HDPE Pipe and Fittings NPS 56 and NPS 60: AASHTO MP7, Type S, with smooth waterway for integral bell and spigot joints.

1. Water-tight Couplings: Integral bell and spigot joints with ASTM F 447, elastomeric seals that mate with pipe and fittings.
2. Finished joint system shall meet the requirements of ASTM D 3212.

2.4 CORRUGATED POLYPROPYLENE PIPE (PP)

A. Corrugated Polypropylene Pipe and Fittings

1. ADS HP Storm or approved equal with smooth waterway for coupling or integral bell and spigot joints.

a. NPS 12 to NPS 30: ASTM F 2736 and AASHTO M330.
b. NPS 36 to NPS 60: ASTMF 2881 and AASHTO M330.
c. Water-tight Couplings: Bell to bell HDPE couplers or integral bell and spigot joints with ASTM F 447, elastomeric seals that mate with pipe and fittings.
d. Finished joint system shall meet the requirements of ASTM D 3212.

2.5 POLYVINYL CHLORIDE PLASTIC PIPE AND FITTINGS (PVC)

A. PVC Sewer Pipe and Fittings, NPS 15 and Smaller: ASTM D 3034, SDR 26, with bell-and-spigot ends for gasketed joints with ASTM F 477, elastomeric seals.

1. Finished joint system shall meet the requirements of ASTM D 3212.

2.6 CONCRETE PIPE (GRCP and SRCP)

A. Reinforced-Concrete Sewer Pipe: ASTM C 76, with bell-and-spigot or groove and tongue ends.

1. Class III, Wall B.
2. Joints shall be as follows:

    a. Where indicated as GRCP on Drawings: gasketed joints with ASTM C 443, rubber gaskets.
    b. Where indicated as SRCP on Drawings: sealant joints with ASTM C 990, bitumen or butyl-rubber sealant.

2.7 ELLIPTICAL CONCRETE PIPE (ECP)

A. Reinforced-Concrete Elliptical Pipe: ASTM C 507, with bell-and-spigot or groove and tongue ends.

1. Class HE-III, Wall B.
2. Sealant joints with ASTM C 990, bitumen or butyl-rubber sealant.

2.8 CONCRETE BOX CULVERTS (CBC)

A. Reinforced-Concrete Box Sections: ASTM C 1433, with bell-and-spigot or groove and tongue ends.

1. Table 1 load classification.
2. Sealant joints with ASTM C 990, bitumen or butyl-rubber sealant.

2.9 GEOTEXTILES

A. Pipe Joint Wrap Geotextile: Nonwoven needle-punched geotextile, 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. Width: Min. 18” or sufficient to extend beyond the joint and base of pipe bell at least 6 inches on each side.
2. Length: One continuous piece of sufficient length to extend around the entire pipe circumference with a 12” overlap.
3. Survivability: Class 1, Type A, B, or C; SCDOT Standard Specs
4. Grab Tensile Strength: 90 lbf; ASTM D 4632.
5. Puncture Strength: 60 lbf; ASTM D 4833.
6. Trapezoidal Tear: 40 lbf; ASTM D-4533
7. Apparent Opening Size: No. 70 sieve, maximum; ASTM D 4751.
8. Permittivity: 2.2 second-1, minimum; ASTM D 4491.
9. UV Stability: 70 percent after 500 hours' exposure; ASTM D 4355.
10. Water Flow Rate: 150 gal/min/ft^2; ASTM D-4491

2.10 NONPRESSURE-TYPE PIPE COUPLINGS

A. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined, and stainless steel tension band and tightening mechanism on each end.

B. Sleeve Materials:

1. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

C. Unshielded Flexible Couplings: Elastomeric sleeve with stainless steel shear ring and stainless steel-metal tension band and tightening mechanism on each end.

1. Manufacturers:

a. Dallas Specialty & Mfg. Co.
b. Fernco Inc.
c. Logan Clay Products Company (The).
d. Mission Rubber Company; a division of MCP Industries, Inc.
e. NDS Inc.
f. Plastic Oddities, Inc.

D. Ring-Type Flexible Couplings: Elastomeric compression seal with dimensions to fit inside bell of larger pipe and for spigot of smaller pipe to fit inside ring.

1. Manufacturers:

a. Fernco Inc.
b. Logan Clay Products Company (The).
c. Mission Rubber Company; a division of MCP Industries, Inc.

2.11 SPECIAL PIPE FITTINGS FOR DEFLECTION AND EXPANSION

A. Ductile-Iron Flexible Expansion Joints: Compound fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include 2 gasketed ball-joint sections and 1 or more gasketed sleeve sections, rated for 250-psig minimum working pressure and for offset and expansion indicated.

1. Manufacturers:

a. EBAA Iron Sales, Inc.
b. Romac Industries, Inc.
c. Star Pipe Products.

2.12 BACKWATER VALVES

A. Gray-Iron Backwater Valves: ASME A112.14.1, gray-iron body and bolted cover, with bronze seat.

1. Manufacturers:

a. Josam Company.
b. Smith, Jay R. Mfg. Co.
c. Wade Div.; Tyler Pipe.
d. Watts Industries, Inc.
e. Watts Industries, Inc.; Enpoco, Inc. Div.
f. Zurn Industries, Inc.; Zurn Specification Drainage Operation.

2. Horizontal Type: With swing check valve and hub-and-spigot ends.
3. Combination Horizontal and Manual Gate-Valve Type: With swing check valve, integral gate valve, and hub-and-spigot ends.
4. Terminal Type: With bronze seat, swing check valve, and hub inlet.

B. PVC Backwater Valves: Horizontal type; with PVC body, PVC removable cover, and PVC swing check valve.

1. Manufacturers:

a. Canplas Inc.
b. IPS Corporation.
c. NDS Inc.
d. Plastic Oddities, Inc.
e. Sioux Chief Manufacturing Company, Inc.
f. Zurn Industries, Inc.; Zurn Light Commercial Specialty Plumbing Products.

2.13 CLEANOUTS

A. PVC Cleanouts: PVC body with PVC threaded plug. Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping.

1. Manufacturers:

a. Canplas Inc.
b. IPS Corporation.
c. NDS Inc.
d. Plastic Oddities, Inc.
e. Sioux Chief Manufacturing Company, Inc.
f. Zurn Industries, Inc.; Zurn Light Commercial Specialty Plumbing Products.

B. Frame and Cover: Traffic grade cast-iron as indicated or, where not indicated, in accordance with the following:

1. Use medium-duty, top-loading classification cleanouts in landscaped and foot-traffic areas.
2. Use heavy-duty, top-loading classification cleanouts in vehicle-traffic service areas.
3. Use extra-heavy-duty, top-loading classification cleanouts in roads areas.

C. Concrete Collar: Where not located as a casting embedded in pavement, provide cast-in-place concrete collar as indicated on Drawings or, where not indicated 18 by 18 by 12 inchesdeep.

2.14 DRAINS

A. Gray-Iron Area Drains: ASME A112.21.1M, round body with anchor flange and round[secured] grate. Include bottom outlet with inside calk or spigot connection, of sizes indicated.

1. Manufacturers:

a. Josam Company.
b. MIFAB Manufacturing, Inc.
c. Smith, Jay R. Mfg. Co.

d. Wade Div.; Tyler Pipe.
e. Watts Industries, Inc.
f. Watts Industries, Inc.; Enpoco, Inc. Div.
g. Zurn Industries, Inc.; Zurn Specification Drainage Operation.

2. Top-Loading Classification(s):
   a. Use medium-duty, top-loading classification drains in landscaped or foot-traffic areas.
   b. Use heavy-duty, top-loading classification drains in vehicle-traffic service areas.
   c. Use extra-heavy-duty, top-loading classification drains in roads areas.

2.15 MANHOLES

A. Standard Precast Concrete Manholes: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.

1. Diameter: 48 inches minimum or as required to accommodate pipe size, unless otherwise indicated.
2. Ballast: Increase thickness of precast concrete sections or add concrete to base section, as required to prevent flotation.
3. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section, and having separate base slab or base section with integral floor.
4. Riser Sections: 4-inch minimum thickness, and lengths to provide depth indicated.
5. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.
6. Joint Sealant: ASTM C 990, bitumen or butyl rubber.
7. Resilient Pipe Connectors: ASTM C 923, cast or fitted into manhole walls, for each pipe connection.
8. Steps: Individual ASTM A 615/A 615M, deformed, 1/2-inch steel reinforcing rods encased in ASTM D 4101, PP wide enough to allow worker to place both feet on 1 step and designed to prevent lateral slippage off of step. Cast or anchor steps into sidewalls at 12 to 16-inch intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches.
9. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and diameter matching manhole frame and cover. Include sealant recommended by ring manufacturer.
10. Flat Slab Adapters For Transition to Square Drainage Structures: Precast reinforced concrete in accordance with Section 719 of the South Carolina Department of Transportation Standard Specifications for Highway Construction.

    a. Configuration: as indicated on South Carolina Department of Transportation Standard Drawing 719-425.

11. Manhole Frames and Covers: Ferrous; 24 inch ID by 7 to 9 inch riser with 4 inch minimum width flange and 26 inch diameter cover. Include indented top design with lettering cast into cover, using wording or design required by agency having authority. Where no specific wording or design is required by agency, wording equivalent to "STORM SEWER" shall be cast.

    a. Material: ASTM A 48, Class 35 gray iron, unless otherwise indicated.
    b. Protective Coating: Foundry-applied, SSPC-Paint 16, coal-tar, epoxy-polyamide paint; 10-mil minimum thickness applied to all surfaces, unless otherwise

2.16 CONCRETE

A. General: Class 3000 concrete in accordance with Section 701 of the South Carolina Department of Transportation Standard Specifications for Highway Construction.

B. Portland Cement Design Mix: 3000 psi minimum, with 0.45 maximum water-cementitious materials ratio.

1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
2. Reinforcement Bars: ASTM A 615/A 615M, Grade 60, deformed steel.

2.17 POLYMER-CONCRETE, CHANNEL DRAINAGE SYSTEMS

A. Description, General: Modular system of precast, polymer-concrete channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling. Include number of units required to form total lengths indicated.

B. Manufacturers:

1. ABT, Inc.
2. ACO Polymer Products, Inc.
3. Innovative Plastics Products. Inc.
4. Mea-Josam Div.; Josam Company.
5. Strongwell; Lenoir City Div.

C. Sloped-Invert, Polymer-Concrete Systems: Include the following components:

1. Channel Sections: Interlocking-joint, precast, modular units with end caps. Include 4-inch inside width and deep, rounded bottom, with built-in invert slope of 0.6 percent and with outlets in number, sizes, and locations indicated. Include extension sections necessary for required depth.

   a. Frame: Include gray-iron or steel frame for grate.

2. Grates with manufacturer's designation "Heavy Duty," with slots or perforations that fit recesses in channels.

   a. Material: Gray iron.

3. Covers: Solid gray iron, if indicated.
4. Locking Mechanism: Manufacturer's standard device for securing grates to channel sections.

D. Narrow-Width, Level-Invert, Polymer-Concrete Systems: Include the following components:

1. Channel Sections: Interlocking-joint, precast, modular units with end caps. Include 5 inch inside width and 9-3/4-inch deep, rounded bottom, with level invert and with NPS 4outlets in number and locations indicated.
2. Grates with slots or perforations that fit recesses in channels.

   a. Material: Gray iron.

3. Covers: Solid gray iron, if indicated.
4. Locking Mechanism: Manufacturer's standard device for securing grates to channel sections.

E. Wide-Width, Level-Invert, Polymer-Concrete Systems: Include the following components:

1. Channel Sections: Interlocking-joint, precast, modular units with end caps. Include 8 inch inside width and 13-3/4 inch deep, rounded bottom, with level invert and with outlets in number, sizes, and locations indicated.
2. Grates with slots or other openings that fit recesses in channels.

    a. Material: Gray iron.

3. Covers: Solid gray iron, if indicated.
4. Locking Mechanism: Manufacturer's standard device for securing grates to channel sections.

F. Drainage Specialties: Precast, polymer-concrete units

1. Large Catch Basins: 24 by 12-inch polymer-concrete body, with outlets in number and sizes indicated. Include gray-iron slotted grate.

    a. Frame: Include gray-iron or steel frame for grate.

2. Small Catch Basins: 19 to 24 inch by approximately 6 inch polymer-concrete body, with outlets in number and sizes indicated. Include gray-iron slotted grate.

    a. Frame: Include gray-iron or steel frame for grate.

3. Oil Interceptors: Polymer-concrete body with interior baffle and 4 steel support channels and two ¼ inch thick, steel-plate covers.

    a. Capacity: [140 gal.] [200 gal.] [260 gal.].
    b. Inlet and Outlet: [NPS 4] [NPS 6].

4. Sediment Interceptors: 27 inch square, polymer-concrete body, with outlets in number and sizes indicated. Include 24 inch square, gray-iron frame and slotted grate.

G. Supports, Anchors, and Setting Devices: Manufacturer's standard, unless otherwise indicated.

H. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.

2.18 PLASTIC, CHANNEL DRAINAGE SYSTEMS

A. Description, General: Modular system of plastic channel sections, grates, and appurtenances; designed so grates fit into frames without rocking or rattling. Include number of units required to form total lengths indicated.

B. Manufacturers:

1. ACO Polymer Prod.
2. MultiDrain Corp.

3. NDS Inc.
4. Tuf-Tite, Inc.
5. Zurn Industries, Inc.; Zurn Light Commercial Specialty Plumbing Products.

C. Fiberglass Systems: Include the following components:

1. Channel Sections: Interlocking-joint, fiberglass modular units, with built-in invert slope of approximately 1 percent and with end caps. Include rounded or inclined inside bottom surface, with outlets in number, sizes, and locations indicated.

   a. Width: [6 inches] [6 or 8 inches] [8 inches].

2. Factory- or field-attached frames that fit channel sections and grates.

   a. Material: Manufacturer's standard metal.

3. Grates with slots or perforations that fit frames.

   a. Material: [Fiberglass] [Galvanized steel] [Gray iron] [Stainless steel].

4. Covers: Solid gray iron, if indicated.
5. Drainage Specialties: Include the following plastic components:

   a. Large Catch Basins: 24 inch square plastic body, with outlets in number and sizes indicated. Include gray-iron frame and slotted grate.
   b. Small Catch Basins: 12 by 24 inch plastic body, with outlets in number and sizes indicated. Include gray-iron frame and slotted grate.

D. PE Systems: Include the following components:

1. Channel Sections: Interlocking-joint, PE modular units, 4 inches wide, with end caps. Include rounded bottom, with level invert and with outlets in number, sizes, and locations indicated.
2. Grates: PE, ladder shaped; with stainless-steel screws.
3. Color: Gray, unless otherwise indicated.
4. Drainage Specialties: Include the following PE components:

   a. Drains: 4-inch diameter, round, slotted top; with NPS 4 bottom outlet.
   b. Drains: 8-inch diameter, round, slotted top; with NPS 6 bottom outlet.
   c. Drains: 4-inch square, slotted top; with NPS 3 bottom outlet.
   d. Drains: 8-inch square, slotted top; with NPS 6 bottom outlet.
   e. Catch Basins: 12-inch square plastic body, with outlets in number and sizes indicated. Include PE slotted grate 11-3/4 inches square by 1-1/8 inches thick.

E. Supports, Anchors, and Setting Devices: Manufacturer's standard, unless otherwise indicated.

F. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.

2.19 CONCRETE DRAINAGE STRUCTURES

A. Drainage Structure Boxes: Precast reinforced concrete in accordance with Section 719 of the South Carolina Department of Transportation Standard Specifications for Highway Construction.

1. Design: ASTM C 913, designed according to ASTM C 890 for A-16 (ASSHTO HS20-44), heavy-traffic, structural loading.
2. Configuration: as indicated on South Carolina Department of Transportation Standard Drawing 719-305.
3. Depth and Size: as indicated on Drawings.
4. Pipe Openings: as required for pipe size and location.

    a. Must be integral to design and provided at time of original casting.
    b. Where possible, orient structure so pipes enter through walls. Pipes may enter through corners provided a minimum of 6” wall space is provided to top and other openings.

5. Risers: Precast reinforced concrete as indicated on South Carolina Department of Transportation Standard Drawing 719-315.
6. Steps: Individual ASTM A 615/A 615M, deformed, 1/2-inch steel reinforcing rods encased in ASTM D 4101, PP wide enough to allow worker to place both feet on 1 step and designed to prevent lateral slippage off of step. Cast or anchor steps into sidewalls at 12 to 16-inch intervals. Omit steps if total depth from floor of box to finished grade is less than 54 inches.
7. Joint Sealant: ASTM C 990, bitumen or butyl rubber.
8. Mortar and Grout: Comply with ASTM C 270, Type M or S.

B. Catch Basins: Conforming to Section 719 of the South Carolina Department of Transportation Standard Specifications for Highway Construction.

1. Transitional Top Slabs (where required): At a minimum, as indicated on South Carolina Department of Transportation Standard Drawing 719-330 with additional reinforcing as required for opening.
2. Frames and Grates: as indicated on Drawings or as required by agency having authority.

    a. Cast Iron: conforming to AASHTO M 105, Class 35B.
    b. Steel Tubing: conforming to ASTM A 53, Schedule 80.
    c. All finished frames and grates shall conform to the alternate load test of AASHTO M 306.

C. Junction Boxes: Conforming to Section 719 of the South Carolina Department of Transportation Standard Specifications for Highway Construction.

1. Top Slabs: At a minimum, as indicated on South Carolina Department of Transportation Standard Drawing 719-330 with additional reinforcing as required for opening.
2. Frames and Covers: Ferrous; 24-inch ID by 7- to 9-inch riser with 4-inch minimum width flange and 26-inch diameter cover. Include indented top design with lettering cast into cover, using wording or design required by agency having authority. Where no specific wording or design is required by agency, wording equivalent to "STORM SEWER" shall be cast.

    a. Material: ASTM A 48, Class 35 gray iron, unless otherwise indicated.
    b. Protective Coating: Foundry-applied, SSPC-Paint 16, coal-tar, epoxy-polyamide paint; 10-mil minimum thickness applied to all surfaces, unless otherwise noted.

D. Curb Inlets: Conforming with Section 719 of the South Carolina Department of Transportation Standard Specifications for Highway Construction.

1. Top Slabs and Throats: As indicated on Drawings and conforming to South Carolina Department of Transportation Standard Drawings 719-016, 719-017, and 719-018 as applicable.
2. Throat Transitions to Curb: Cast-in-place concrete, hand formed to provide smooth transition to adjoining curb. Finish to match adjoining curb.
3. Frames and Covers: Ferrous; 24 inch ID. Frame designed to be embedded in concrete with top flush to concrete surface. 2-1/2 inch minimum width flange and 24 inch diameter cover. Include indented top design with lettering cast into cover, using wording or design required by agency having authority. Where no specific wording or design is required by agency, wording equivalent to "STORM SEWER" shall be cast.

    a. Material: ASTM A 48, Class 35 gray iron, unless otherwise indicated.
    b. Protective Coating: Foundry-applied, SSPC-Paint 16, coal-tar, epoxy-polyamide paint; 10-mil minimum thickness applied to all surfaces, unless otherwise noted.

E. Gutter Inlets: Conforming to Section 719 of the South Carolina Department of Transportation Standard Specifications for Highway Construction.

1. Transitional Top Slabs (where required): At a minimum, as indicated on South Carolina Department of Transportation Standard Drawing 719-330 with additional reinforcing as required for opening.
2. Frames and Grates: as indicated on Drawings or as required by agency having authority.

    a. Cast Iron: conforming to AASHTO M 105, Class 35B.
    b. Steel Tubing: conforming to ASTM A 53, Schedule 80.
    c. All finished frames and grates shall conform to the alternate load test of AASHTO M 306.

F. Weir Inlets: Conforming to Section 719 of the South Carolina Department of Transportation Standard Specifications for Highway Construction.

1. Top Slabs: At a minimum, as indicated on South Carolina Department of Transportation Standard Drawing 719-330 with additional reinforcing as required for opening.
2. Frames and Covers: Ferrous; 24 inch ID. Frame designed to be embedded in concrete with top flush to concrete surface. 2-1/2 inch minimum width flange and 24 inch diameter cover. Include indented top design with lettering cast into cover, using wording or design required by agency having authority. Where no specific wording or design is required by agency, wording equivalent to "STORM SEWER" shall be cast.

    a. Material: ASTM A 48, Class 35 gray iron, unless otherwise indicated.
    b. Protective Coating: Foundry-applied, SSPC-Paint 16, coal-tar, epoxy-polyamide paint; 10-mil minimum thickness applied to all surfaces, unless otherwise noted.

G. Pond Outlet Structures: Conforming to Section 719 of the South Carolina Department of Transportation Standard Specifications for Highway Construction.

1. Top Slabs (where indicated): At a minimum, as indicated on South Carolina Department of Transportation Standard Drawing 719-330 with additional reinforcing as required for opening.
2. Frames and Covers (where indicated): Ferrous; 24 inch ID. Frame designed to be embedded in concrete with top flush to concrete surface. 2-1/2 inch minimum width flange and 24 inch diameter cover. Include indented top design with lettering cast into cover, using wording or design required by agency having authority. Where no specific

wording or design is required by agency, wording equivalent to "STORM SEWER" shall be cast.

a. Material: ASTM A 48, Class 35 gray iron, unless otherwise indicated.
b. Protective Coating: Foundry-applied, SSPC-Paint 16, coal-tar, epoxy-polyamide paint; 10-mil minimum thickness applied to all surfaces, unless otherwise noted.

3. Frames and Grates (where indicated): as indicated on Drawings or as required by agency having authority.

a. Cast Iron: conforming to AASHTO M 105, Class 35B.
b. Steel Tubing: conforming to ASTM A 53, Schedule 80.
c. Plastic: HDPE

4. Fastenings: Stainless steel, as recommended by manufacturer.

2.20 PVC DRAINAGE STRUCTURES

A. Drain Basins: Nyloplast type or approved equal, manufactured from PVC pipe stock meeting the requirements of ASTM D 3034. Fabrication shall utilize a thermo-molding process to reform the pipe stock to the required configuration. The pipe connection stubs shall be manufactured from PVC pipe stock and formed to provide a watertight connection with the indicated pipe material. Finished joint system shall meet the requirements of ASTM D 3212.

1. Grates: Ductile Iron meeting the requirements or ASTM A 536, Grade 70-50-05.

a. Furnished by the same manufacturer as part of an integral system.
b. Shall be capable of supporting ASSHTO H-25 loading.
c. Protective Coating: Foundry-applied black paint.

2. Manufacturers:

a. Advanced Drainage Systems, Inc.
b. Hancor, Inc.

B. Inline Drains: Nyloplast type or approved equal, manufactured from PVC pipe stock meeting the requirements of ASTM D 3034. Fabrication shall utilize a thermo-molding process to reform the pipe stock to the required configuration. The pipe connection stubs shall be manufactured from PVC pipe stock and formed to provide a watertight connection with the indicated pipe material. Finished joint system shall meet the requirements of ASTM D 3212.

1. Grates: Ductile Iron meeting the requirements or ASTM A 536, Grade 70-50-05.

a. Furnished by the same manufacturer as part of an integral system.
b. Shall be capable of supporting ASSHTO H-25 loading.
c. Protective Coating: Foundry-applied black paint.

2. Manufacturers:

a. Advanced Drainage Systems, Inc.
b. Hancor, Inc.

2.21 PIPE INLETS AND OUTLETS

A. Head Walls: Precast reinforced concrete, with apron and tapered sides.

B. Riprap: Broken, irregular size and shape, graded stone conforming to Section 804 of the South Carolina Department of Transportation Standard Specifications for Highway Construction

1. Gradation: Class B.

C. Turf Reinforcement Mat: Three dimensional, woven, highly UV resistant, polypropylene geotextile specifically designed for erosion control applications on steep slope and high velocity, vegetated waterway applications. Conforming to FHWA FP-03, Section 713.18. Include manufacturer's recommended installation anchor materials.

1. Manufacturers:

a. Propex Geosynthetics: (Pyramat)
b. North American Green: (P550)
c. American Excelsior Co.: (Recyclex)

2.22 DRY WELLS

A. Description: ASTM C 913, precast, reinforced, perforated concrete rings. Include the following:

1. Floor: Cast-in-place concrete.
2. Cover: Liftoff-type concrete cover with cast-in lift rings.
3. Wall Thickness: 4 inches minimum with 1 inch diameter or 1 by 3 inch maximum slotted perforations arranged in rows parallel to axis of ring.

a. Total Free Area of Perforations: Approximately 15 percent of ring interior surface.
b. Ring Construction: Designed to be self-aligning.

4. Filtering Material: Naturally or artificially graded mixture of crushed gravel or stone, in accordance with the gradation requirements for Coarse Aggregate #57 as defined by the South Carolina Department of Transportation Standard Specifications for Highway Construction.

a. Material shall be free of shale, clay, friable material, debris, waste, frozen materials, vegetation, organic material, or other deleterious matter.

B. Description: Manufactured PE side panels and top cover that assemble into 50 gal. storage capacity units.

1. Manufacturers:

a. Flo-Well Products, Ltd.

2. Side Panels: With knockout ports for piping and seepage holes.
3. Top Cover: With knockout port for drain.
4. Filtering Material: Naturally or artificially graded mixture of crushed gravel or stone, in accordance with the gradation requirements for Coarse Aggregate #57 as defined by the South Carolina Department of Transportation Standard Specifications for Highway Construction.

a. Material shall be free of shale, clay, friable material, debris, waste, frozen materials, vegetation, organic material, or other deleterious matter.

2.23 STORMWATER DISPOSAL SYSTEMS

A. Chamber Systems:

1. Manufacturers:

a. Advanced Drainage Systems, Inc.
b. StormTech, LLC
c. Cultec, Inc.
d. Hancor, Inc.
e. Infiltrator Systems, Inc.
f. R-Tank by ACF Environmental.

2. Storage and Leaching Chambers: Molded PE or PP with open cellular structures or arched structures with perforated sides and open bottom. Include number of chambers, distribution piping, end plates, and other standard components as required for system total capacity.
3. Filtering Material: Naturally or artificially graded mixture of crushed gravel or stone, in accordance with the gradation requirements for Coarse Aggregate #57 as defined by the South Carolina Department of Transportation Standard Specifications for Highway Construction.

a. Material shall be free of shale, clay, friable material, debris, waste, frozen materials, vegetation, organic material, or other deleterious matter.

4. Filter Mat: as recommended by manufacturer.

B. Pipe Systems: Perforated manifold, header, and lateral piping complying with AASHTO M 252M for NPS 10 and smaller, AASHTO M 294M for NPS 12 to NPS 48, and AASHTO MP7 for NPS 54 and NPS 60. Include proprietary fittings, couplings, seals, and filter fabric.

1. Manufacturers:

a. Advanced Drainage Systems, Inc.
b. Hancor, Inc.

2. Filtering Material: Naturally or artificially graded mixture of crushed gravel or stone, in accordance with the gradation requirements for Coarse Aggregate #57 as defined by the South Carolina Department of Transportation Standard Specifications for Highway Construction.

a. Material shall be free of shale, clay, friable material, debris, waste, frozen materials, vegetation, organic material, or other deleterious matter.

3. Filter Mat: as recommended by manufacturer.

2.24 STORMWATER OIL AND SEDIMENT SEPARATORS

A. Description: ASTM C 478 or ASTM C 913 as applicable. Precast, reinforced, concrete structures, with provision for sealant joints. Installed unit shall be capable of bearing an AASHTO HS 20 traffic loading.

1. Joint Sealant: ASTM C 990, bitumen or butyl rubber.
2. Resilient Pipe Connectors: ASTM C 923, cast or fitted into manhole walls, for each pipe connection.
3. Internal components: Shall be of by the same manufacturer and of integral design to the complete system. Shall be of durable materials and shall not require cleaning or replacement as part of routine maintenance. System shall be of a design that provides for removal of accumulated oil and sediment by a self-contained vacuum truck of the type typically used for stormwater and sanitary sewer line cleaning.
4. Manhole Frames and Covers: Ferrous; 24 inch ID by 7 to 9 inch riser with 4 inch minimum width flange and 26 inch diameter cover. Include indented top design with lettering cast into cover, using wording or design required by agency having authority. Where no specific wording or design is required by agency, wording equivalent to "STORM SEWER" shall be cast.

    a. Material: ASTM A 48, Class 35 gray iron, unless otherwise indicated.
    b. Protective Coating: Foundry-applied, SSPC-Paint 16, coal-tar, epoxy-polyamide paint; 10-mil minimum thickness applied to all surfaces, unless otherwise

5. Perfomance: The device shall remove oil and sediment from stormwater to the following standards:

    a. Free Oil: 95% of the floatable free oil.
    b. Total Suspended Solids: 80% of the average annual total suspended solids load without scouring previously captured pollutants.
    c. Capacity: Device shall have sufficient storage capacity to provide for annual pollutant removal without loss of filtration efficiency.

6. Manufacturers:

    a. Stormceptor, Inc.
    b. Contech, Inc, (Vortech)
    c. CDS Technologies, Inc.
    d. First Defense by Hydro International, Inc.

PART 3 - EXECUTION

3.1 SCDOT JURSIDICTION

A. For drainage pipe culverts located within areas of SCDOT jurisdiction, installation shall be in accordance with Supplementary Technical Specification SC-M-714 of the South Carolina Department of Transportation Standard Specifications for Highway Construction.

3.2 EARTHWORK

A. Excavation, trenching, and backfilling are specified in Section titled "Earth Moving."

B. Protect and maintain erosion and sedimentation controls, which are specified in Section titled "Site Clearing," during earthwork operations.

3.3 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.

C. Install manholes or drainage structures for changes in direction unless fittings are indicated. Use manholes or drainage structures for branch connections unless direct connection into existing sewer is indicated.

D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

E. Tunneling: Install pipe under streets or other obstructions that cannot be disturbed by tunneling, jacking, or a combination of both.

F. Install gravity-flow, nonpressure drainage piping according to the following as applicable:

1. Install piping pitched down in direction of flow, at minimum slope of 0.20 percent, unless otherwise indicated.
2. Install piping below frost line.
3. Install ductile-iron culvert piping according to ASTM A 716.
4. Install ductile-iron and special fittings according to AWWA C600 or AWWA M41.
5. Install corrugated steel piping according to ASTM A 798/A 798M.
6. Install HDPE corrugated sewer piping according to CPPA's "Recommended Installation Practices for Corrugated Polyethylene Pipe and Fittings."
7. Install PP sewer piping in accordance with ASTM D 2321 and manufacturer’s written instructions.
8. Install PVC sewer piping according to ASTM D 2321 and ASTM F 1668.
9. Install reinforced-concrete sewer piping, elliptical concrete pipe, and concrete box culverts according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."

G. Where applicable, install corrosion-protection piping encasement over the following underground metal piping according to ASTM A 674 or AWWA C105:

1. Ductile-iron pipe and fittings.
2. Special pipe fittings.

3.4 PIPE JOINT CONSTRUCTION

A. Join gravity-flow, nonpressure drainage piping according to the following as applicable:

1. Join ductile-iron culvert piping according to AWWA C600 for push-on joints.

2. Join ductile-iron and special fittings according to AWWA C600 or AWWA M41.
3. Join corrugated steel sewer piping according to ASTM A 798/A 798M.
4. Join corrugated HDPE piping according to CPPA 100 and the following:

    a. Use silttight couplings for Type 2, silttight joints.
    b. Use watertight couplings for Type 3, watertight joints.

5. Join PP sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric gasket joints.
6. Join PVC sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric gasket joints.
7. Join reinforced-concrete sewer piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual" for rubber-gasket, bitumen, or butyl-rubber sealant joints as applicable.
8. Join dissimilar pipe materials with nonpressure-type flexible couplings.

B. Wrap pipe joints with pipe joint wrap geotextile at least 18 inches in width. For larger pipe diameters where an 18 inch width is insufficient to completely cover the pipe bell, use a width sufficient to cover and extend beyond the bell at least 6 inches.

3.5 BACKWATER VALVE INSTALLATION

A. Install horizontal-type backwater valves in piping where indicated.

B. Install combination horizontal and manual gate valve type in piping and in manholes where indicated.

C. Install terminal-type backwater valves on end of piping and in manholes where indicated.

3.6 CLEANOUT INSTALLATION

A. Install cleanouts and riser extension from sewer pipe to cleanout at grade. Use pipe fittings of same material as pipe at branches for cleanouts and PVC pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.

B. Install cast-iron frames and covers.

1. Use medium-duty, top-loading classification cleanouts in landscaped and foot-traffic areas.
2. Use heavy-duty, top-loading classification cleanouts in vehicle-traffic service areas.
3. Use extra-heavy-duty, top-loading classification cleanouts in roads areas.
4. Set cleanout frames and covers located in earthen areas in cast-in-place concrete collar, 18 by 18 by 12 inchesdeep. Set with tops 1 inch above surrounding earth grade
5. Set cleanout frames and covers in pavement with tops flush with pavement surface.

3.7 DRAIN INSTALLATION

A. Install type of drains in locations indicated.
1. Use medium-duty, top-loading classification drains in landscaped or foot-traffic areas.
2. Use heavy-duty, top-loading classification drains in vehicle-traffic service areas.
3. Use extra-heavy-duty, top-loading classification drains in roads areas.

B. Embed drains in 4-inchminimum depth of concrete around bottom and sides.

C. Fasten grates to drains if indicated.

D. Set drain frames and covers with tops flush with pavement surface.

E. Assemble trench sections with flanged joints.

F. Embed trench sections in 4-inch minimum concrete around bottom and sides.

3.8 MANHOLE INSTALLATION

A. General: Install manholes, complete with appurtenances and accessories indicated.

B. Install precast concrete manhole sections according to ASTM C 891.

C. For manholes that occur in pavements, set tops of frames and covers flush with finished surface. Set tops 2 inches above finished surface elsewhere, unless otherwise indicated.

3.9 CONCRETE DRAINAGE STRUCTURE INSTALLATION

A. General: Install drainage structures, complete with appurtenances and accessories indicated.

B. Install precast concrete drainage structure sections according to ASTM C 891.

C. Set tops, frames, grates and covers to elevations indicated.

D. Fabricate inlet throats to shape and elevations indicated.

E. Seal and grout all opening around pipe penetrations watertight.

3.10 PVC DRAINAGE STRUCTURE INSTALLATION

A. Install manufactured, PVC drainage structures, complete with appurtenances and accessories indicated, according to manufacturer's written instructions and the following:

1. Install PVC drainage structures according to ASTM D 2321 and ASTM F 1668.
2. Join piping to structure according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric gasket joints.
3. Finished joint system shall meet the requirements of ASTM D 3212.

B. Set frames, grates and covers to elevations indicated.

3.11 PIPE INLET AND OUTLET INSTALLATION

A. Construct inlet and outlet head walls, aprons, and sides of reinforced concrete, as indicated.

1. Comply with the requirements of Sections 701, and 702 of the South Carolina Department of Transportation Standard Specifications for Highway Construction for measuring, mixing, transporting, and placing concrete.

B. Install outlets that spill onto grade, with flared end sections that match pipe, where indicated.

C. Construct riprap of broken stone, as indicated.

D. Install turf reinforcement mat as indicated and in accordance with manufacturer's written instructions.

3.12 DRY WELL INSTALLATION

A. Excavate hole to diameter of at least 6 inches greater than outside of dry well. Do not extend excavation into ground-water table.

B. Install precast, concrete-ring dry wells according to the following:

1. Assemble rings to depth indicated.
2. Extend rings to height where top of cover will be approximately 8 inches below finished grade.
3. Backfill bottom of inside of rings with filtering material to level at least 12 inches above bottom.
4. Extend effluent inlet pipe 12 inches into rings and terminate into side of tee fitting.
5. Backfill around outside of rings with filtering material to top level of rings.
6. Install cover over top of rings.

C. Install manufactured, PE dry wells according to manufacturer's written instructions and the following:

1. Assemble and install panels and cover.
2. Backfill bottom of inside of unit with filtering material to level at least 12 inches above bottom.
3. Extend effluent inlet pipe 12 inches into unit and terminate into side of tee fitting.
4. Install filter fabric around outside of unit.
5. Install filtering material around outside of unit.

3.13 CONCRETE PLACEMENT

A. Place cast-in-place concrete according to Sections 701, and 702 of the South Carolina Department of Transportation Standard Specifications for Highway Construction for measuring, mixing, transporting, and placing concrete.

3.14 CHANNEL DRAINAGE SYSTEM INSTALLATION

A. Assemble and install components according to manufacturer's written instructions.

B. Install with top surfaces of components, except piping, flush with finished surface.

C. Assemble channel sections to form slope down toward drain outlets. Use sealants, adhesives, fasteners, and other materials recommended by system manufacturer.

D. Embed channel sections and drainage specialties in 4 inch minimum concrete around bottom and sides.

E. Fasten grates to channel sections if indicated.

3.15 STORMWATER DISPOSAL SYSTEM INSTALLATION

A. Chamber Systems: Excavate trenches of width and depth, and install system and backfill according to chamber manufacturer's written instructions. Include storage and leaching chambers, filtering material, and filter mat.

B. Piping Systems: Excavate trenches of width and depth, and install piping system, filter fabric, and backfill according to piping manufacturer's written instructions.

3.16 STORMWATER OIL AND SEDIMENT SEPARATOR INSTALLATION

A. General: Install stormwater oil and sediment separators, complete with appurtenances and accessories indicated.

B. Install separators according to manufacturer's written instructions

C. Install precast concrete sections according to ASTM C 891.

D. For separators that occur in pavements, set tops of frames and covers flush with finished surface. Set tops 2 inches above finished surface elsewhere, unless otherwise indicated.

3.17 PLUGGING STORM DRAINAGE SYSTEM STUB-OUTS FOR FUTURE EXPANSION

A. Close open ends of underground piping indicated as stub-outs for future expansion. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of piping have been closed. Use procedure below:

1. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.

B. Backfill to grade according to Section titled "Earth Moving."

3.18 CLOSING ABANDONED STORM DRAINAGE SYSTEMS

A. Abandoned Piping: Close open ends of abandoned underground piping indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of abandoned piping have been closed. Use either procedure below:

1. Close open ends of piping with at least 8-inch thick, brick masonry bulkheads.
2. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.

B. Abandoned Manholes and Structures: Excavate around manholes and structures as required and use one procedure below:

1. Remove manhole or structure and close open ends of remaining piping.
2. Remove top of manhole or structure down to at least 36 inches below final grade. Fill to within 12 inches of top with stone, rubble, gravel, or compacted dirt. Fill to top with concrete.

C. Backfill to grade according to Section titled "Earth Moving."

3.19 IDENTIFICATION

A. Materials and their installation are specified in Section titled "Earth Moving." Arrange for installation of green warning tape directly over piping and at outside edge of underground structures.

1. Use detectable warning tape over piping and over edges of underground structures.

3.20 FIELD QUALITY CONTROL

A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.

1. Submit separate reports for each system inspection.
2. Defects requiring correction include the following:

a. Alignment: Less than full diameter of inside of pipe is visible between structures.
b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 95 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 procedure until results are satisfactory.

B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.

1. Do not enclose, cover, or put into service before inspection and approval.
2. Test completed piping systems according to authorities having jurisdiction.
3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
4. Submit separate report for each test.
5. Gravity-Flow Storm Drainage Piping: Test according to requirements of authorities having jurisdiction, UNI-B-6, and the following:

a. Test plastic piping according to ASTM F 1417.
b. Test concrete piping according to ASTM C 924.

C. Leaks and loss in test pressure, if applicable, constitute defects that must be repaired.

D. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

E. Video Documentation: Upon completion and prior to final inspection, complete a videotaped documentation of the completed piping system, along its interior length, utilizing equipment made expressly for the purpose. Provide a written report, inspection logs, and a copy of the inspection videotape to the Architect.

3.21 CLEANING

A. Clean interior of piping of dirt and superfluous materials. Collect flushed materials in sediment trapping devices: do not flush into downstream drainage systems or receiving waterbodys.

END OF SECTION 334100

SECTION 335216-GASOLINE FUEL SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The General Provisions, Special Provisions, and General Requirements of the Specifications shall apply to the work specified in this section

1.2 SUMMARY

A. This section includes piping, tanks, tank appurtenances, pumps and dispensers.

B. The Contractor shall install fuel storage and dispensing facility as described in this specification and shown on the drawings provided.

C. The Contractor shall perform all work necessary for a complete installation of facilities.

D. The Contractor shall obtain all necessary approvals and permits and pay all permit fees. The contractor shall complete and submit the appropriate forms as needed for a Stage II exemption and provide owner with any additional compliance information.

E. The Contractor shall provide all products, consumables, necessary parts, and accessories although such items may not be specifically mentioned.

F. Nothing in this specification or on the drawings is to be construed to permit work not conforming to all applicable codes, regulations and vendor instructions.

G. Section includes:
1. Aboveground fuel piping
2. Underground primary fuel piping
3. Underground fuel piping containment system
4. Flanges, unions and couplings
5. Valves
6. Flexible connections
7. Aboveground storage tanks
8. Fuel pumps and controls
9. Specialty fittings
10. Dispensers
11. Piping sumps
12. Dispenser pans
13. Dispenser hook isolation panel

H. Related sections:
1. Section 335230 – Inventory and Leak Detection System
2. Section 335220 – Fuel Management System: Installation and product requirements for Inventory and Leak Detection System and Fuel Management System for the fueling system.
3. Section – Pipe Hangers
4. Section – Piping Identification

1.3 REFERENCES

A. American Petroleum Institute:
   1. API 2000 - Venting Atmospheric and Low-Pressure Storage Tanks: Nonrefrigerated and Refrigerated.

B. American Society of Mechanical Engineers:
   1. ASME B16.3 - Malleable Iron Threaded Fittings.
   2. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.
   3. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
   4. ASME B31.4 - Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids.
   5. ASME B31.9 - Building Services Piping.

C. American Society for Testing and Materials:
   1. ASTM A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   2. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
   3. ASTM D2310 - Standard Classification for Machine-Made "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
   4. ASTM D2513 - Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings.
   5. ASTM D2683 - Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing.
   6. ASTM D2996 - Standard Specification for Filament-Wound Fiberglass (Glass-Fiber-Reinforced Thermosetting Resin) Pipe.

D. American Water Works Association:
   1. AWWA C105 - American National Standard for Polyethylene Encasement for Ductile-Iron Pipe Systems.

E. Manufacturers Standardization Society of the Valve and Fittings Industry:
   1. MSS SP 58 - Pipe Hangers and Supports - Materials, Design and Manufacturer.
   2. MSS SP 69 - Pipe Hangers and Supports - Selection and Application.
   3. MSS SP 70 - Cast Iron Gate Valves, Flanged and Threaded Ends.
   4. MSS SP 71 - Cast Iron Swing Check Valves, Flanged and Threaded Ends.
   5. MSS SP 80 - Bronze Gate, Globe, Angle and Check Valves.
   6. MSS SP 85 - Cast Iron Globe & Angle Valves, Flanged and Threaded.
   7. MSS SP 89 - Pipe Hangers and Supports - Fabrication and Installation Practices.
   8. MSS SP 110 - Ball Valves Threaded, Socket Welding, Solder Joint, Grooved and Flared Ends.

F. NACE International:
   1. NACE RP-01-69 - Control of External Corrosion on Underground or Submerged Metallic Piping Systems.

G. National Fire Protection Association:
   1. NFPA 30 - Flammable and Combustible Liquids Code.
   2. NFPA 30A – Code for Motor Vehicle Fuel Dispensing Facilities and Repair Garages.
   3. NPFA 70, National Electric Code, 2010

H. Underwriters Laboratories Inc.:
   1. UL 142 - Steel Aboveground Tanks for Flammable and Combustible Liquids.
   2. UL 2085 – Protected Aboveground Tanks for Flammable Liquid Storage Tanks.
   3. UL 157 – Gaskets and Seals.

1.4 SUBMITTALS

A. Shop Drawings: Indicate tanks, system layout, pipe sizes, location, and elevations. For fuel tanks, indicate dimensions and accessories including manholes.

B. Product Data:
   1. Piping: Submit data on pipe materials, fittings, and accessories.
   2. Valves and Specialty Fittings: Submit manufacturers catalog information with valve data and ratings for each service.
   3. Hangers and Supports: Submit manufacturers catalog information including load capacity.
   4. Fuel Piping Specialties: Submit manufacturers catalog information including capacity, rough-in requirements, and service sizes.
   5. Tanks: Submit manufacturers catalog information including capacity, installation requirements, and warranty.
   6. Tank Anchorage: Submit anchor bolt design calculations noting size and type of tank anchor bolts.
   7. Sumps: Submit manufacturers catalog information including capacity, installation requirements, and warranty.
   8. Dispensers Submit manufacturer catalog information including capacity, installation requirements, and warranty.
   9. Pumps: Submit certified pump curves showing performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable. Include electrical characteristics and connection requirements. Submit also manufacturer model number, dimensions, service sizes, and finishes.
   10. Dispenser Hook Isolation Panel: Submit manufacturers catalog information including installation requirements, and warranty.

C. Manufacturer's Installation Instructions: Pumps and dispensers.

D. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.5 OPERATION AND MAINTENANCE INSTRUCTION

A. Provide Operation and Maintenance Manual and instruction in accordance with Part 1.6B of this section.

B. Prior to turning over completed system to Owner, Contractor shall provide up to four hours of instruction on system operation and maintenance to Fuel System Operator’s personnel.

1.6 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of piping system, storage tanks, and system components.

B. Submit Operating and Maintenance Data as follows:
   1. Format of manual:

a. Prepare data in the form of an instructional manual.
b. Binders: Commercial quality, 8-1/2" x 11" three-ring binders with hardback, cleanable, plastic covers, 2-inch maximum ring size. When multiple binders are used, correlate data into related consistent groupings.
c. Cover: Identify each binder with typed or printed title OPERATION AND MAINTENANCE MANUAL, list title of this project, identify subject matter of contents.
d. Tabs: Tabbed flyleaf with typed description of product for each separate product or system.
e. Text: Manufacturer's printed data (when available) or type written data on 20 pound bond paper.
f. Drawing presentation: Reduce full size drawings to 11" x 17" size. Reinforce binder tabs.

C. Contents of Manual
1. Table of contents.
2. Engineer and Contractor information. (Name, address, telephone, etc.)
3. Design criteria and description of operation.
4. Operating Procedures: Include start-up, break-in, routine normal operating instructions and sequences, including regulation, control, stopping, shutdown and emergency instructions. Include summer, winter and any special operating instructions.
5. General Product Information: List names, addresses and telephone numbers of subcontractors and suppliers, including local source of supplies and replacement parts.
6. Provide all application and permits related to the fuel system, including all inspection reports, required corrections and testing reports.
7. Warranties and Bonds: Include copies.
8. Product Data: For major equipment, include manufacturers' installation/operation/ maintenance manual, parts list, design data, performance curves, illustrations, assembly drawings and diagrams. For minor items, include specifications and model numbers.
9. Recommended Spare Parts: List of original manufacturers' recommended spare parts, current prices and quantities to be stocked at the facility.
10. Service/maintenance and lubrication schedules and list of lubricants required.
11. Drawings: Relevant as-built design drawings including mechanical schematics, electrical drawings, connection diagrams and panel board directories.
12. Mark each sheet to clearly identify specific products and component parts and data applicable to the installation. Delete inapplicable information.

D. Instruction of Owner Personnel
1. Before final inspection and at agreed upon times, instruct Owner's designated personnel in operation, adjustment and maintenance of products, equipment and systems.
2. Use the OPERATION AND MAINTENANCE MANUAL as basis of instruction. Review contents of the MANUAL with personnel in detail to explain all aspects of operation and maintenance.
3. Prepare and insert additional data in the MANUAL when need for such data becomes apparent during instruction.

E. Submittals
1. Submit one copy of completed MANUAL in final form 15 days prior to final inspection. Copy will be returned with Engineer's comments. Revise MANUAL as required for final submittal.
2. Submit six copies of revised MANUAL in final form prior to final inspection. Four copies will be for Owner's use two copies for Engineer's file.

F. Demonstration
   1. Instruction of Owner Personnel
      a. Before final inspection and at agreed upon times, instruct Owner's designated personnel in operation, adjustment and maintenance of products, equipment and systems.
      b. Use the OPERATION AND MAINTENANCE MANUAL as basis of instruction. Review contents of the MANUAL with personnel in detail to explain all aspects of operation and maintenance.
      c. Prepare and insert additional data in the MANUAL when need for such data becomes apparent during instruction.

1.7 QUALITY CONTROL

A. Perform work in accordance with industry standards and all applicable codes.

B. Equipment shall meet California Air Resources Board (CARB) requirements as specifically indicated in specifications and drawings.

C. Perform work in accordance with ASME B31.9 code for installation of piping systems and ASME Section IX for welding materials and procedures.

D. Maintain one copy of each document on-site.

1.8 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum five years being manufactured.

B. Contractor: Company specializing in performing Work of this section with minimum five years experience.

1.9 DELIVERY, STORAGE AND HANDLING

A. Accept materials on-site in shipping containers with labeling in place. Inspect for damage.

B. Protect piping and fittings from soil and debris with temporary end caps and closures. Maintain in place until installation. Furnish temporary protective coating on cast iron and steel valves.

1.10 ENVIRONMENTAL REQUIREMENTS

A. Do not install underground piping when bedding is wet or frozen.

1.11 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.12 WARRANTY

A. Furnish two-year manufacturer warranty for all equipment and piping.

PART 2 - PRODUCTS

2.1 ABOVEGROUND FUEL PIPING

A. Steel Pipe: ASTM A53, Schedule 40.
   1. Fittings: ASTM A234/A234M, wrought carbon steel and alloy steel welding type.
   2. Joints: ASME B31.9 welded.

2.2 FLANGES, UNIONS AND COUPLINGS

A. Pipe Size 2 inches and Smaller:
   1. Ferrous pipe: 150 psi malleable iron threaded unions.

B. Pipe Size 2 inches and Larger:
   1. Ferrous pipe: 150 psi forged steel slip-on flanges; 1/16 inch thick preformed neoprene gaskets.
   2. Dielectric Connections: Provide a brass nipple 3" long or brass coupling. Dielectric shall be petroleum-compatible plastic insert type.

2.3 UNDERGROUND PRIMARY FUEL PIPING

A. Manufacturers:
   1. Smith Fibercast
   2. Ameron
   3. Approved equal

B. FRP: ASTM D2310 and ASTM D2996, UL listed for nonmetallic underground piping for petroleum products, and filament wound fiberglass reinforced epoxy pipe with integral epoxy liner and exterior coating.
   1. Fittings: Compression molded, filament wound, fiberglass-reinforced epoxy.
   2. Joints: Tapered bell and spigot adhesive bonded.

2.4 UNDERGROUND FUEL PIPING CONTAINMENT SYSTEM

A. Manufacturers:
   1. Smith Fibercast
   2. Ameron
   3. Approved equal

B. FRP: ASTM D2310 and ASTM D2996, UL listed filament wound fiberglass reinforced epoxy pipe with integral epoxy liner and exterior coating.

C. Fittings: Two piece, compression molded, filament wound, fiberglass-reinforced epoxy, mechanically joined.

2.5 VALVES

A. Ball Valves
   1. Manufacturers:
      a. Morrison Bros.
      b. Universal Valve Company

c. Approved equal
2. MSS SP 110, (Class 150, 400 psi) CWP, bronze, two piece body, chrome plated brass ball, regular port, Teflon seats and stuffing box ring, blow-out proof stem, lever handle threaded ends.

B. Solenoid Control Valves
1. Manufacturers:
a. Magnetrol
b. Morrison
c. Approved equal
2. The valves shall be full port.
3. The valve shall operate as shut-off diaphragm valve utilizing two two-way solenoid valves.
4. The valve shall be able to operate with a minimum of 5 psi differential.
5. The valve shall be able to operate in the range of 10 gpm to 180 gpm and shall be positioned from full closed to full open.
6. The valve shall be rated for gasoline service.
7. The valve shall be able to fully close in the event of electrical power failure or activated by the emergency shut-off switch.

2.6 FLEXIBLE CONNECTORS

A. Manufacturers:
1. Flex-ing
2. Hosemaster
3. Approved equal

B. Flexible Hose: Flexible hose shall be U.L listed, have integral male swivel fittings, suitable for aboveground and underground fuel systems, compatible with approved secondary containment systems, stainless steel or teflon corrugated inner hose, stainless steel braided exterior sleeve, suitable for minimum 200 psi, CWP and 250 degrees F.

C. Expansion Joint: Expansion joint shall be U.L listed, stainless steel wetted parts and with flanged fittings rated at 150 lbs. The expansion joint shall be unrestrained single expansion joint absorbing lateral deflection as well as axial compression.

2.7 ABOVEGROUND FUEL STORAGE TANKS

A. Manufacturers:
1. Modern Welding (Used as basis of design)
2. Containment Solutions
3. Approved equal

B. Product Description: Tank rated for multiple hazards and constructed of multiple layers consisting of inner steel tank surrounded by insulating concrete and outer steel tank providing multi-hazard rating including 2 hour fire resistance to meet requirements of UL 2085.

C. The standard primary storage tank and secondary containment tank shall be an integral cylindrical in design. It shall be constructed to UL specified steel thickness, with continuous welds.

D. The primary storage tank shall be constructed of ASTM A-569 or A-36 carbon steel, as required for compatibility of product being stored.

E. The primary and secondary tanks shall be constructed and listed in accordance with UL 142 Standards.

F. The primary tank shall be pressure tested to UL 142 Standard (minimum 3 to maximum 5 psi) at the factory, and shall be field tested by the contractor to a maximum 3 psi.

G. The standard fire protection material shall be lightweight concrete and surround the primary tank. The tank design shall provide a minimum two (2) hour fire rating per UFC Appendix Standard A-II-F (formerly UFC 79-7), and UL 2085 Protected Secondary Containment Tanks.

H. The fire protective material shall allow liquid leaking from the primary tank to penetrate the material and communicate with the leak detection tube according to UL 2085 Protected Secondary Containment Tanks.

I. The fire protective material shall be of a monolithic pour, poured at the factory.

J. The fire protective material shall provide a minimum of an R-10 insulating factor.

K. The fire protected primary tank shall be tested by a qualified engineering firm to be resistant to penetration of the primary tank by a 150 grain, M 2 Bullet, traveling at a velocity of at least 2700 feet per second, when fired from a .30 caliber rifle, located a maximum of 30 meters from the target.

L. The fire protected tank must be able to be repaired in the field by a factory representative, when impacted by a bullet.

M. The factory representative must be able to certify that the primary and secondary containment do not leak, and that the fire protective material regains its minimum two (2) hour protection.

N. The secondary tank shall be tested liquid tight at the factory (minimum 3 to maximum 5 psi), and shall also be field tested by the contractor to a maximum 3 psi.

O. The secondary tank shall provide reinforcement for the lightweight concrete.

P. The secondary tank shall provide true 360° Radius "pressure testable" containment for the primary tank.

Q. The port openings in the top of the secondary tank shall be constructed with full welds to prevent moisture from seeping between the fire proofing material and secondary and primary tanks.

R. The top of the secondary tank shall be sloped so that water will not accumulate on top of the tank.

S. The secondary tank shall have a 2 inch monitoring port including a tube which provides a means to detect product leakage from the primary tank into fire protection material that directly surrounds the primary tank. This design shall be listed under UL 2085.

T. The exterior surface of the secondary tank shall be cleansed of foreign material and coated with a corrosion resistant industrial paint (3 to 5 mils dry film thickness). The standard color shall be white.

U. Tank shall have ladder, access platform and pipe supports supplied and installed by manufacturer.

V. See drawings for capacity:

W. See drawings.

2.8 SUBMERSIBLE FUEL PUMPS

A. Manufacturers:
   1. FE Petro (used as basis of design)
   2. Red Jacket

B. Submersible pump system:
   1. Pump:
      a. Pump shall be a variable speed submersible pump.
      b. The entire pumping assembly shall have UL listing and shall meet all requirements of UL Standard 79.
      c. Pump discharge head and manifold assembly shall be manufactured from ASTM A48 Class 25 gray iron.
      d. An optional variable length telescopic feature shall be provided such that the length of the pump is field adjusted at the job site to fit the specific pump length required.
      e. Pump shall be gasoline compatible, have integral check valve with expansion relief valve setting @ 65 PSI, siphon capability, separate suction port, and thermal over-current overload protector with automatic reset.
      f. Pump can be removed/replaced without removing pump housing.
   2. Pump Controller:
      a. Controller shall be compatible with the pump and manufactured by the same company, and provide the starting relay and power for the pump.
      b. Pump controller shall be capable of output pressure adjustment.
      c. Controller shall be capable of reporting abnormal operating conditions as follows:
         1) Dry run warning
         2) Low incoming voltage detection
         3) Pump motor failure detection
         4) Open circuit detection
         5) Short circuit detection
         6) Relay fault
         7) Extended run
      d. Controller shall have manual reset button, built-in surge protection, and RS-485 communications port.
   3. Controller shall have the capability to be configured as:
      a. Stand alone operation
      b. Alternation circuit
      c. Master/slave
      d. Master/slave and alternating circuit concurrently

   4. Controller programming:

a. Master/slave and alternating pumps concurrently

C. Size:
1. See drawings.

2.9 MECHANICAL LEAK DETECTOR

A. Manufacturers:
1. Vaporless Manufacturing
2. Approved Equal

B. Leak detector shall be capable of detecting 3GPH leak at 10 PSI line pressure within 1 hour.

C. Leak detector shall be UL listed and third-party certified for total volume of fuel in the product piping.

D. Leak detector shall have high-grade elastomer o-rings to withstand gasoline and wear.

E. Leak detector shall have a control panel that will prevent fueling if a leak is detected.

F. Size:
1. See drawings.

2.10 DISPENSER ISOLATION

A. Manufacturer:
1. R.S. Electronic Controls
2. Approved equal

B. Isolation box shall accommodate up to thirty-two (32) input signals and be capable of stand alone or tandem operation.

C. Provide compatible dispenser isolation controls that will isolate the 120 volt control signal from each dispenser so as to prevent foreign voltage in each dispenser.

D. Isolation box shall have green lights on the cover to indicate power is present and power is present at any one of the thirty-two (32) positions.

E. Isolation box shall have built-in surge protection.

2.11 DISPENSERS

A. Manufacturers:
1. Wayne (used as basis of design)
2. Gasboy
3. Approved equal

B. Twin-Hose Dispenser:
1. Dispenser shall be a U.L. listed remote electronic commercial-style dispenser with dual hoses, meters, and switch detect output.
2. Dispenser shall have filter with hydrosorb or ethanol compatible elements depending on gasoline.

3. Nozzles shall be hung on the front of the dispenser (lane oriented).
4. Dispenser cabinet shall be factory painted with stainless steel panels.
5. Rated dispenser flow rate shall be 22 gpm.
6. Dispenser shall have gallon readout and totalizer.
7. Dispensers shall operate on 115VAC/60Hz.
8. Hose retriever shall accommodate 15’ hose and not exceed 92” in height when retracted.
9. Dispenser shall have flow limiter limiting flow to 10 gpm. (Husky)
10. Dispenser shall be compatible with fuel management systems using an RS-485 or current loop communication.
11. Dispenser shall have dual pulse card.
12. Dispenser shall be compatible with fuel management systems and have integral contactless card reader for each hose.

C. Hoses:
1. Hoses shall be 15’ long and UL listed.
2. Hose couplings shall be installed by manufacturer.
3. Hose shall have UL listed breakaway coupling that is easily re-connectable.
4. Hose shall have swivel at nozzle.

D. Nozzles:
1. Nozzle shall be UL listed.
2. Nozzle shall have no flow interlock.
3. Nozzle shall have pressure interlock.
4. Nozzle shall be designed to be retained in fill pipe.
5. Nozzle shall be designed to shut-off if it falls out of vehicle fill neck.

2.12 SPECIALTY FITTINGS

A. Manufacturers:
1. OPW
2. Pomeco
3. Morrison
4. Approved equal

B. Vent Cap: Pressure/Vacuum vent shall be UL listed, CARB certified for EVR, corrosion resistant, and be installed on top of vent risers from fuel storage tanks. The vent cap shall have an internal wire screen designed to protect the tank vent lines against intrusion and blockage from water, debris, and insects.

C. Manholes: Manholes shall be round, rated for H20 loading, raintight with Buna-N gaskets, have recessed handles, and recessed “Roto-Lock” style fasteners. The cover shall composite; the ring shall be cast iron or fabricated steel, and the skirt galvanized steel.

D. Spill Containers: The spill container shall be designed to prevent spilled product from entering the soil near the fill and vapor return risers connections on fuel storage tanks during normal tank filling operation, or in the event of tank overfill. The spill container shall be suitable for aboveground tanks.

E. Overfill Valve: The overfill valve shall be designed to prevent the overfill of the fuel storage tanks by providing a positive shut-off of product delivery. The valve shall have a two-stage shut-off such that when liquid level reaches 92% of tank capacity the main valve will close and allow

a flowrate of approx. 5 gpm through a bypass valve. The bypass valve will close at 95% of tank capacity. The overfill valve shall be located in the 4" fill riser, be activated by a float, be an integral part of the drop tube, be CARB certified for EVR, compatible with product, and easily removable for inspection/replacement. The over fill valve shall be suitable for aboveground tanks and 100 psi pressure/delivery.

F. Extractor, Fill Adapters, Fill Caps: Fittings shall be suitable for use on fuel storage tanks, liquid tight connections, corrosion resistant, and compatible with product.

G. Emergency Shear Valve: Emergency shear valve shall be UL listed, and shall shut-off the flow of fuel in the event the dispenser becomes dislodged. The valve shall have a integral shear groove, three-point boss mount system, double-poppets, integral union, fusible link that trips at 165 degrees F, test port, thermal relief valve, and corrosion resistant finish.

2.13 PIPING SUMPS, DISPENSER PANS AND FLEXIBLE ENTRY BOOTS

A. Piping Sumps:
1. Manufacturers:
   a. Western Fiberglass
   b. S. Bravo Systems
   c. Approved equal
2. Sumps shall be constructed of fiberglass or steel with fiberglass coating and compatible with product.
3. Sumps shall be designed to prevent any external liquids from entering sump, as well as preventing liquids from escaping into the surrounding environment.
4. Sides and bottom of aboveground transition sumps shall be designed to withstand internal hydrostatic pressure when sump is completely full of liquid.
5. Size:
   a. See drawings.

B. Dispenser Pans:
1. Manufacturers:
   a. Western Fiberglass
   b. S. Bravo Systems
   c. Approved equal
2. Dispenser pans shall be UL listed and constructed of fiberglass or steel with fiberglass coating.
3. Dispenser pans shall have rain lip that extends 1" above the concrete surface and prevents surface water from entering the pan.
4. Dispenser pans shall have mounting frame that is factory fabricated for the dispenser with heavy gauge galvanized steel and pre-drilled for dispenser anchor bolt holes. Frame anchors shall be installed to secure the sidewall of the pan to the concrete. Use factory supplied anchor bolts.
5. Dispenser pans shall have adjustable stabilizer bar that is fully adjustable for accurate positioning of shear valves and easy connections of pipe fittings.
6. Sides and bottom of dispenser pans shall be designed to withstand internal hydrostatic pressure when pan is completely full of liquid.

C. Flexible Entry Boots:
1. Manufacturers:
   a. Diversified Products Mfg.

b. Approved equal

2. Flexible entry boots shall accommodate all types of piping and conduits without special modification or work.
3. Flexible entry boots shall be able to accept piping entering at a 15 degree or less angle without undue stress or leaking.
4. Flexible entry boots shall be able to withstand a minimum of 6’ of liquid head pressure.

2.14 ISLAND FORMS

A. Manufacturers:
1. Baker Industries
2. Morgan Brothers Company
3. OPW
4. Approved equal

B. Island Forms: Island forms to be fabricated from 12–gauge hot-rolled steel with an 1-1/4 top bead and bottom flange on straight sections, cross bracing on all sections, all welded construction, both sides are factory primed, and have mating companion flanges with a “key” to assure perfect alignment.

C. See drawings for size and configuration.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify excavations are to required grade, dry, and not over-excavated.

B. All equipment shall be installed in strict accordance with manufacturer instructions.

3.2 PREPARATION

A. Ream pipe and tube ends. Remove burrs.

B. Remove scale and dirt, on inside and outside, before assembly.

C. Prepare piping connections to equipment with flanges or unions.

D. Excavate and backfill in accordance with Division 2 requirements.

3.3 INSTALLATION – BURIED PIPING SYSTEMS

A. Establish elevations of buried piping with not less than 18 inches of cover including slab thickness unless approved by engineer.

B. Establish minimum separation of from other services piping in accordance with local code.

C. Remove scale and dirt on inside of piping before assembly.

D. Excavate pipe trench in accordance with Division 2 requirements.

E. Install pipe to elevation as indicated on drawings.

F. Place bedding material at trench bottom to provide uniform bedding for piping, level bedding materials in one continuous layer not exceeding 4 inches. Install pipe on prepared bedding.

G. Route pipe in straight line.

H. Install pipe to allow for expansion and contraction without stressing pipe or joints.

I. Provide warning tape min 6” over pipe and method of tracing non-metallic pipe.

J. Pipe Cover and Backfilling:
   1. Backfill trench in accordance with drawings.
   2. Maintain optimum moisture content of fill material to attain required compaction density.
   3. Evenly and continuously backfill remaining trench depth in uniform layers with backfill material.
   4. Do not use wheeled or tracked vehicles for tamping.

K. Contractor shall coordinate rough piping inspection with engineer. Piping shall not be backfilled until approved by engineer.

L. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

3.4 INSTALLATION OF ABOVEGROUND PIPING

A. Install piping in accordance with NFPA 30A and IFC 2016, whichever is more stringent.

B. Provide non-conducting dielectric connections wherever jointing dissimilar metals. Install in accordance with NACE RP-01-69.

C. Route piping in orderly manner and maintain gradient.

D. Install piping to conserve building space and not interfere with use of space.

E. Group piping whenever practical at common elevations.

F. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

G. Provide clearance for access to valves and fittings.

H. Where pipe support members are welded to structural building framing, scrape, brush clean, weld, and apply one coat of zinc rich primer.

I. Prepare pipe, fittings, supports, and accessories not pre-finished, ready for finish painting.

J. Install identification on piping systems. Install valves with stems upright or horizontal, not inverted.

K. At completion of piping installation all piping shall be cleaned and flushed.

L. Provide non-destructive testing in accordance with B31.3 on 10% of the welds of the primary and 10% of the welds on the secondary piping. Provide report of testing to owner for review and approval prior to covering up work.

M. Contractor to provide design/build piping supports at aboveground tank.

3.5 FUEL TANK INSTALLATION

A. Install tanks in accordance with tank manufacturers' installation instructions and recommendations.

B. Install piping connections to tanks with flexible connectors as shown on drawings. Provide venting in accordance with API 2000.

C. Fill tanks with appropriate fuel to a volume sufficient for priming, all regulatory and vendor testing, start-up and commissioning of the fueling system (minimum 2,500 gallons per tank). All fuel dispensed to prime and test fueling system shall be temporarily stored in approved, clean portable containers and returned to the fuel storage tanks.

3.6 TESTING PIPING SYSTEMS

A. Piping to be wrapped or double-contained shall be tested before wrapping or enclosing.

B. Do not put water in pumps, tanks, nozzle dispensers or other equipment, which may be contaminated or damaged by pressure or corrosion from water.

C. Piping which has been hydrostatically tested with water shall be drained and blown dry with air after successful testing. Moisture shall not be allowed to remain in piping overnight.

D. CAUTION: Do not over pressure tanks. Use suitable precaution when testing with air pressure to protect personnel and property in the event of failure.

E. Except where more stringent tests are required by the building authority, leak tests shall be as follows:

Service	Material	Test Pressure	Medium	Notes
VR1	CS/FRP	50	Air	A
G	CS/FRP	50	Air	A
Secondary Piping	CS/FRP	5	Air	A, B
Sumps	FRP	---	Water	C
Dispenser Pans	FRP	---	Water	C

F. Written certification of the test results shall be provided to the Owner.

3.7 TEST NOTES

A. Hold pressure for 30 minutes, check for leaks, correct deficiencies and retest until no leaks are found.

B. Hold pressure for 30 minutes. Sealed secondary piping shall be pressured and soap tested for leaks.

C. Fill with water, mark water level and recheck level in 24 hours, check for water leakage or water loss. Correct deficiencies and retest until no leaks are found over a period of one hour.

3.8 OTHER TESTS

A. All equipment shall be aligned, lubricated and test run and all instrumentation shall be calibrated and tested in accordance with installation and operating manuals, by Contractor. The systems shall be in good operating condition when turned over to the Owner.

B. Contractor shall dispense fuel from each nozzle and dispense enough fuel to completely flush the fueling system. All filters shall be replaced after testing and flushing of the system prior to being turned over to the owner.

C. Provide four hours of instruction and operation to owner's representative and all systems.

3.9 PAINT APPLICATION

A. Prime and paint all bare metal surfaces exposed to weather except galvanized finishes.

B. Prepare surfaces and apply paint in accordance with paint specification.

C. Colors:
1. Pipe Guards: Yellow
2. Aboveground Piping: White
3. Equipment: Touch up factory color as required.

3.10 SIGNS

A. Install signs at each dispenser indicating service and product use precautions.

B. Install all signage required by agencies having jurisdiction including all signage required in the local fire codes and on drawings.

C. Mount other signs at elevations and in locations such that they conform to regulations and are clearly visible to users of the facility.

D. Install wrap around marker inside fillports to identify product as well as on surface adjacent to product fillports.

3.11 PRE-FUNCTIONAL COMMISSIONING AND FUNCTIONAL PERFORMANCE TESTING

A. The Contractor shall complete pre-functional commissioning and functional performance testing as outlined in this part. The Contractor shall develop pre-functional commissioning and functional performance testing checklists in a format approved by the Owner to document this testing. The checklists must be filled out by the Contractor or his designated agent as the commissioning and testing is completed, and approved by the Owner prior to final acceptance of the gasoline fueling system.

B. Pre-functional Commissioning

1. Pre-functional commissioning shall be completed prior to placing any product in the tanks. Pre-functional testing shall include the following, at a minimum:

a. Verification of correct make, model, and voltage of equipment in accordance with approved submittals under Part 1.03(B) of this section.
b. Verification that manufacturer's cut sheets, installation and startup manuals, and operation and maintenance manuals have been provided to the Owner for all equipment subject to these commissioning requirements.
c. Recording of serial number of each component of the gasoline fueling system subject to these commissioning requirements.
d. Confirmation that applicable installation and startup requirements have been met in accordance with all engineering design drawings and specifications, manufacturer's installation and startup instructions, and current standard industry practices. Such requirements shall include, but not be limited to, physical installation of equipment and associated piping and accessories, and electrical wiring and controls applicable to the equipment being commissioned.

C. Functional Performance Testing

1. Functional performance testing shall be completed after approval to operate the fueling system is received from the authority having jurisdiction and product is placed in the tanks. Functional performance testing shall include the following, at a minimum:
   a. Confirmation that fuel safety systems, including emergency shutdown devices and fueling system shutdown upon activation of fire alarm, are fully functional.
   b. Confirmation that submersible pump operation, including operating and static pressures, alternating and lead-lag function, and mechanical pipe leak detectors is in accordance with system design requirements and manufacturer's specifications.
   c. Confirmation that fuel dispensing meets the following design criteria:
      1) Single nozzle flow rate is 8-9 gallons per minute (gpm).
      2) Flow rate with all nozzles running is between 7 and 9 gpm.

END OF SECTION

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SECTION 335220 - FUEL MANAGEMENT SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The General Provisions, Special provisions, and General Requirements of the Specifications shall apply to the work specified in this section.

1.2 SUMMARY

A. Section establishes performance and design requirements for an automated fuel management system that will control and/or record the dispensing of fuel. The vendor shall provide a stand-alone system, capable of unattended operation for 7 days a week, 24 hours a day. Fuel products shall be limited to equipment and operators with authorized keys or cards. The fuel management system shall reliably read all keys and mag or proximity cards and have the ability to lock out any key or card.

B. The Contractor shall install fuel management system as described in this specification and shown on the drawings.

C. The Contractor shall perform all work necessary for a complete installation of facilities.

D. The Contractor shall provide all products, consumables, necessary parts, and accessories although such items may not be specifically mentioned.

E. Nothing in this specification or on the drawings is to be construed to permit work not conforming to all applicable codes, regulations and vendor instructions.

F. Related sections:
1. Section 355216 – Gasoline Fueling System
2. Section 355230 – Inventory and Leak Detection System
3. Section 260500 – Fueling System Electrical Materials and Methods

1.3 REFERENCES

A. National Fire Protection Association:
1. NFPA 70 – National Electric Code (NEC) 2010.

B. Underwriters Laboratories Inc.:
1. UL 1238 – UL Standard for Safety Control Equipment for Use with Flammable Liquid Dispensing Devices.

1.4 SUBMITTALS

A. Product Data:
1. Submit manufacturer’s catalog information including panel, boards, site controller, software, inventory monitoring and leak detection panel interface, printer, and fuel island terminal.
2. Submit manufacturer’s catalog information on card reader integral with the dispenser.

B. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.5 OPERATION AND MAINTENANCE INSTRUCTION

A. Provide Operation and Maintenance Manual and instruction in accordance with Part 1.6B of this section.

B. Prior to turning over completed system to Owner Authorized Representative, Contractor shall provide up to four hours of instruction on system operation and maintenance to Owner Authorized Representative's personnel.

1.6 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of piping system, storage tanks, and system components.

B. Submit Operating and Maintenance Data for all products and equipment of this Section, in accordance with provisions of Division 1.

C. Demonstration
   1. Instruction of Owner Authorized Representative Personnel
      a. Before final inspection and at agreed upon times, instruct Owner Authorized Representative's designated personnel in operation, adjustment and maintenance of products, equipment and systems.
      b. Use the OPERATION AND MAINTENANCE MANUAL as basis of instruction. Review contents of the MANUAL with personnel in detail to explain all aspects of operation and maintenance.
      c. Prepare and insert additional data in the MANUAL when need for such data becomes apparent during instruction.

1.7 QUALITY CONTROL

A. Perform work in accordance with industry standards and all applicable codes, including NEC 2016.

B. Maintain one copy of each document on-site.

1.8 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum five years being manufactured.

B. Contractor: Company specializing in performing Work of this section with minimum five years' experience.

1.9 DELIVERY, STORAGE AND HANDLING

A. Accept materials on-site in shipping containers with labeling in place. Inspect for damage.

1.10 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.11 WARRANTY

A. The system must include a 2-year warranty on all components covering parts and on-site labor. A factory-trained Authorized Service Representative (ASR) must be located within 150 miles of the site.

PART 2 - PRODUCTS

2.1 FUEL MANAGEMENT SYSTEM

A. Manufacturers:
1. Wayne iX Fleet Fuel Management System (used as basis of design)
2. Gasboy (CFN Plus)
3. Approved equal

B. SYSTEM COMPONENTS
1. The system shall be an integrated set of components consisting of a site controller capable of tracking fuel usage at each nozzle.
2. The system shall have the capability of using a card reader integral to the dispenser for fuel system authorization purposes.
3. The system will utilize proximity card for authorization purposes.
4. System to be programmed such that each rental car agency is a customer/vendor and provide reports for total fuel dispensed daily.
5. System shall be capable to automatically monitor transactions and fuel usage and download information to site controller.
6. Site controller shall work in Online and offline modes, in case of communication failures with FHO the system continue to work offline with limits and restrictions. When communication is re-established, the system shall synchronize data automatically.
7. The site controller shall be a stand-alone unit comprising of all required peripherals including the central processing unit, pump control module, and communication modules. The controller shall be locked by key to prevent unauthorized access.
8. The site controller shall be web enabled to allow independent Real-Time control, monitoring and reporting via the web using user ID with password and SSL protected link (https://).
9. The site controller shall communicate with a high performance server or a completely dedicated Host Computer (Desktop PC) for the purpose of centralized control and monitoring of multiple sites.
10. The system shall support: HID, Mag Card and Proximity Card.

C. Hardware Specifications
1. Capability to control up to 32 fueling positions
2. Real-time clock with battery backup along with surge suppressors for transient and noise immunity.
3. Manual system override++
4. The system shall include a power fail recovery mechanism.
5. Resolution to .001 gallon/liter
6. Built-in hardware and software diagnostics

7. Supply voltage: 110 VAC – 240 VAC
8. Power consumption: 1A max.
9. Humidity: 80% Non-condensing
10. Operating temperature: -22 F to +158 F (-30 C to +70 C)
11. Communication interface: RS-485–9600 bps, Half-Duplex, RS-232, Ethernet RJ-45-10 Mbps, EIA 802.15.4
12. Accessible via Internet browser to control and monitor the system. No requirement to install dedicated software.
13. Provide Ethernet switch.

D. Card Reader

1. Dispenser mounted integral card reader
2. Top illumination
3. LCD operates well in all lightening conditions
4. The keys sensors shall use piezoelectric technology for highest reliability
5. HID reader shall be optional and shall be integrated internally and behind the terminal faceplate panel. An external HID reader is not acceptable.
6. Proximity Reader, Magnetic card reader, and alphanumeric keypad shall be standard means of data capture with card reader.

E. System must be able to connect to Gilbarco, Gasboy or Wayne electronic dispensers without the use of Pump Control Devices. Must communicate with dispensers via the RS485 interface, current loop or Ethernet.

F. Software Specifications:

1. The site controller shall store up to 25,000 transactions and 50,000 vehicles/devices with the ability to set limitations and restrictions.
2. Secured remote capabilities for monitoring, management and maintenance activities
3. Web enabled reporting and alarms for Tank Level Sensing (Veeder-Root TLS or Incon) systems (VR-350 and VR-450 protocols)
4. Fuel management software for reconciliation reports
5. The software shall support multiple fuel site controllers and allow data consolidation.
6. The software shall support multiple fleets and multiple departments.
7. Capability to control up to 48 fueling positions (24 twin hose dispensers)
8. The software shall synchronize data with all sites.
9. The software shall be installed on the host computer running Windows operating system and SQL database that supports ODBC connectivity.
10. The system shall be a centralized web server communicating with all sites to provide centralized data base and on-line network access for fleet managers, key personnel and remote maintenance entities.
11. The software shall communicate with all sites to provide 24/7 on-line access through the network.
12. The software shall create and control several fleets and departments and support different privilege levels for limited access for different users (A specific Fleet manager shall only be able to manage only his fleet vehicles).
13. The software shall provide advanced on-line services for multiple sites and multiple fleets in a region.
14. The host software web interface shall use SSL security.

15. The software shall provide secure log-in through the Web for each fleet manager, for monitoring & control and report generation including exception reports.
16. The host software application can interface to other applications via Web Services, import and export of files to FTP and ODBC standard.
17. The software shall allow Exporting data to different file formats (using a dropdown menu) such as CSV, TXT, and XML.
18. The user interface for all software components shall be a web browser

G. Custom Reports
1. The software shall provide a highly flexible custom reporting utility. Data elements can be selected and put in any order by the user to create their own custom report.
2. This report shall have the ability to be saved as a template for later use.
3. Must have advanced customized reporting capabilities with filters and templates (Web based).
4. The custom reports feature shall enable report generation of transactions performed in the fuel station in various profiles.
5. The following field names shall be used to generate custom reports tables:
6. Station, Date, Time, Fleet, Transaction Type, Vehicle #, Product, Quantity, Total Sale, Receipt No., Fleet Code, Pay Mode, Transaction Id, Authorized By, Department, PPV, Odometer, Engine Hour, Pump, Tank, Nozzle, Density, Temperature, Vehicle Type, Ref/Slip No., Driver name, Dept code, Card number, Device name.
7. The custom report shall allow summary by the following fields (Break by):
8. Date, Plate, Pump, Product, Pay Mode, Station name, Fleet code, Authorized by, driver name, dept code, or a selection of any of the above fields
9. The custom reports shall allow sorting by the following fields (Sort by):
10. Date & Time (Ascending/Descending), Pump, Transaction ID, Product, Amount (Ascending/Descending), Qty, Plate, Pay mode, Station name, fleet code, Receipt ID, Driver name, Dept code or a selection of any of the above fields.
11. The above powerful capabilities shall allow flexible reporting such as:
12. Summary Report – summarizing all transactions of a specific fleet of vehicles.
13. Vehicle Report – offering the Fleet Manager a detailed transaction report of vehicles pertaining to his fleet, in two cross sections:
14. Transactions - providing information regarding each transaction, including the vehicles license plate number, odometer reading, engine hours, fuel type, fuel volume and the transaction ID.
15. Consumption - listing information regarding each vehicle (device) providing a summation of data (volume consumption, fuel cost, other costs) for each vehicle in a specified time frame.
16. Exception Reports
17. The software shall provide Exception Reports for the Fleet Manager. It must provide the ability to spot any abnormal incidents that occurred within his fleet. The following exception reports are required for each fleet:
18. Volume Exception Report – shall list noted exceptions relating to the fuel volume consumed in the transactions compared with the related vehicle's fuel tank volume. For example, if the volume of a specific transaction is larger than the fuel tank volume of the refueling vehicle, a message regarding this incident should appear in this report.

H. Programmable Set Points:
1. Maximum fuel dispensed per transaction shall be 20 gallons.
2. Timeout for not flow shall be 90 seconds.
3. Operating hours shall be from 6 am to 12 am.

4. System needs to be configured to automatically reset the transaction pointer based on a % full of the transaction file so a memory full condition can not happen.

I. Fuel Allocation:
1. Control disbursements for a specified field such as driver, department, and vehicle, etc.
2. Allocation must be available by gallons or dollars
3. Commands to add to, subtract from, or print allocation balances

PART 3 - EXECUTION

3.1 EXAMINATION

A. All equipment shall be installed in strict accordance with manufacturer instructions. Contractor to take special note to electrical phasing described in the manuals of all fueling components.

3.2 TRAINING

A. Provide eight hours of instruction on operation of fuel management system to Owner Authorized Representative's representative.

3.3 SIGNS

A. Install all signage required by agencies having jurisdiction including all signage required in the local fire codes.

B. Mount other signs at elevations and in locations such that they conform to regulations and are clearly visible to users of the facilities.

3.4 PRE-FUNCTIONAL COMMISSIONING AND FUNCTIONAL PERFORMANCE TESTING

A. The Contractor shall complete pre-functional commissioning and functional performance testing as outlined in this part. The Contractor shall develop pre-functional commissioning and functional performance testing checklists in a format approved by the Owner to document this testing. The checklists must be filled out by the Contractor or his designated agent as the commissioning and testing is completed, and approved by the Owner prior to final acceptance of the fuel management system.

B. Pre-functional Commissioning
1. Pre-functional commissioning shall be completed prior to placing any product in the tanks. Pre-functional testing shall include the following, at a minimum:

a. Verification of correct make, model, and voltage of equipment in accordance with approved submittals under Part 1.3 of this section.

b. Verification that manufacturer's cut sheets, installation and startup manuals, and operation and maintenance manuals have been provided to the Owner for all equipment.

c. Recording of serial number of each fuel management system.

d. Confirmation that applicable installation and startup requirements have been met in accordance with all engineering design drawings and specifications, manufacturer's installation and startup instructions, and current standard industry practices. Such requirements shall include, but not be limited to, physical installation of equipment and electrical wiring and controls applicable to the equipment being commissioned.

e. Confirmation that system is programmed in accordance with Part 2.1(H) of this section.

f. Confirmation that fuel management system is accessible through the facility's local area network.

C. Functional Performance Testing

1. Functional performance testing shall be completed after approval to operate the fueling system is received from the authority having jurisdiction and product is placed in the tanks. Functional performance testing shall include the following, at a minimum:

a. Confirmation that each nozzle is authorized by the Fuel Management System and fuel dispensed is recorded.
b. Confirmation at 1 dispenser per island that nozzle will not dispense fuel due to lack of fuel flow for 90 seconds.
c. Confirmation at 4 dispensers that total volume of fuel dispensed before automatic stoppage of flow is 20 gallons. System is set in full service mode which does not require a card reader
d. Set up monthly report to include usage by nozzle and overall fuel usage by department (i.e. rental car agency)
e. Set up monthly invoice for fuel usage by department (i.e. rental car agency)
f. Set up security levels for access by the rental car companies to obtain their fuel usage by nozzle and over all usage.
g. System needs to be configured to automatically reset the transaction pointer based on a % full of the transaction file so a memory full condition cannot happen.

END OF SECTION

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SECTION 33 52 30 INVENTORY AND LEAK DETECTION SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section establishes performance and design requirements for an inventory monitoring and leak detection system for the fueling system. This system will provide automatic tank gauging, interstitial leak sensing for the product piping, and automatic inventory of the fueling system. The inventory control system shall consist of a monitoring console, tank vault, piping sump, and dispenser pan sensors, tank level probes, overfill alarms, and overfill alarm acknowledgement switches.

B. The Contractor shall install inventory monitoring and leak detection system as described in this specification and shown on the drawings.

C. The Contractor shall perform all work necessary for a complete installation of facilities.

D. The Contractor shall provide all products, consumables, necessary parts, and accessories although such items may not be specifically mentioned.

E. Nothing in this specification or on the drawings is to be construed to permit work not conforming to all applicable codes, regulations and vendor instructions.

F. Related sections:
   1. Section 335216 – Gasoline Fueling System
   2. Section 335220 – Fuel Management System:
   3. Section 260500 – Fueling System Electrical Materials and Methods

1.2 REFERENCES

A. National Fire Protection Association:
   1. NFPA 70 – National Electric Code.
   2. NFPA 30 – Flammable and Combustible Liquids Code.
   3. NFPA 30A – Automotive and Marine Services Station Code.

B. Underwriters Laboratories Inc.:
   1. UL 1238 – UL Standard for Safety Control Equipment for Use with Flammable Liquid Dispensing Devices.
   2. UL 698 – Industrial Control Equipment for Use in Hazardous (Classified) Locations.
   3. UL 886 – Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations.

1.3 SUBMITTALS

A. Product Data:
   1. Submit manufacturer’s catalog information including console, boards, probes, sensors, external alarms, and acknowledgment switches.

B. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.4 OPERATION AND MAINTENANCE INSTRUCTION

A. Provide Operation and Maintenance Manual and instruction.

B. Prior to turning over completed system to Owner Authorized Representative, Contractor shall provide up to four hours of instruction on system operation and maintenance to Fuel System Operator's personnel.

1.5 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of inventory and leak detection system components.

B. Submit Operating and Maintenance Data for all products and equipment of this Section, in accordance with provisions of Division 1.

C. Demonstration
   1. Instruction of Owner Authorized Representative Personnel
      a. Before final inspection and at agreed upon times, instruct Owner Authorized Representative's designated personnel in operation, adjustment and maintenance of products, equipment and systems.
      b. Use the OPERATION AND MAINTENANCE MANUAL as basis of instruction. Review contents of the MANUAL with personnel in detail to explain all aspects of operation and maintenance.
      c. Prepare and insert additional data in the MANUAL when need for such data becomes apparent during instruction.

1.6 QUALITY CONTROL

A. Perform work in accordance with industry standards and all applicable codes.

B. Maintain one copy of each document on-site.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum five years being manufactured.

B. Contractor: Company specializing in performing Work of this section with minimum five years experience. Contractor shall be Authorized Service Company for equipment manufacturer.

1.8 DELIVERY, STORAGE AND HANDLING

A. Accept materials on-site in shipping containers with labeling in place. Inspect for damage.

1.9 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.10 WARRANTY

A. The system must include a 2-year warranty on all components covering parts and on-site labor. A factory-trained Authorized Service Representative (ASR) must be located within 150 miles of the site.

PART 2 - PRODUCTS

2.1 INVENTORY MONITORING AND LEAK DETECTION SYSTEM

A. Manufacturers:
   1. Incon (Used as basis of design)
   2. Veeder-Root
   3. Approved equal

B. The system shall have the following features:
   1. Continuous inventory monitoring
   2. 0.2 GPH in-tank leak detection and inventory for up to 12 tanks
   3. Interstitial and piping sump leak sensing for up to 64 sensors
   4. External inputs
   5. Relay outputs/inputs
   6. Programmable alarms
   7. Data communication (RS232)
   8. Magnetostrictive probe technology
   9. Liquid sensors for monitoring piping sumps, dispenser pans, and fuel tanks, including modules
   10. Integral printer
   11. Sitefax modem
   12. Remote alarm consisting of light, horn, and silence switch
   13. Ethernet card for network compatibility
   14. PC Software for remote access.
   15. Inner Station Diagnostics (ISD) or similar program to remotely access monitoring panel.

2.2 INTERSTITIAL PIPING LEAK DETECTION

A. The system shall be able to perform automatic, continuous leak sensing in the dry piping sumps and dispenser pans associated with the double-walled piping system to detect a breach in the inner pipe. The system shall have the ability to sense the presence of hydrocarbons and/or fluid and provide an alarm for the worst case condition (fuel). The form factor of the sensor must provide for easy field installation/removal. The system shall have the ability to continuously monitor the integrity of the sensor for an open condition, alarm condition, or normal operation condition.

2.3 ENVIRONMENTAL COMPLIANCE REPORTS

A. The system shall have the ability to provide a record of the last three occurrences of each type of alarm or warning condition detected by the system. The system shall provide the following types of reports related to environmental compliance matters:
   1. System status messages
   2. Liquid sensor warning and alarm messages

3. Normally closed sensor warning and alarm conditions
4. High or low liquid level conditions
5. In-tank warning and alarm messages
6. External input messages
7. Software module alarm message

2.4 PRODUCT INVENTORY CONTROL

A. The tank management system shall collect product height and temperature data from up to three level probes and compute gross and temperature-compensated net gallons. The system shall provide inventory and delivery information to generate a complete set of printed inventory or delivery reports. The system shall automatically generate an inventory increase report when a delivery of product to a tank has taken place. The system shall have the ability to store up to the ten most recent inventory increases in memory. The system shall provide the ability to monitor aboveground storage tanks for inventory management.

2.5 INVENTORY MANAGEMENT REPORTS

A. The system shall monitor inventory in U.S. or Metric units for up to four tanks and produce a combination of automatic and manual reports for each tank, which include the following information:
   1. Fuel volume
   2. Fuel height
   3. Water height
   4. Fuel cost
   5. Fuel temperature
   6. Ullage volume
   7. Temperature-compensated fuel volume
   8. Last inventory increase amount
   9. Time and date
   10. Tank identification
   11. Fuel type identification
   12. 90% ullage volume

B. An inventory status report shall be generated and transmitted to the PC automatically three times a day with the information stored in memory or manually from the console input. The system shall transmit an automatic delivery report to the PC after each bulk delivery to a tank. The information shall include station header, product label, date, starting and ending volumes, temperature of the fuel as well as the net volume increase. The information shall be available in U.S. or Metric units.

2.6 COMMUNICATIONS

A. The tank monitoring system shall provide the ability to communicate with locally attached electronic devices through an RS-232 port or remote locations via an RS-232 port. The system shall provide data in a display or packed computer data format. The communications protocol shall be compatible with the PC management software specified in Part 2. The tank monitoring system shall provide all reports through the PC management software. These shall include all reports associated with inventory management, environmental compliance and diagnostics/troubleshooting. The system shall provide for setup and configuration through the management software.

2.7 INPUT/OUTPUT CAPABILITIES

A. Output Relay: The system shall provide the ability to enable the external audible/visual alarms or control external devices through a relay contact closure. The system shall provide 2 Form C contact relays. The system shall provide the ability to program the relay in either a Normally Open or Normally Closed orientation. The system shall provide the ability to assign sensor, or system alarm conditions to a select relay. The system shall provide the ability to designate a 20 character label to a device connected to the output relay through system programming.

B. Input Interface: The system shall provide the ability to accept an input from an external device and enable a relay to control an external device. The system shall have the ability to define the type of input connected to the system. The system shall have the ability to name, through systems programming, each external device connected to an input position.

2.8 ALARMS

A. The tank monitoring system shall provide an audible and visual indication of all system, interstitial leak, and external sensor alarm conditions. The system alarm conditions shall include:
   1. Maximum product level -95%
   2. High product level limit – 93%
   3. Overfill alarm – 90%
   4. High water alarm 3”
   5. Low product level limit 4’ off bottom of tank

B. The tank monitoring system shall provide an audible and visual alarm indication for external sensor leak failures (fuel, water, sensor out). In conjunction with providing and audible and visual alarm, the system shall transmit all alarm conditions to the PC management software. The system shall have the ability to transmit the alarm condition immediately or program a delay time before sending. The system shall also have the ability to enter a repeat function in the programming to repeat sending the alarm condition. The system shall provide the operator with the ability to disable the audible portion of an alarm but the visual alarm shall not be disabled until the alarm condition has been corrected. The system shall be equipped with an external audible and visual alarm with acknowledgement switch. The external alarm box and acknowledgement switch shall be manufactured in a watertight gasketed enclosure for installation in an outdoor environment. The external alarm box and acknowledgement switch shall interface to the tank monitoring system via an internal relay. The system shall have the ability to store up to three alarm occurrences in memory.

2.9 SETUP (STARTUP/INSTALLATION)

A. The system shall contain parameter-driven software to adapt the tank monitor to site specifications. The parameters must be enterable in assigned fields at the time of system startup. In addition, the parameters must be field updatable so that changes in tank diameter/dimensions as well as site specifications can be added. The system shall provide the use of a security code to prohibit unauthorized entry to the systems set-up parameters. The system security code shall be a six-digit number entered through the front-panel keyboard or through the external communications interface. The security code shall have the capability of containing alpha or numeric characters. A four-line, 24-character custom location header to identify the site must be user-programmable. The header must appear automatically on inventory status reports, leak

detection reports and automatic delivery reports each time they are printed. Set-up parameters shall include the following:
1. System setup data
2. Communications setup data
3. In-tank setup data
4. Liquid sensor setup data
5. External sensor setup data
6. Output relay setup data

2.10 DIAGNOSTICS/TROUBLESHOOTING

A. All diagnostic information shall be generated by the system itself. The system shall not allow the user to change or enter diagnostic information in any way. The following diagnostic information shall be included in the system:
1. Probe diagnostics (probe type, serial number, probe length, dry and wet calibration values)
2. System diagnostics (software revision level, software part number, software creation date)
3. In-tank diagnostics
4. Liquid and vapor sensor diagnostics
5. Alarm history report

2.11 REPORTS

A. All diagnostic information shall be transmitted to the PC management software documentation and historical record keeping.

PART 3 - EXECUTION

3.1 EXAMINATION

A. All equipment shall be installed in strict accordance with manufacturer instructions.

3.2 STARTUP AND COMMISSIONING

A. The inventory control system shall be commissioned by an authorized manufacturer's representative. The startup and commissioning shall consist of installation checkout, operation checkout and customer training on use of the equipment. The manufacturer shall supply a Warranty Registration and Checkout Form to properly document the site information to include:
1. Installation location
2. Installer
3. Equipment identification
4. Tank information
5. Startup distributor information
6. Customer approval

3.3 TRAINING

A. Provide four (4) hours of instruction to Leak Detection System Operator's personnel on operation of monitoring equipment.

B. Installer's Training Requirements: The manufacturer shall require and provide mandatory certification training for all of its authorized distributors and service contractors/installers. The

certification program shall consist of three certification levels covering installation, setup/operation, and service/trouble shooting of the manufacturer's tank monitoring systems. The manufacturer shall provide certification information on contractor/installer to regulatory agencies that require certification documentation. The manufacturer shall offer recertification training to keep contractors/installers current with updated information. The manufacturer shall conduct regional training seminars throughout North America. The manufacturer shall provide a home study certification program for installing contractors.

3.4 SIGNS

A. Install all signage required by agencies having jurisdiction including all signage required in the local fire codes.

B. Mount other signs at elevations and in locations such that they conform to regulations and are clearly visible to users of the facilities.

3.5 PRE-FUNCTIONAL COMMISSIONING AND FUNCTIONAL PERFORMANCE TESTING

A. In addition to startup and commissioning as described in Part 3.2 of this section, the Contractor shall complete pre-functional commissioning and functional performance testing as outlined in this part. The Contractor shall develop pre-functional commissioning and functional performance testing checklists in a format approved by the Owner to document this testing. The checklists must be filled out by the Contractor or his designated agent as the commissioning and testing is completed, and approved by the Owner prior to final acceptance of the inventory and leak detection system.

B. Pre-functional Commissioning
   1. Pre-functional commissioning shall be completed prior to placing any product in the tanks. Pre-functional testing shall include the following, at a minimum:

      a. Verification of correct make, model, and voltage of equipment in accordance with approved submittals under Part 1.3 of this section.

      b. Verification that manufacturer’s cut sheets, installation and startup manuals, and operation and maintenance manuals have been provided to the Owner for all equipment.

      c. Recording of serial number of each monitoring console, level probe, piping sump and dispenser pan liquid sensor, dual-float hydrostatic sensor, vacuum sensor, and external overfill alarm and acknowledgement switch.

      d. Confirmation that applicable installation and startup requirements have been met in accordance with all engineering design drawings and specifications, manufacturer’s installation and startup instructions, and current standard industry practices. Such requirements shall include, but not be limited to, physical installation of equipment and electrical wiring and controls applicable to the equipment being commissioned.

      e. Checking for proper operation of all liquid sensors, dual-float hydrostatic sensors, vacuum sensors, and external overfill alarms and acknowledgement switches following testing methodologies specified by the manufacturer and standard industry practices.

f. Confirmation of operation of programmed alarm conditions, including low product level and overfill limit, including notification to Airport Command Center.

g. Confirmation that loss of power to the inventory and leak detection system or any fuel alarm activation will shut down the fueling system ("fail-safe" operation).

h. Confirmation that inventory and leak detection system is accessible through the facility's local area network.

C. Functional Performance Testing
1. Functional performance testing shall be completed after approval to operate the fueling system is received from the authority having jurisdiction and product is placed in the tanks. Functional performance testing shall include the following, at a minimum:

a. Verification of correct product level readings by comparison with manual stick readings in each tank.

END OF SECTION