Technical Specifications
Volume 2 of 2
100% Construction Documents
ALW Project No. 21414

December 9, 2021
Revised: 1.10.2022 - Addendum #1

North Florida Innovation Labs

Leon County Research & Development Authority

EDA Award No. 04-79-07447

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TECHNICAL SPECIFICATIONS

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SECTION 200000
GENERAL MECHANICAL REQUIREMENTS

PART 1 - GENERAL

1.01 REFERENCE

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

1.02 DESCRIPTION

A. Intent of Drawings and Specifications is to obtain complete systems, tested, adjusted, and ready for operation.
B. Except as otherwise defined in greater detail, the terms "provide", "furnish" and "install" as used in Division 20, 21, 22 and 23 Contract Documents shall have the following meanings:
   1. "Provide" or "provided" shall mean "furnish and install".
   2. "Furnish" or "furnished" does not include installation.
   3. "Install" or "installed" does not include furnishing.
C. Include incidental details not usually shown or specified, but necessary for proper installation and operation.
D. Check, verify and coordinate work with Drawings and Specifications prepared for other trades. Include modifications, relocations or adjustments necessary to complete work or to avoid interference with other trades.
E. Information given herein and on Drawings is as exact as could be secured but is not guaranteed. Do not scale drawings for exact dimensions.
F. Where Architectural features govern location of work, refer to Architectural Drawings.
G. Contractor may install additional piping, fittings and valves, not shown on drawings, for testing purposes or for convenience of installation. Where such materials are installed, they shall comply with Specifications and shall be sized to be compatible with system design. Remove such installed materials when they interfere with design conditions or as directed by Architect.

1.03 RELATED WORK

A. Utility Services:
   1. Determine utility connection requirements and include in Base Bid all costs to Owner for utility service.
   2. Include costs for temporary service, temporary routing of piping or any other requirements of a temporary nature associated with utility service.
B. Temporary Services: Refer to Section 01500 (Temporary Facilities and Controls).
C. Concrete Work:
   1. Refer to Section 03300 (Cast-In-Place Concrete).
   2. Provide anchor bolts, metal shapes and templates required to be cast in concrete or used to form concrete for support of mechanical equipment.
D. Painting:
   1. Refer to Sections 09911 (Painting) and 09912 (Interior Painting).
   2. Equipment:
      a. Furnish equipment with factory applied prime and finish coats unless otherwise specified.
      b. If factory finish on equipment furnished by Contractor is damaged in shipment or during construction, refinish equipment to satisfaction of Architect.
      c. Furnish one can of touch up paint for each factory-applied coat of product.
   3. Piping:
      a. Paint the following piping including fittings, valve bodies, and supports.
         1) Exposed cast iron and steel piping located outside building and inside the mechanical rooms.
         2) Exception: galvanized piping and supports

3) Exposed piping located in spaces with finished ceilings

b. Paint Colors:
   1) Exposed piping within finished spaces and mechanical rooms: color selected by the architect
   2) Exterior natural gas: yellow
   3) Exterior fire protection: red

1.04 REQUIREMENTS OF REGULATORY AGENCIES

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

1.05 REFERENCE STANDARDS

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

1.	AGA	American Gas Association
2.	AHRI	Air-Conditioning, Heating and Refrigeration Institute
3.	AMCA	Air Movement and Control Association
4.	ANSI	American National Standards Institute
5.	ASHRAE	American Society of Heating Refrigerating and Air Conditioning Engineers
6.	ASPE	American Society of Plumbing Engineers
7.	ASSE	American Society of Sanitary Engineering
8.	AWS	American Welding Society
9.	AWWA	American Water Works Association
10.	ASME	American Society of Mechanical Engineers
11.	ASTM	American Society for Testing and Materials
12.	CDA	Copper Development Association
13.	CGA	Compressed Gas Association
14.	CISPI	Cast Iron Soil Pipe Institute
15.	DIPRA	Ductile Iron Pipe Research Association
16.	EPA	United States Environmental Protection Agency
17.	FMG	FM Global
18.	FS	Federal Specifications
19.	IAPMO	International Association of Plumbing and Mechanical Officials
20.	ICC	International Code Council
21.	IEEE	Institute of Electrical and Electronics Engineers
22.	ISO	International Organization for Standardization
23.	MCA	Mechanical Contractors Association
24.	MSS	Manufacturers Standardization Society
25.	NEC	National Electrical Code
26.	NEMA	National Electrical Manufacturers Association
27.	NFPA	National Fire Protection Association
28.	NIST	National Institute of Standards & Technology
29.	NSF	National Sanitation Foundation
30.	NSPI	National Spa and Pool Institute
31.	OSHA	Occupational Safety and Health Administration
32.	PDI	Plumbing and Drainage Institute
33.	PPI	Plastic Pipe Institute
34.	SMACNA	Sheet Metal and Air Conditioning Contractors National Association
35.	UL	Underwriters Laboratories, Inc.
36.	US DOT CFR	United Stated Dept. of Transportation, Code of Federal Regulations
37.	WCF	Water Conditioning Foundation

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

1.06 SUBMITTALS

A. Shop Drawings (Product Data):
   1. Refer to Section 01330 (Submittal Procedures).
   2. Include composite wiring diagrams for electrically powered equipment and devices.
   3. Do not submit "Coordination Drawings", which are normally prepared by Contractor to coordinate work among various trades and to facilitate installation, work unless specifically requested in technical sections. These types of drawings typically include dimensioned piping, ductwork or electrical raceway layouts.
   4. Unless specifically requested in Division 20, 21, 22 or 23 technical sections, submittals of coordination drawings will be returned without review.
B. Certificates and Inspections: Obtain and pay for inspections required by authorities having jurisdiction and deliver certificates approving installations to Owner unless otherwise directed.
C. Operation and Maintenance Manuals:
   1. Refer to Section 01782 (Operation and Maintenance Data).
   2. Additional Requirements:
      a. Wiring diagrams
      b. Startup and shutdown procedures
      c. Composite electrical diagrams
      d. Flow diagrams
      e. Lubrication instructions
      f. Factory and field test records (Refer to Test and Balancing in Part 3 of this Section.)
      g. Air and water balance reports
      h. Valve identification charts as specified in Section 20 0553 (Mechanical System Identification)
      i. Access panel identification charts as specified in Section 20 0553 (Mechanical System Identification)
      j. Additional information, diagrams or explanations as designated under respective equipment or systems specification sections.
   3. Instruct Owner's representative in operation and maintenance of equipment. Instruction shall include complete operating cycle on all apparatus.
D. Record Documents: Refer to Section 01781 (Project Record Documents).

1.07 JOB CONDITIONS

A. Building Access: Arrange for necessary openings in building to allow for admittance of all apparatus.
B. Electrical Coordination:
   1. Refer to Section 20 0513 (Motors)
   2. Provide the following items as specified under their respective Division(s) (Division 20, 21, 22 and 23):
      a. Motors
      b. Electrically powered equipment
      c. Electrically controlled equipment
      d. Starters, where specified
      e. Variable frequency drives, where specified
      f. Control devices, where specified
      g. Temperature Control wiring
      h. Wiring diagrams to electrical installer for apparatus indicating external connection and internal controls.
      i. Disconnect devices furnished with equipment:
         1) Devices shall have an interrupting rating not less than that of the upstream overcurrent device as shown on electrical drawings.
         2) Provide equipment electrical connection points labeled with listed electrical short circuit current rating (sccr). Sccr shall not be less than interrupting rating of

upstream overcurrent device as shown on electrical drawings. Sccr shall be marked on equipment control enclosure in accordance with ul508, or other acceptable, accredited third-party testing agency standards.

3. Refer to Division 26 for the following devices required for control of motors or electrical equipment, unless noted otherwise.
   a. Starters
   b. Disconnect devices
   c. Control devices:
      1) Pushbuttons
      2) Pilot lights
      3) Contacts
   d. Conduit, boxes and wiring for power wiring.
   e. Conduit, boxes and wiring for control wiring, except temperature control wiring.
4. Notify the electrical installer of any change in size, rating, voltage, or means of control of any motor or other electrical equipment.

C. Cutting and Patching:
   1. Refer to Division 01 (General Requirements).
   2. Do not pierce beams or columns without permission of Architect and then only as directed. If openings are required through walls or floors where no sleeve has been provided, hole shall be core drilled to avoid unnecessary damage and structural weakening.

D. Housekeeping and Cleanup: Refer to Refer to Section 01524 (Construction Waste Management).

1.08 WARRANTY

A. Refer to Division 01 (General Requirements).
B. Warrant that systems will operate without objectionable noise, vibration and uncontrolled expansion.

PART 2 - PRODUCTS

2.01 PRODUCT SUBSTITUTIONS

A. Refer to Division 01 (General Requirements).

PART 3 - EXECUTION

3.01 GENERAL

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

3.02 DELIVERY, STORAGE, HANDLING, AND PROTECTION

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

3.03 FLOOR, WALL, ROOF AND CEILING OPENINGS

A. Coordinate location of openings, chases, furred spaces, etc., with appropriate installers. Provide sleeves and inserts that are to be built into structure during progress of construction.
B. Remove temporary sleeves, if used to form openings, prior to installation of permanent materials. Utilize minimum 24 gauge galvanized sheet metal for permanent sleeves unless otherwise noted.

C. Submit product data and installation details for penetrations of building structure. Include schedule indicating penetrating materials (metal pipe, plastic pipe, conduit, etc.), sizes of each, opening sizes and sealant products intended for use.
D. Where penetrations of fire-rated assemblies are involved, seal penetrations with appropriate firestopping systems as specified in Section 20 0573 (Mechanical Systems Firestopping).
E. Provide minimum 1” clearance around penetration openings intended for pipe. Size fire-resistant penetration openings as recommended by the firestopping systems manufacturer.
F. Openings for underground pipes passing through foundations or under footings shall have minimum clearance of 1-1/2” to concrete. Do not disturb footing bearing soil.
G. Openings for underground pipe passing through on grade concrete slabs shall have minimum 1/4” clearance to concrete. Seal openings with urethane caulk.
H. Size insulated pipe openings for outside diameter of unless otherwise specified.
I. Openings for duct penetrations shall be no more than 1/2” larger on all sides than size of duct or duct including duct insulation, if applicable. Where firestopping systems are required at penetrations, size in accordance with recommendations of firestopping systems manufacturer, but opening shall not exceed 1” average clearance on all sides. Openings for ducts with fire dampers shall be in accordance with fire damper installation requirements.
J. Duct penetrations through concrete floors in mechanical rooms containing liquid heat exchangers and/or pumps shall have 2” high water stopped curbs surrounding openings. This applies to mechanical rooms above the lowest floor level.
K. Seal non fire-rated floor penetrations with non-shrink grout equal to Embeco by Master Builders, or urethane caulk, as appropriate.
L. Seal non fire-rated wall openings with urethane caulk.
M. Finish and trim penetrations as shown on details and as specified.
N. Provide chrome or nickel plated escutcheons in finished areas where exposed piping penetrates walls, floors or ceilings. Size escutcheons so they fit pipe or pipe coverings, providing a finished appearance. Finished areas shall not include mechanical/electrical rooms, janitor closets, storage rooms, etc., unless they have suspended ceilings. Escutcheons applied in wet areas, foodservice areas, and restrooms shall be chrome plated brass or stainless steel.
O. Trim duct penetrations exposed in finished areas with 2” wide galvanized or aluminum trim collars properly sized to fit duct. Collars shall be same gauge as duct, prime finish unless noted otherwise. Finished areas shall not include mechanical rooms, janitor closets, storage rooms, etc., unless suspended ceilings are specified.

3.04 EQUIPMENT SHUTOFF VALVES

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

3.05 EQUIPMENT ACCESS

A. Install piping, conduit and accessories to permit access to equipment for maintenance. Relocate piping, equipment or accessories to provide access at no additional cost to Owner. The bottom side of all HVAC equipment items such as VAV boxes, reheat coils or inline fans shall be located no more than 18 inches above the ceiling grid where possible due to duct or structural conflicts.
B. Install equipment with sufficient maintenance space for removal, repair or changes to equipment. Provide ready accessibility to equipment without moving other future or installed equipment or system components. Provide a minimum clearance of 2’-6” from any wall adjacent to the mechanical equipment.
C. Provide access doors in walls, chases or above inaccessible ceilings for valves, unions or equipment/devices requiring access for servicing, repairs or maintenance, unless otherwise noted. Access frames and doors shall be as manufactured by Milcor, Incorporated, or similar, of style applicable to surface. Provide access doors used in fire rated construction with UL Label. Provide steel, prime coated access doors unless otherwise specified. Provide stainless

steel doors in ceramic tile walls, toilet rooms, locker rooms and in areas subject to excessive moisture. Provide access doors of sufficient size to allow complete maintenance. Coordinate location of access doors with other installers.

3.06 EQUIPMENT SUPPORTS

A. Provide supporting steel not indicated on Drawings as required for installation of equipment and materials including angles, channels, beams, hangers, etc.
B. All equipment in mechanical rooms shall be placed on 4-inch high housekeeping pads.

3.07 EQUIPMENT GUARDS

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

3.08 SUPPORT PROTECTION

A. In occupied areas, mechanical rooms and areas requiring normal maintenance access, guard certain equipment to protect personnel from injury.
B. Protect lower edges of equipment and mechanical supporting devices that are suspended less than 7 feet above floors, platforms and catwalks. Apply 1/2” thick closed-cell elastomeric (Type A) insulation. Attach insulation with adhesive. Refer to Section 20 0700 (Mechanical Systems Insulation).
C. Protect threaded rod or bolts at supporting elements as described above. Trim threaded rod or bolts such that they do not extend beyond supporting element.

3.09 MECHANICAL SYSTEMS IDENTIFICATION

A. Refer to Section 20 0553 (Mechanical Systems Identification).

3.010 TEST AND BALANCING

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

3.011 START-UP

A. Start, test and adjust systems and equipment. Turn over to Owner ready for operation. This includes "Owner-Furnished, Contractor-Installed" (OFCI) and "Contractor-Furnished, Contractor-Installed" (CFCI) systems and equipment.
B. Follow manufacturer's pre-start-up check-out, start-up, trouble shooting and adjustment procedures.
C. Provide services of a technician/mechanic that is knowledgeable in start-up and check-out of types of systems and equipment on project.
D. Provide start-up services by manufacturer's representative when the Contractor does not have qualified personnel, or where specified.

E. Coordinate start-up with all trades.

3.012 LUBRICATION

A. Upon completion of work and before turning over to Owner, clean and lubricate bearings except sealed and permanently lubricated bearings. Use only lubricant recommended by manufacturer.
B. Lubricate mechanical equipment until Owner accepts the work.

3.013 CLEANING

A. Clean systems after completing installation.
B. Clean piping and ductwork both internally and externally to remove dirt, plaster dust or other foreign materials. When external surfaces of piping are rusted, clean and restore surface to original condition.
C. Clean pipeline strainers and filters to restore them to original condition or replace with them with new elements.
D. Clean equipment and plumbing fixtures as recommended by manufacturers.
E. Replace throwaway or replaceable media air filters used during construction period with new filters or new filter media after construction has been completed and before building is turned over to Owner. Provide replacement filters as specified.
F. Clean dirt, plaster dust and other foreign matter from coils, terminal devices, diffusers, registers and grilles.
G. Thoroughly clean equipment of stains, paint spots, dirt and dust. Remove temporary labels not used for instruction or operation.
H. Provide additional cleaning of individual piping systems and apparatus as hereinafter specified.

END OF SECTION

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SECTION 200513
MOTORS

PART 1 - GENERAL

1.01 DESCRIPTION

A. All motors whether integral with equipment or purchased separately.

1.02 RELATED WORK

A. Section 20 0000 - General Mechanical Requirements
B. Section 26 2913 - Enclosed Controllers
C. Section 20 0514 Variable Frequency Drives (VFD) System

1.03 SUBMITTALS

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

1.04 PRODUCT CRITERIA

A. Motors covered by this Specification shall conform to applicable requirements of NEMA, IEEE, ANSI, and NEC Standards and shall be UL Listed where applicable for service specified.
B. Motors shall be designed for conditions in which they will be required to perform; i.e., general purpose, splash proof, explosion proof, standard duty, high torque or other special type as required by equipment manufacturers.
C. Select motors so they do not exceed nameplate rating nor operate into service factor to meet specified duty.
D. Motors located inside air handling units or exposed located in outdoor or wash down environments shall have totally enclosed fan cooled (TEFC) enclosures.
E. Motors shall be furnished for starting in accordance with utility requirements and be compatible with starters specified hereinafter or under electrical sections of Specifications.
   1. Refer to Section 26 2913 - Enclosed Controllers for reduced voltage starting requirements.
   2. Starters for NEMA rated 460-volt motors, 60 horsepower and above to be reduced voltage starting type.

PART 2 - PRODUCTS

2.01 MATERIALS

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

2.02 MOTORS

A. Voltage Ratings
   1. Refer to equipment schedules and specification sections for voltages required.

2. Unless otherwise indicated, motors 1/3 horsepower and smaller shall be rated 115 volt for operation on 120 volt, single phase, 60 hertz service.
3. Unless otherwise indicated, motors 1/2 horsepower and larger shall be rated:
   a. 460 volt for operation on 480 volt, single phase, 60 hertz service.

B. Motors shall be 4 pole (approximately 1750 rpm) unless otherwise noted.
C. Single-phase motors shall be furnished with built-in thermal overload protection.
D. Use NEMA Design B motors, normal starting torque with regreasable ball bearings, and Class B insulation unless specified otherwise or unless manufacturer of equipment on which motor is being used has more stringent requirements.
   1. Provide motors with bearings rated for minimum AFBMA 9, L-10 life of 26,280 hours (belted) and 100,000 hours (direct-coupled) at full-load.
E. Motors shall be rated continuous duty and have 1.15 service factor unless otherwise noted.
F. Motors Driven by Variable Frequency Drives (VFD)
   1. Motors shall comply with the latest NEMA MG-1, Section IV, Part 31.
   2. Motors shall have service factor not less than 1.0 at rated load.
   3. Insulation shall be Class F or H.
   4. Furnish each motor with shaft grounding ring utilizing conductive microfiber similar to AEGIS SGR to protect motor bearings from electrical damage.
G. Vibration shall not exceed 0.15” per second, unfiltered peak unless otherwise noted.
H. Motors (180 frames and larger) shall have provisions for lifting eyes or lugs capable of safety factor of 5.
I. Full load nominal efficiency of motors 1 horsepower and larger, except special-purpose motors including two-speed or multi-speed motors, and rewound motors, shall meet or exceed listed values when tested in accordance with IEEE Standard 112 Method B as defined by NEMA Standard MG 1-12.6C. Efficiency values listed are based on NEMA Premium Efficiency Electric Motors of NEMA MG 1-2011, Table 12-12.

	Open Drip-Proof Motors			Totally Enclosed Fan-Cooled Motors		
	1200 rpm	1800 rpm	3600 rpm	1200 rpm	1800 rpm	3600 rpm
hp	(6 pole)	(4 pole)	(2 pole)	(6 pole)	(4 pole)	(2 pole)
1 hp	82.5	85.5	77.0	82.5	85.5	77.0
1.5 hp	86.5	86.5	84.0	87.5	86.5	84.0
2 hp	87.5	86.5	85.5	88.5	86.5	85.5
3 hp	88.5	89.5	85.5	89.5	89.5	86.5
5 hp	89.5	89.5	86.5	89.5	89.5	88.5
7.5 hp	90.2	91.0	88.5	91.0	91.7	89.5
10 hp	91.7	91.7	89.5	91.0	91.7	90.2
15 hp	91.7	93.0	90.2	91.7	92.4	91.0
20 hp	92.4	93.0	91.0	91.7	93.0	91.0
25 hp	93.0	93.6	91.7	93.0	93.6	91.7
30 hp	93.6	94.1	91.7	93.0	93.6	91.7
40 hp	94.1	94.1	92.4	94.1	94.1	92.4
50 hp	94.1	94.5	93.0	94.1	94.5	93.0

	Open Drip-Proof Motors			Totally Enclosed Fan-Cooled Motors		
	1200 rpm	1800 rpm	3600 rpm	1200 rpm	1800 rpm	3600 rpm
hp	(6 pole)	(4 pole)	(2 pole)	(6 pole)	(4 pole)	(2 pole)
60 hp	94.5	95.0	93.6	94.5	95.0	93.6
75 hp	94.5	95.0	93.6	94.5	95.4	93.6

J. Single-phase motors for hard starting applications including outdoor applications shall be capacitor start type. Motors for fans and pumps located indoors may be split phase or permanent split-capacitor. Motors shall be equipped with permanently lubricated and sealed ball bearings and shall be selected for quiet operation. Motors 1/8 horsepower and below may be shaded pole type.
   1. Refer to individual equipment section for additional requirements or specific type of motors.

K. Three-phase, two-speed motors shall be one winding, consequent pole, variable torque type and single-phase, two-speed motors shall be capacitor start capacitor run type.

PART 3 - EXECUTION

3.01 INSTALLATION

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

END OF SECTION

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SECTION 200514
VARIABLE FREQUENCY DRIVE (VFD) SYSTEM

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 20 0513 – Motors
B. Section 23 2123 - Pumps
C. Section 23 3400 - Fans
D. Section 23 7400 – Packaged Rooftop Air Handling Units
E. Section 26 2816 - Enclosed Switches and Circuit Breakers
F. Section 26 2913 - Enclosed Controllers

1.02 REFERENCE

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

1.03 SYSTEM DESCRIPTION

A. Provide Variable Frequency Drives (VFD) for each fan or other driven equipment sized to accommodate motors shown on drawings or schedules. All VFD's shall be from same manufacturer.
B. VFD manufacturer shall review driven equipment and motors for VFD compatibility. Submit written statement from manufacturer of driven equipment along with VFD shop drawing submittals, indicating verification of compatibility.
C. Contractor shall verify distance from motors to VFD's. VFD manufacturer shall provide sufficient equipment to assure proper operation and to avoid premature motor failure.
D. VFD manufacturer shall provide filter equipment as necessary to limit voltage transient ring wave stress placed on stator windings to withstand rating value of motors supplied per Section 20 0513 - Motors.
E. VFD shall vary speed of its respective fan or other driven equipment motor in response to control signal from packaged controller.
F. VFD system shall consist of the following:
    1. Variable frequency drive
    2. UL Listed disconnect device
    3. Electrical noise attenuation device as required to meet electrical noise criteria.
    4. Motor starter for bypass mode operation with VFD/OFF/BYPASS selector and drive input and output isolation contactors where VFD bypass starters are specified.
    5. Line reactor
    6. Step-up or step-down isolation transformer as required
G. VFD system shall be furnished by a manufacturer with at least 5 yrs experience in design, construction and application of VFD.

1.04 SUBMITTALS

A. Shop Drawings for each VFD system including, but not limited to, the following:
    1. Manufacturer's name
    2. Identification of system components
    3. Type of enclosure, front elevation and plan view, equipment weight, conduit access locations
    4. Capacities/ratings
    5. Warranty
    6. System wiring and block diagram showing system components
    7. Performance, control and protection data with specified features clearly shown
    8. Operating and monitoring devices with specified features clearly indicated
    9. Start-up operation, maintenance, spare parts, and field tests
    10. Manufacturer's installation instructions

11. Other appropriate data
12. Variations from this Specification

B. After quality control tests are complete, submit written certification that drive and components have passed factory quality control tests.
C. Submit product and performance data on electrical noise attenuation device if required to meet electrical noise criteria specified. Isolation transformer is not electrical noise attenuation device.

1.05 ELECTRICAL NOISE CRITERIA

A. Voltage and current distortion generated by VFD and attenuation devices measured at input of VFD assembly and as installed in place, shall not exceed the following criteria as referenced by IEEE Standard 519.
   1. Total harmonic distortion (THD) shall not exceed 5% RMS of fundamental input voltage at full load with maximum RMS value on any signal harmonic based on IEEE 519-1992 Table 10.3.
   2. Point of Common Coupling: Secondary distribution (480Y) of service transformer.
   3. The service transformer for this application shall not be subjected to harmonic currents in excess of 5% of transformer rated current in accordance with ANSI/IEEE Standard 519-1992, paragraph 10.4.1.

1.06 START-UP OPERATION AND MAINTENANCE DATA

A. Manufacturer shall provide services of factory trained engineer or technician to approve installation; start-up test and adjust for proper operation.
B. Should drive be deficient, drive manufacturer shall be required to make changes necessary to bring units into compliance with specified performance requirements. Cost of changes and retest shall be borne by drive manufacturer.
C. Upon completion of this service, submit a report signed by manufacturer's service representative, including start-up and test log. Report shall document all setpoints and user-adjustable parameters as configured on each drive.
D. Manufacturer shall provide a 3-year parts and labor warranty on all VFDs including those provided with packaged air handling unit systems covering parts, labor and travel expenses.
E. Acceptable VFD manufacturers must have an authorized service provider within a two-hour drive from the project location and be able to respond to a warranty related problem within two hours.
F. All motors intended for VFD use shall be labeled for “inverter duty”.
G. All VFDs shall be provided with a manual bypass starter.
H. All VFDs must be provided from the factory to with the ability to communicate directly with the BAS.
I. Where possible the VFDs are to be located in a conditioned space.

PART 2 - PRODUCTS

2.01 MANUFACTURER

A. Manufacturers: ABB, Eaton, Danfoss, Yaskawa.

2.02 HARMONIC MITIGATION

A. Drives 15 hp and larger shall incorporate one of the following harmonic mitigation features:
   1. Ultra-low harmonic drives: ABB ACS800 Series.
B. Drives smaller than 15 hp: 6-pulse technology with 5% line reactor.

2.03 FABRICATION

A. VFD shall be variable torque, solid state, microprocessor based control, modular design for standard induction AC motor.
B. VFD components shall be factory mounted and wired in NEMA 1 enclosure with lock.
C. VFD components shall be factory mounted and wired in Motor Control Center enclosure.

D. Circuitry shall be plug-in, plug-out modular. Printed circuit boards shall have protective coating to reduce corrosion.
E. Unit shall conform to NEMA and NEC standards and be CSA, UL or ETL Listed. Control circuitry shall be electrically isolated from power circuitry. Entire assembly panel shall have UL or equivalent panel sticker.
F. Invertor section shall be pulse width modulated (PWM) design and most current insulated gate bipolar transistors (IGBTs) technology.

2.04 PERFORMANCE REQUIREMENTS

A. Input: 460 (+ 10%, - 15%) VAC, 3-phase, 60 (± 2) Hz
B. Output: 460 VAC, 3-phase, 10 to 60 Hz
C. Operating Environment Conditions: Ambient 0 to 40°C temperature, relative humidity up to 95% non-condensing.
D. Linear acceleration and deceleration adjustable from 5 to 60 seconds. Provide adjustable v/Hz ratio and low speed boost features.
E. Output Current Rating: Continuous full load output current rating of drive shall not be less than that listed for motor of equivalent horsepower in NEC table 430-150.
F. Drive overload capacity to be minimum 110% of motor FLA based on NEC ratings for one minute.
G. Time to Shutdown: Inversely proportional to square of overload current (t = k/I2).
H. Motor Regeneration Protection: Unit shall have capacity of dissipating regeneration energy without damage to or shutdown of drive. Unit shall be capable of starting into rotating load.
I. Output Frequency Stability: ± 0.5% of base frequency in 24 hrs throughout range of rated operating conditions.
J. Output Voltage Regulation: ± 2% of maximum rated output voltage.
K. Output voltage rise time shall be no faster than 1000 V/micro sec measured at the motor terminals. If power and control cable between VFD and motor is more than 100 ft, provide dv/dt output filter.
L. Power Loss Ride-Through: 3 cycles or 50 milliseconds.
M. Linearity (speed reference to output frequency): ± 1.0%
N. Input Power Factor: Minimum of 0.95 regardless of speed and load.
O. Minimum drive efficiency as percent of input power shall be as follows:

Percent Load	Frequency (Hz)			
	60	50	30	15
100	97	96	95	90

2.05 CONTROL FEATURES

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

2.06 OPERATING AND MONITORING DEVICES

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

1. Door interlock to disconnect VFD input power
2. Manual stop/start device
3. Operating mode selector device marked "Manual-Off-Automatic"
4. Manual speed control potentiometer
5. Power on indication
6. Drive run indication
7. Drive fault indication with testable feature
8. Fault reset device

B. Power circuits shall be protected by, electronic protection circuits. Electronic protection circuits shall provide orderly shutdown without blowing fuses and prevent component loss under the following abnormal conditions.
   1. Instantaneous overcurrent and over voltage trip of output
   2. Solid state protective circuit shall provide NEC motor running overload protection tested in accordance with UL Standard 991
   3. Power line overvoltage or undervoltage
   4. Phase sequence detection or insensitivity to incoming power phase sequence
   5. Single and 3-phase short circuit protection
   6. Control circuit malfunction
   7. Overtemperature
   8. Ground fault for all 3 phases

C. VFD shall protect itself from damage due to phase-to-phase or phase-to-ground faults without fuse blowing or use of isolation transformers. VFD's which require isolation transformers to provide ground fault protection are not acceptable.

D. In addition, provide the following protection features:
   1. Input line-to-line and line-to-ground transient protection up to 3000 V
   2. Control circuit transformer fusing
   3. Grounded control chassis
   4. Diagnostic indication
   5. One set of spare fuses for each type used in drive for each VFD

E. Interlock VFD control circuits with driven motor's disconnect switches where such motor disconnect switches are provided. Disconnecting on-line motor shall shut down VFD. VFD shall restart upon reconnection of motor.

F. VFD shall employ adjustable torque limit control, which shall override speed command and decrease frequency while maintaining correct volts/hertz ratio whenever load level surpasses VFD design level or set point.

G. Speed indicating meter or digital indication (0 - 100%) calibrated in percent speed or frequency meter with 0 to 90 Hz scale to indicate motor speed.

H. Integral digital programming and operating display which shows Hz, Percent Output Current, Output Voltage, Percent Output Power, Operating Parameters and their values, and Diagnostic Fault Codes. In addition, Keypads shall be incorporated to facilitate digital programming of drive adjustments. Analog potentiometer adjustments are not acceptable.

I. Provision shall be included to provide selectable programming security by inhibiting program parameter changes with internal dip switch setting or with password security.

J. Control shall incorporate microprocessors for operator interface, diagnostics, and fault managements, and power management.

K. Optional DOS-based programming software, which includes provision for serial communication with drive, shall be available for shipment at time of equipment order placement.

L. Fault buffers to sequentially store last 4 faults. Parameter and fault information to be stored in non-volatile memory.

M. VFD with Bypass Device (Manual Bypass Starter):

1. Manual selector switch to select power through VFD or bypass line with label marked "VFD/OFF/BYPASS".
2. Mechanically- and electrically-interlocked VFD/BYPASS contactors with padlocking capability on input side of VFD and bypass device. Interlock shall be accomplished such that shorting together of any 2 control circuit points can not cause non-selected device to be energized. Provide mechanically-and electrically-interlocked device that connects only output of selected starting device (primary VFD or bypass device) to VFD system output lug. Single shorting of any 2 control circuit points shall not cause both VFD and bypass device outputs to be interconnected.

2.07 QUALITY CONTROL TESTS

A. For all VFDs, the complete drive assembly shall be factory tested with actual AC induction motors, 100% load and temperature cycled within environment chamber at 40°C (104°F). Documentation of tests shall be furnished to verify successful completion of test at Engineer's request.

2.08 DISCONNECT DEVICE

A. Provide integral switch to disconnect incoming electrical power to units. Disconnect device shall be UL Listed device of the following:
   1. Motor circuit switch: horsepower rated
   2. Enclosed molded case breaker; ampere rated and providing over current protection
   3. Molded case switch; ampere rated enclosed switch with or without over current protection
   4. Rotary switch: with or without fuser
B. Unit shall have an interrupting rating not less than that of the upstream overcurrent device as shown on electrical drawings.
C. Disconnect shall be capable of being padlocked in OFF position and complying with OSHA Requirements. Operating handle shall indicate whether switch is “ON” or “OFF”.
D. Switch shall have dual cover interlock to prevent unauthorized opening of switch door when handle is in “ON” position and to prevent closing of switch mechanism with door open. Provide defeater mechanism to defeat the interlock for user required access.

2.09 MOTOR CONTROL EQUIPMENT (BYPASS STARTERS)

A. Bypass starter shall be NEMA or IEC Rated device of the following:
   1. Electromechanical across-the-line starter with solid state overload protection.

2.010 LINE REACTORS

A. Series line reactors shall be designed for harmonic filtering service and shall be UL component recognized. Construction shall be copper wire wound on steel cores. Inductors shall be 3-phase. Series line reactors shall be sized at 5% impedance and appropriately for total connected load. Design maximum temperature rise for inductors shall be 115°C.
B. Core shall be made of laminated grain oriented electrical steel (grade M6 or better). Brackets shall be ASTM structural steel or structural aluminum. Coils shall be wedged in place and core locked in place using vertical ties or rods.
C. Windings shall be copper wire, MW35C (round) or MW36C (rectangular) or copper foil. Terminations shall be tin plated copper alloy ring lugs, UL recognized terminal blocks, or solid copper bus. Terminations shall be pressure crimped or TIG welded to windings. Sheet insulation shall be DuPont Nomex 410 of thickness meeting UL insulation systems.
D. Inductors shall be double impregnated (vacuum/pressure impregnate and bake followed by varnish dip and bake). Insulation systems shall be rated Class H (180°C), 600 V. Inductors shall be Hi-Pot tested (2500 V, 60 Hz, 1 minute) line-to-line and line-to-ground.
E. Inductors shall be air-gapped to avoid saturation. Inductance shall be measured under full load and shall be within ± 5% of design value.
F. Line reactor shall be included integral to drive enclosure.

1. Where mounting line reactor in VFD enclosure is not possible, enclosure shall be steel with enamel finish and no knockouts. Enclosure shall match construction of VFD enclosure and shall have hinged lockable cover. Screened openings shall be provided for enclosure ventilation. Enclosure shall be built with integral mounting brackets for platform or wall mounting. Coordinate location with other trades.

2.011 SPARE PARTS

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

PART 3 - EXECUTION

3.01 INSPECTION

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

3.02 PROTECTION

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

3.03 INSTALLATION

A. Install VFD system in accordance with details, approved Shop Drawings and manufacturer's instructions and recommendations.
B. Provide field low voltage wiring of VFD system components. Provide field interconnecting wiring between VFD and by-pass starter if bypass starter is specified and the wiring is not installed at factory. Install wiring in metal conduit and in accordance with Electrical sections of this Specification and applicable Electrical Code.
C. Provide control wiring between interlocks in VFD control circuits and driven motor's disconnect switches, where such motor disconnect switches are provided.
D. Do not connect ground from one unit to another unit's cabinet.
E. Use separate conduits for incoming and outgoing power conductors from each unit.
F. Use separate conduit for control wiring for each unit. Control wiring shall not occupy same conduit as power wiring.
G. Use minimum 18 ga shielded wiring with ground for control wiring.
H. Install floor mounted drives on 3-1/2" (85mm) high concrete housekeeping pad.

3.04 START UP

A. Perform start-up of VFD in accordance with procedures as defined by manufacturer for proper operation.
B. Adjust critical frequency avoidance feature to step over frequencies which cause excessive vibration in driven equipment.

3.05 FIELD QUALITY CONTROL

A. WARRANTY: The warranty period shall begin at Substantial Completion for a minimum of 3 years.

END OF SECTION

SECTION 200520
EXCAVATION AND BACKFILL

PART 1 - GENERAL

1.01 DESCRIPTION

A. This Section lists methods and materials for trench excavation and backfill for underground mechanical, plumbing and fire protection piping systems inside and outside the building.

1.02 RELATED WORK

A. Section 20 0000 - General Mechanical Requirements

1.03 SUBMITTALS

A. List of materials to be used for backfill.

PART 2 - PRODUCTS

2.01 MATERIAL COMPATIBLITY

A. Corrosive Fill Materials: Do not use of backfill or bedding materials that may become corrosive to pipe or piping components, with or without the presence of moisture. These materials include but are not limited to controlled density backfill products as well as backfill materials containing fly ash, cinders, or other corrosive materials.

2.02 FILL MATERIAL

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

PART 3 - EXECUTION

3.01 PREPARATION

A. Establish grade lines and locations of piping and manholes. Provide necessary stakes and batter boards.
B. Verify invert elevations of existing utilities prior to excavation for new utility piping.
C. Locate existing underground utilities and mark their locations at least 48 hours, but not more than 10 business days prior to excavation.
D. Review soil test reports and existing site conditions prior to bid. Take all necessary precautions to maintain safety and proper work procedures.

3.02 EXCAVATION

A. Provide excavation for all underground work, including piping, manholes, catch basins, tanks, concrete structures, etc., unless otherwise shown or specified. Lay piping in open trench except when Architect gives written permission for tunneling.
B. Include all necessary clearing; tree removal; grubbing; pavement removal; substructure removal such as walls, footings and piers and all incidental work such as tunneling, sheet piling, shoring, underpinning, pumping, bailing and transportation. Coordinate excavation extending beyond construction limits with Owner.
C. Notify the Architect about existing unstable soils before commencing excavation.

D. Saw cut existing on-grade concrete floor slabs, where required.
E. Trench excavations shall be a minimum of 16” wide, true to line and grade. Provide shoring as required and maintain proper safety procedures. Remove stones larger than 3/4" to a minimum 4” below the trench bottom. Maintain trenches free of excess moisture, jobsite debris, and corrosive media.
F. Do not over-excavate trench bottoms except where required due to existing soil conditions or specific material installation requirements.
G. Keep trenches open only as necessary for installation, testing, inspection, and Architect’s field observations.
H. Do not excavate parallel to and deeper than building footing bottoms, unless the trench bottom is above a 45 degree angle of repose from the footing.
I. Do not blast rock without written permission of Architect and Owner.
J. Remove all excess excavation material from site unless directed otherwise.
K. Use mechanical methods to remove rock in trenches for piping systems.
L. Include rock excavation in the Bid unless otherwise indicated.

3.03 PIPE INSTALLATION

A. Keep underground piping to proper line and grade and sealed at all times to prevent entrance of animals or foreign matter.
B. Provide bracing and sheet piling as necessary to support trenches. Comply with Local Regulations, applicable provisions of OSHA Regulations on trenching, or with provisions of “Manual of Accident Prevention in Construction” published by Associated General Contractors of America.
C. Under no circumstances lay pipe or install appurtenances in water. Keep trench free from water until pipe joint material has hardened.
D. Presence of ground water in soil or necessity of sheet piling or bracing trenches shall not constitute condition for which any increase may be made in Contract price, except when sheet piling is left in place on written order of Owner, Contract price will be adjusted.
E. Cut off sheet piling left in place not less than 2” below new finished grade. Do not remove sheet piling until trench is substantially backfilled.
F. Place underground piping outside and inside building in open excavated trenches. Where trench bottom does not contain stones larger than 1” in size or where bedrock is not encountered, trench may be excavated to final pipe grade. Where bedrock or stones larger than 1” is encountered, excavate entire length of trench to depth 4” below final pipe grade elevation and provide 4” of pipe bedding material compacted to minimum of 90% Standard Proctor Density consisting of Type 2B, Type 3 or Type 5 fill to establish final pipe grade. Shape bedding for clearance for all joints and fittings, tamped in place and graded evenly to insure uniform bearing for full length of pipe. Do not support piping by blocking, planking or mounding of bedding material.

3.04 BACKFILL

A. Exterior:
    1. Do not backfill outside building or beyond construction limits only after piping and appurtenances have been inspected, recorded, tested and approved.
    2. Backfill by hand around pipe in 6” layers to depth of 12” above top of pipe with Type 2B, Type 3 or Type 5 fill. Do not to disturb pipe or damage pipe coating. Do not use Type 3 fill where it will come in contact with polyethylene encasement. Compact backfill thoroughly with compactor of suitable weight or with approved mechanical tamper. Do not use water flooding or jetting.
    3. Place remaining backfill in 8” layers with Type 1 fill. Compact backfill until it matches the density of surrounding soils.
    4. Backfill under walks, roads, driveways or parking areas from 12” above pipe to subgrade with Type 2A, Type 2B, Type 3 or Type 4 fill. Backfill in 12” layers and compact with

mechanical means to density 95% modified proctor. Test compaction testing shall be determined by testing consultant, based on site conditions, materials and workmanship.

5. When excavation occurs on public property or areas beyond property line, all excavation, pipe laying, backfilling, grading and surfacing shall conform as herein specified, except additional requirements for public utility or other authorities shall be complied with when in order. Check with each utility and incorporate cost of any additional requirements in Base Bid.

B. Interior:
   1. Backfill inside building only after piping and appurtenances have been inspected and approved. Backfill to 12” above pipe with Type 2B, 3 or 5 fill in 6” layers. Remainder of backfill shall be Type 2A, Type 2B, Type 3, Type 4, or Type 6 fill in 12” layers.
   2. Install lines passing under foundations with minimum of 1-1/2” clearance to concrete and insure there is no disturbance of bearing soil.

3.05 ROCK EXCAVATION

A. Consider material over one cubic yard in size encountered during excavation as rock. Rock excavation will be paid as extra if it cannot be removed by 200 net horsepower crawler tractor with ripper attachment all in good running condition and operated by an experienced individual.
B. Excavate rock to 4” below intended pipe invert.

3.06 FINISHING

A. On completion of trenching and backfilling operations, restore grades to original elevation or to new subgrade elevation.
B. When trenching is through existing areas or beyond constructions limits, replace surfaces to existing conditions.
C. When trenching through existing landscaped areas backfill to a subgrade elevation 6” below original surface elevation. Provide 6” of topsoil. Provide landscaping to match existing landscaping or as otherwise approved by the Architect.
D. Patch existing concrete floor slabs to match existing finishes.

END OF SECTION

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SECTION 200529
MECHANICAL SUPPORTING DEVICES

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 20 0000 - General Mechanical Requirements
B. Section 20 0700 - Mechanical Systems Insulation
C. Section 23 0550 - Vibration Isolation (Spring Hangers and Mounts)
D. Section 23 2116 – Pipe and Pipe Fittings
E. Section 23 3114 - Ductwork (for additional duct supports requirements)

1.02 REFERENCE

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

1.03 DESCRIPTION

A. Provide all supporting devices as specified and as required for proper support of piping, ductwork, equipment, materials and systems.
B. Support for all conditions of operation, including variations in installed and operating weight of equipment, piping and ductwork, to prevent excess stress and allow for proper expansion and contraction.
C. Support of fire protection pipe shall comply with this Section and NFPA 13, Installation of Sprinkler Systems, 2007 Edition.

1.04 SUBMITTALS

A. Shop Drawings for each piping system for all pipe sizes and all applicable equipment including, but not limited to, the following:
   1. Manufacturer's name
   2. Model numbers
   3. Materials of construction and load ratings lbs
   4. Schedule of hangers and support devices with pipe support spacing
   5. Insulated pipe supports along with application chart or table
   6. Insulation protection saddles and weight bearing insulation table
   7. Details and calculations for sizing supplementary steel utilized for trapeze or specially designed supports
   8. Structural attachments, inserts and concrete anchors
   9. Calculations and drawings for concrete anchors for each application
   10. Drawings showing specific locations of any weld attachments to structure, including weight supported by such attachments
   11. Equipment mounting devices
   12. Pipe guides and anchors
   13. All other appropriate data

1.05 DESIGN CRITERIA

A. Materials and application of pipe hangers and supports shall conform to latest requirements of ANSI/ASME Code for Pressure Piping B31.1 and MSS Standard Practice SP-58 (Materials, design and Manufacture), SP-69 (Selection and Application), and SP-89 (Fabrication and Installation Practices), except as supplemented or modified herein.
B. Support materials shall be steel or stainless steel unless specifically indicated.
C. Support devices shall be factory fabricated by manufacturers and have published load ratings.
D. Unless otherwise indicated, design structural support members and support devices, including couplings, rods, trapeze supports and strut systems, with safety factor in accordance with AISC Manual of Steel Construction, but not less than 2.0.
E. Determine maximum deflection using the following equation.

$$D = \frac{H \text{ or } L}{250}$$

Where D = Max deflection in inches
H = Member height in inches
L = Member length in inches

F. Unless otherwise indicated, hangers, support devices and hardware shall be steel and shall have factory standard black, primed, galvanized or electroplated finish for indoor application
G. Material in contact with pipe shall be compatible with piping material so that neither shall have deteriorating action on the other. If materials such as copper, stainless steel or other materials are not compatible, provide nonmetallic separation between uninsulated piping and metal supports. Plastic coated steel supports are acceptable.
H. Unless otherwise indicated, steel support devices exposed to ventilation air stream shall be stainless steel or steel with either galvanized finish or paint finish. Paint type shall be approved by Architect/Engineer.
I. This Contractor is responsible for proper placement and sizing of supporting devices to accommodate insulation thickness and pitching of pipe. Coordinate with Contractor performing work specified in Section 20 0700 - Mechanical Systems Insulation.
J. Piping connected to coils, which are in assembly mounted on vibration isolators, shall have vibration supports as indicated above.
K. Where piping can be conveniently grouped to allow trapeze type supports, supporting steel shall be by means of standard structural shapes.
L. Hangers and rods shall be plumb when pipelines are at their normal operating temperatures.
M. Unless otherwise indicated, continuous insert channels are not allowed.
N. Punching, drilling, or welding of building structural steel is not allowed unless approved by Structural Engineer.
O. Application of concrete inserts and concrete anchors shall be reviewed and approved by Structural Engineer prior to installation.
P. Any proposed weld attachments to building structure shall be reviewed by Structural Engineer prior to execution of work. This review may result in use of other welding codes or standards, which may apply to "structural work". Execution of this work may be assigned to General Trades responsible for building structural steel. Cost for this work, however, will remain the responsibility of this Contractor.

PART 2 - PRODUCTS

2.01 STRUCTURAL SUPPORTS

A. Provide all supporting steel, not indicated on structural drawings, that is required for installation of mechanical equipment and materials, including angles, channels, beams, etc. to suspend or floor support equipment.

2.02 PIPE HANGERS AND SUPPORTS (METALLIC)

A. Manufacturers: Anvil (formerly Grinnell), Erico, Tolco, National Pipe Hanger Corporation, or B-Line, equal to Anvil figures listed. Corresponding MSS Type is indicated where applicable.
B. Hangers/supports for copper pipe where supports directly contact to pipe shall be either copper plated or PVC coated.
C. For insulated pipe supports, refer to Insulated Pipe Supports in Part 3 of this Section.
D. Clevis and Roller Type Hangers:

System	Pipe Size	Clevis	Roller

Hot Pipes with Insulation (120°F and above)	2” and smaller	65 (MSS Type-1), 260 (MSS Type-1)	---
	2-1/2” to 6”	---	171 (MSS Type-41), 181 (MSS Type-43)
	8” and larger	---	171 (MSS Type-41)
Ambient Bare Pipes (60°F to 119°F)	2” and smaller	65 (MSS Type-1), 260 (MSS Type-1)	---
	2-1/2” and larger	260 (MSS Type-1), 216 (MSS Type-4)	---

1. For pipe size 2-1/2” and larger, where there is transverse movement at support points due to thermal expansion/contraction, clevis type hangers similar to Anvil Figure 260 (MSS Type-1) may be used if vertical angle of hanger rod is less than 4°.

E. Adjustable Swivel Band Hangers: Anvil Figure 96
   1. Do not use for pressure piping larger than 2” diameter.
   2. Do not use for drainage piping larger than 4” diameter.

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

System	Pipe Size	Straps or Clamps	Rollers	Slides
Hot Pipes with Insulation (120°F and above)	2” and smaller	243, 244	---	---
	2-1/2” and larger	---	177, 271 (MSS Type-45), 274 (MSS Type-46)	257 or 436 with 212 or 432 clamps, Type 1, 2 or 3 for longitudinal movement only and Type 4, 5 or 6 for both longitudinal and transverse movement of piping.
Ambient Bare Steel Pipes (60°F to 119°F)	(6” and smaller	B-Line BVT	---	---
	8” and larger	137 (MSS Type-24)		
Ambient Bare (Copper) pipes (60°F to 119°F)	all sizes	B-Line BVT		

2.03 INSULATION PROTECTION SHIELDS

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

Pipe Size	Length	Gauge
1/4” thru 3”	12”	18
4”	12”	16

2.04 WEIGHT BEARING INSULATION INSERTS

A. Insert thickness shall match pipe insulation thickness. Pipe insulation jackets shall be continuous through sections containing inserts.
B. Minimum length of inserts shall be 12”, or 2” longer than insulation protection shields, whichever is longer. Quantity and placement of inserts shall be based on weight of pipe and fluid plus 1.5 safety factor.
C. Hot Pipes (120°F and above):
   1. Type H or Type G insulation. Maximum compression strength for load calculation shall be 90 psi.

2.05 PRE-INSULATED PIPE SUPPORTS

A. Pipe Shields, Inc., Bergen Pre-Insulated Pipe Supports, Rilco, or Tri-State Industries equal to Pipe Shields models listed
B. Insulation shall consist of water-resistant calcium silicate of same thickness as adjoining pipe insulation, thermal conductivity not more than 0.38 Btu·in/(hr·ft^{2}·°F at 75°F mean temperature, minimum density of 13 lb/ft^{3}, and compressive strength not less than 100 psi.
C. Structural inserts shall be water-resistant, high-density calcium silicate with minimum density of 32 lb/ft^{3} and minimum compressive strength of 600 psi. Structural inserts shall be used as recommended by manufacturer to meet load ratings.
D. Use vapor barrier steel jacket around insulation. Insulation jackets shall be galvanized steel conforming to ASTM A-527. Hanger bearing surface shall consist of galvanized sheet metal insulation protection shield or casing.
E. When recommended by manufacturer, use double layer insulation protection shield at support bearing surface. Insulation shall extend 1” beyond insulation protection shield to maintain vapor barrier integrity.
F. Pre-insulated pipe supports shall be load rated. Load ratings shall be established by pipe support manufacturer based upon testing and analysis in conformance with the latest edition of the following codes and standards: ASME B31.1, MSS SP-58, MSS SP-69, and MSS SP-89.
G. Load tests shall be made on both supporting materials and configurations. All tests shall be performed by independent testing laboratory. Results of pertinent tests shall be available upon request.
H. Unless otherwise indicated, pre-insulated pipe supports shall be as indicated in the following schedule. Model numbers are based on Shaw Pipe Shields, Inc.
   1. Pipe supported on hangers: Models A2000, A4000, A9000, D3000 and D3200
   2. Pipe supported on flat surfaces: Models A2000, A4000, A6000, A7000, A7200, and A7400
   3. Pipe supported on pipe rolls: Models A4000, A6000, A8000, A8200, and A8400
   4. Pipe supported on slides: Model "B" Series
   5. A1000, A3000 or A5000 may be used for hot pipes (120°F and above)
I. Select proper model to conform to pipe service, support style, and support spacing.
J. Submit chart or table indicating selected model along with pipe sizes, rated loads, support device types and support spacing for each piping system.
K. Pipe support spacing shall be in accordance with manufacturer's recommendations, but in no case shall exceed maximum spacing indicated under Hanger and Support Spacing in Part 3 of this Section.

2.06 HANGER RODS (METALLIC)

A. Rods shall conform to the latest MSS Standards except as modified herein. Furnish rods complete with adjusting and lock nuts.
B. Rods shall have electroplated zinc or hot dip galvanized finish.

C. Unless otherwise indicated, size rods for individual hangers and trapeze support as indicated in the following schedule. Rod size may be reduced one size for double rod hangers. Total weight of equipment, including valves, fittings, pipe, pipe content and insulation, shall not exceed limits indicated.

Max. Pipe Size With Single Rod	Rod Diameter (millimeters(inches))	Max Load (lbs) of Hanger Rod (Not exceeding (650°F) Service Temp.)
2”	3/8	730
3”	1/2	1350
5”	5/8	2160

2.07 BOLTS, NUTS, STUDS AND WASHERS

A. ASTM A307, electroplated zinc finish

2.08 ROD ATTACHMENTS

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

2.09 U-BOLTS

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

2.010 RISER CLAMPS

A. Anvil Fig. 261 (MSS Type-8), galvanized finish
B. Anvil Fig. CT-121, copper plated carbon steel, plastic coated in area at pipe contact, for bare copper tubing
C. Proset system, proseal plug and fire-fill for sleeved and cored holes.

2.011 CONCRETE ANCHORS

A. Manufacturers: Hilti, Powers Fasteners or Red Head
B. Anchors shall be designed and detailed by Contractor’s structural engineer registered in project’s jurisdiction. Calculations and drawings shall be submitted.
C. Anchors shall meet ICC Acceptance criteria, and ICC-ESR reports shall specifically list the current applicable codes.
D. Anchors installed in hardened concrete for purpose of transmitting structural loads from one connected element to another, or for safety related elements such as sprinkler pipes, heavy suspended pipes, and barrier rails shall have ICC-ESR report demonstrating anchors have met requirements of AC 193 for mechanical anchors.
E. Post-installed expansion anchors and undercut anchors installed in hardened concrete shall be qualified for strength design and tested according to ACI 355.2. Designs shall be per the requirements of ACI 318, Appendix D.
F. Anchors shall be zinc plated in accordance with ASTM B633.
G. Select anchors with load ratings based on cracked concrete conditions.

2.012 METAL FRAMING SUPPORT SYSTEM (STRUT SYSTEM)

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

2.013 CASEWORK PIPE SUPPORTS

A. Hinged pipe clamp and Strutcatcher, nylon 12 Grilamid, Clic by Litchfield International.
B. Vibration isolation pipe clamp, yellow zinc chromate finish, B-Line BVT Series Vibraclamp or Kwik-Clip by B-Line.

2.014 FIXTURE SUPPLY SUPPORT

A. Galvanized steel stud support bracket, pre-drilled tube support mounting holes, adjustable stud width, Erico TSGB or equal.
B. UV resistant nylon tube support, rated for 0°F through 130°F, resealable locking mechanism, Erico TPC or equal.
C. Support bracket and tube support to be from same manufacturer.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install supports to allow for free expansion of piping. Support piping from building structural members using concrete inserts, beam clamps, ceiling plates, wall brackets, or floor stands. At no time shall hangers and supports overload building structural members. Fasten ceiling plates and wall brackets securely to structure and test to demonstrate adequacy of fastening.
B. Select and size building attachments properly in accordance with MSS Standards and manufacturer's published load rating information.
C. Coordinate hanger and support installation to properly group piping of all trades.
D. Suspend hangers by means of hanger rods. Perforated band iron and flat wire (strap iron) are not allowed.
E. Piping and ductwork shall be supported independently from other piping or ductwork.
F. Pipe hangers and supports shall not penetrate vapor barrier of pipe insulation.
G. Do not support equipment, piping or ductwork from metal roof decking or ceiling grid.
H. Install adequate supports so as not to over stress either piping or equipment to which piping is connected.
I. Refer to Section 20 0000 - General Mechanical Requirements for requirements of personnel injury protection guards for supporting devices.

3.02 HANGER AND SUPPORT SPACING - HORIZONTAL PIPE

A. Space pipe hangers and supports for horizontal pipe accordance with the following schedule, with exceptions as indicated herein:
B. Steel Pipe (Standard Weight and Extra Strong) (Unless Otherwise Noted):

Pipe Size	Max Spacing
1-1/4” and smaller	7’-0”
1-1/2”	9’-0”
2”	10’-0”
2-1/2”	11’-0”
3”	12’-0”
4”	4.2 m(14’-0”

C. `Steel Pipe (Fire Protection Sprinkler): Support piping in accordance with NFPA 13.
D. Copper Tube (Unless Otherwise Noted):

Pipe Size	Max Spacing
19 mm(3/4” and smaller	1.5 m(5’-0”)
1” to 1-1/4”	6’-0”
1-1/2” to 2-1/2”	8’-0”
3” and larger	10’-0”

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

Pipe Size	Max Spacing
1-1/4” and smaller	6’-0”

1-1/2” and larger	10’-0”

F. Plastic Pipe
   1. PVC Pipe:

Pipe Size	Max Spacing
All sizes	4’-0”

   2. Support plastic pipe at all changes of direction. Adequate consideration shall be given to piping expansion.

G. Cast Iron Pipe:
   1. Maximum hanger and support spacing shall be 10 ft for all pipe sizes. Provide minimum of one hanger per pipe section close to joint on barrel, at each pipe fitting, at change of direction and branch connections.
   2. Support Cast Iron No-Hub pipe as recommended in CISPI Publication "Cast Iron Soil Pipe and Fittings Handbook, Chapter IV - Installation of Cast Iron Soil Pipe and Fittings."

H. Maximum spacing shown above may be restricted by strength of attachment to building structure. Submit data with calculations with published load ratings showing attachment to be utilized and maximum spacing allowable for that type of attachment and pipe size.

I. Spacing less than indicated above may be required to conform to building structure design or loading limitations.

J. If pipe size changes between support points, maximum spacing shall be based on the smaller pipe size.

K. If trapeze hangers are used to support multiple services, spacing shall be based on the most restrictive pipe size and material on trapeze hanger.

L. For non-metallic pipe, follow manufacturer's installation recommendations in addition to requirements noted herein.

M. Install supports for vertical piping and anchors as recommended by pipe manufacturer.

N. Place hangers and supports to meet requirements of Section 23 2116 - Pipe and Pipe Fittings or specific pipe system sections, with regard to pitch for drainage and venting and clearance between services.

O. Hangers and supports shall bear on outside of insulation when pipes are to be insulated.

P. Place hangers and supports within 1 ft of each fitting, such as elbows and tees, and at each valve, strainer, and other piping specialty for piping 4” and larger.

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

3.03 RISER SUPPORTS

A. Insulated Piping and non-insulated piping (120°F and above):
   1. Unless otherwise indicated, support vertical piping as indicated below:
   2. Support vertical piping at bottom of riser, secured and anchored to building structure. Provide guides on vertical piping. Use spring hangers at top of riser and at take offs from riser at each floor. Use spring hangers for minimum 3 hangers away from top and bottom elbows and from each take off at riser.
   3. Guide vertical piping 2” and smaller at every floor. Guide 2-1/2” and larger at every other floor. Spring hangers (Type 6) and guides (Type VSG) are specified in Section 23 0550 - Vibration Isolation.

B. Ambient Bare Piping:
   1. Unless otherwise indicated, maximum vertical support spacing for ambient bare steel and cast iron pipes shall be 15 ft.
   2. Maximum vertical support spacing for other piping including copper tubing and plastic piping shall be 10 ft.

3. Install riser clamps and intermediate supports as required.
4. Rest riser clamps on floor or on pipe sleeve.

3.04 INSULATION PROTECTION SHIELDS

A. Install insulation protection shields at support points as specified under Insulated Pipe Supports.
   1. Use one shield (bottom) for clevis hanger.
   2. Use 2 shields (top and bottom) for roller hanger/support or strap/clamp support. Apply 2 metal straps to hold top and bottom shields onto insulation jacket.

3.05 INSULATED PIPE SUPPORTS

A. Install insulated pipe support at each support point of insulated pipe. Provide insulation protection shields except where saddles are used.
B. Pipe Size 1-1/2” and Smaller:
   1. Use insulation protection shields. Pipe insulation specified in Section 20 0700 - Mechanical Systems Insulation shall be continuous through support points.
C. Pipe Size 2” and Larger:
   1. Use pre-insulated pipe supports. Refer to Part 2 for acceptable products.
   2. In lieu of pre-insulated pipe supports, field-assembled insulated pipe supports may be used. If used, submit application details including materials, thickness, compression strength, load bearing surfaces, load calculations of support assembly and total pipe weight based on support spacing.
   3. Field-assembled insulated pipe supports shall consist of weight bearing insulation inserts and insulation protection shields.
   4. Insulation protection saddles may be used in lieu of assembled insulated pipe supports on roller hangers/supports for hot water pipes, low pressure steam and steam condensate pipes.

3.06 TRAPEZE SUPPORTS

A. Construct trapeze supports with struts, angles, or channels and hang them by inserts or welded beam attachments and rods.
B. Determine trapeze supports spacing by the smallest pipe on trapeze.

3.07 CONCRETE ANCHORS

A. Anchor application, size, and placement shall be reviewed and approved by Structural Engineer prior to installation.

END OF SECTION

SECTION 200553
MECHANICAL SYSTEMS IDENTIFICATION

PART 1 - GENERAL

1.01 REFERENCE

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

1.02 SUBMITTALS

A. Product Data: For identification materials and devices
B. Valve Schedules: For each piping system

PART 2 - PRODUCTS

2.01 IDENTIFYING DEVICES

A. Painted Identification System:
   1. Stencils:
      a. Standard fiberboard stencils, prepared for required applications.
      b. Letter sizes complying with ANSI A13.1 for piping and similar applications
      c. Not less than 1-1/4” high letters for ductwork.
      d. Not less than 3/4” high letters for access door signs and similar operational instructions.
   2. Stencil Paint:
      a. Standard exterior type stenciling paint, oil-based, alkyd enamel.
      b. Black color, except as otherwise indicated.
      c. Either brushing grade or pressurized spray-can form and grade.
   3. Identification Paint:
      a. Standard identification enamel.

B. Marker System:
   1. Manufacturers: Brady USA, Marking Services Inc. (MSI), Kolbi, or Seton
   2. Manufacturer's standard, preprinted with color coding, lettering size and length of color field according to ASME A13.1.
   3. Use pressure-sensitive type or "snap-on" type.
   4. "Strap-on" type may be used for piping over 6” size including insulation.
   5. Arrows: Each pipe marker shall have arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as separate unit of plastic.
   6. Dimensions:
      a. 1-1/2” wide tape markers on pipes with outside diameters (including insulation, if any) of less than 6 inch.
      b. 2-1/2” wide tape markers for on pipes with outside diameters (including insulation, if any) of 6 inch or greater.

C. Valve Tags:
   1. Minimum 1-1/2” diameter, 0.032” thick, polished brass or 316 stainless steel.
   2. Stamp-engraved piping system abbreviation in 1/4” high letters and sequenced valve numbers 1/2” high.
   3. Provide a printed and framed valve tag schedule that is to be installed in the main mechanical room.

D. Laminated Plastic Nameplates:
   1. Engraving stock melamine plastic laminate, in the sizes and thickness indicated, engraved with engravers standard letter style of the sizes and wording indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate.
   2. Nameplates shall be approximately 1-1/2" x 4", 1/16” thick, and have 1/2” high lettering. Face of plastic nameplates shall be black with white letters.

3. Fasteners shall be self-tapping, stainless steel screws or contact type with permanent adhesive.

PART 3 - EXECUTION

3.01 GENERAL

A. After painting of all exposed mechanical pipe systems and/or covering is completed, identify equipment and piping as indicated. Locate identification as conspicuously as possible except where such would distract from finished area.
B. Where markers are used in high heat applications or exposed to harsh chemical or acid environments, specifically select marker materials for those applications.
C. Identification shall be installed prior to installation of acoustical ceilings and similar removable concealment.

3.02 DUCTWORK IDENTIFICATION

A. Identify air supply, return, exhaust, intake, and relief ductwork with stenciled signs and arrows.
B. Show ductwork service and direction of flow in black and white, and indicate what unit the ductwork either comes from or goes to.
C. Locations:
   1. Provide identification in each space where ductwork is exposed, or concealed only by removable ceiling system.
   2. Provide identification near points where ductwork originates or continues into concealed enclosures.
   3. Provide identification at 50 foot intervals along exposed runs.
D. Duct Access Doors: Stenciled signs on each access door in ductwork and housings, indicating purpose of access (to what equipment item).

3.03 PIPING SYSTEM IDENTIFICATION

A. Install pipe identification on each system. Place flow directional arrows at each pipe identification location.
B. Locate pipe identification as follows:
   1. On piping exposed to view in occupied spaces, machine rooms, accessible maintenance spaces and exterior non-concealed locations.
   2. Near each valve and control device.
   3. At each branch, excluding short take-offs for fixtures and terminal units.
   4. Near locations where exposed pipes pass through walls, floors, ceilings, or enter non-accessible enclosures.
   5. At access doors or panels, manholes and similar access points which permit view of concealed piping.
   6. Near major equipment items and other points of piping origination and termination.
   7. On piping above removable acoustical ceilings.
   8. Not less than once in each room.
   9. Not less than once every 25 feet.
C. Identify piping with marker system.
   1. For "strap-on" type, ensure marker is fitted snugly to pipe or pipe insulation surface with sufficient straps.

3.04 VALVE IDENTIFICATION

A. Identify valves with brass tags bearing system identification and valve sequence number in 1/2” black characters. Attach tag to valve body with brass jack chain and "S" hook for brass tag and SS jack chain or SS braided wires with swag sleeves and "S" hook for stainless steel tag. Non-metallic fasteners are not allowed.
B. Valve numbers shall be prefixed with corresponding piping system identification in 1/4” black letters.

C. Valve tags are not required at terminal devices unless valves are greater than 10 ft from device or located in another room not visible from terminal unit.
D. Furnish typewritten valve schedule indicating valve number, fixtures, equipment or areas served by each numbered valve and incorporate in O&M Manuals.

3.05 EQUIPMENT IDENTIFICATION

A. Identify major equipment, including fan coil units, fans, air terminal devices, pumps, water heaters, tanks, compressors, etc.
B. Identify equipment with laminated plastic nameplates.
C. Identify control equipment and panels with laminated plastic nameplates.
D. Indicate the area that equipment serves by zone(s) or room number(s).
E. Identify the following general categories of equipment and operational devices:
    1. Main control and operating valves, including safety devices.
    2. Meters, gauges, thermometers and similar units.
    3. Fuel-burning units including boilers, furnaces, and heaters.
    4. Pumps, compressors, chillers, condensers and similar motor-driven units.
    5. Heat exchangers, coils, evaporators, cooling towers, heat recovery units and similar equipment.
    6. Exhaust fans, fans, blowers, primary balancing dampers and VAV boxes.
    7. HVAC central-station and zone-type units.
    8. Tanks and pressure vessels.
    9. Air conditioning indoor and outdoor units.
    10. VFDs and transmitters and Control Boxes.
    11. Domestic water heaters.
F. Nameplate Markings:
    1. Identify model number, size, capacity, electrical characteristics, serial number, along with other items scheduled for equipment on drawings.
    2. Indicate motor horsepower, voltage, phase, cycles, RPM, full load amps, locked motor amps, frame size, manufacturer's name and model number, Service Factor, Power Factor, efficiency, minimum circuit amps, minimum feeder conductor size, disconnect or fuse size, refrigerant, and other pertinent information.
    3. Refer to NFPA-70 (NEC), Articles 110.21, 422.60, 422.61, 422.62, 424.28, 424.29, and 424.86.
G. Locate motor nameplates for easy reading. Relocate or provide new nameplates on motors if original nameplates are not located for easy reading.

3.06 FIELD CONTROL DEVICE IDENTIFICATION

A. Identify control equipment, panels, and field control devices with Laminated Plastic Nameplates.
B. Nameplate:
    1. Approximately 2" x ¾" size.
    2. White with black letters.
    3. Engraved with the name of the device as described in the BAS software.
C. For exposed devices, nameplate shall be located on or near the device.
D. For concealed devices, nameplate shall be affixed in an exposed location to allow maintenance personnel to determine the location of the device without removing the concealing material.
E. If several small devices are located on one concealed unit, only the main unit need be identified with an exposed nameplate.
F. The following devices shall be so labeled:
    1. Temperature Elements: XXX-TMP
    2. VAV Boxes and Lab Air Valves: XXX-VAV
    3. VAV Controllers (if remote from box): XXX-VAV Cont
    4. Static Pressure Transmitters: AHU-XX SP

5. Discharge Air Temp Transmitters: AHU-XX Zone ZZ DAT

3.07 ACCESS PANEL IDENTIFICATION

A. Furnish typewritten charts with identification and location of all access panels serving equipment and valves and incorporate in O&M Manuals.

END OF SECTION

SECTION 200700
MECHANICAL SYSTEMS INSULATION

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 20 0000 - General Mechanical Requirements
B. Section 20 0529 - Mechanical Supporting Devices

1.02 REFERENCE

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

1.03 DESCRIPTION

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

1.04 DEFINITIONS

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

1.05 SUBMITTALS

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

1.06 DELIVERY, STORAGE AND HANDLING

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

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

2.02 MATERIALS

A. Products used for or related to air conditioning and ventilating systems shall conform to NFPA 90A possessing flame spread rating of not over 25 and smoke developed rating no higher than 50.
B. Unless otherwise indicated, all products, material itself or on a composite basis, shall meet ASTM E-84, UL 723 or NFPA 255 and shall not exceed 25 flame spread and 50 smoke developed.
C. Outdoor insulation may have flame spread rating up to 75 and smoke developed rating up to 150.
D. Insulation applied on stainless steel shall meet requirements of ASTM C795 and NRC 1.36.

2.03 INSULATION

A. Insulation materials shall be fire retardant, moisture and mildew resistant, vermin proof, and suitable to receive jackets, adhesives and coatings as indicated.
B. Glass fiber insulation shall be of inert inorganic material, non-corrosive to mechanical surfaces.
C. Insulating cement shall be Quick-Cote by PK Insulation MFG Co. or Ryder GP, with dry density of no more than 38 lb/ft3 thermal conductivity of 0.96 at 400°F mean temperature, and service temperature to 1200°F.
D. Filling and finishing cement shall be Super-Stik by PK Insulation MFG Co., or Ryder MW, with dry density of no more than 24 lb/ft3, thermal conductivity of 0.74 at 500°F mean temperature, and service temperature to 1900°F.
E. Type A Insulation (Closed Cell Elastomeric Thermal Insulation):
   1. Minimum nominal density of 6 lb/ft^3, thermal conductivity not more than 0.28 at 75°F mean temperature, maximum water vapor transmission of 0.08 perm-inch and suitable for temperatures from -70 to 220°F, Armacell Model AP/Armaflex, K-Flex USA, or Aeroflex Model Aerocel.
F. Type F Insulation (Flexible Glass Fiber):
   1. Minimum density of 0.75 lb/ft^3 with thermal conductivity of not more than 0.29 at 75°F mean temperature, and suitable for temperatures to 250°F. Owens Corning "All Service Duct Wrap", Johns Manville Microlite. Minimum R value 4.2.
G. Type G Insulation (Cellular Glass):
   1. 100% cellular glass cells with no organic material, noncombustible, 0.00 perm-inch permeability, 7.5 lb/ft^3 average density, compression strength 90 psi, thermal conductivity of not more than 0.31 at 50°F mean temperature and service temperature of 900°F. Pittsburgh Corning Foamglas or approved equal.
H. Type H Insulation (High Temperature Block or Pipe):
   1. Hydrous calcium silicate, suitable for temperatures to 1200°F, thermal conductivity not more than 0.50 at 400°F, dry density 13 lb/ft3 minimum and compressive strength 100 psi, Industrial Insulation Group (formerly Johns Manville), Thermo-12 Gold.
I. Type R Insulation (Rigid Glass Fiber):
   1. Minimum nominal density of 3 lb/ft3 with thermal conductivity of not more than 0.23 at 75°F mean temperature. Minimum compressive strength at 10% deformation shall be 25 lb/ft2.
   2. Pipe insulation shall be suitable for temperatures to 850°F, Johns Manville Micro-Lok 850, Owens Corning Fiberglas ASJ/SSL-II.
   3. Duct and equipment insulation shall be suitable for temperatures to 450°F, Johns Manville Spin-Glas Type 814, Owens Corning Type 703. Minimum R value 4.2.

4. Pipe and tank wrap faced with specified jacket may be used for equipment and round ducts insulation, provided that it meets all insulation characteristics requirements stated above and maintains same R-value as specified.

J. Type RR Insulation (Rigid Glass Fiber):
   1. Minimum nominal density of 6 lb/ft3 with thermal conductivity of not more than 0.22 at 75°F mean temperature. Insulation shall be suitable for temperatures to 450°F. Minimum compressive strength at 10% deformation shall be 200 lb/ft2, Johns Manville Spin-Glas Type 817 or Owens Corning 705.
   2. TUFF-R Polyisocyanurate Insulation by Celotex may be used for Type RR insulation specified for exterior rectangular ductwork, provided minimum thickness is 3/4” and R-value is not less than R-value specified.
   3. Pipe and tank wrap faced with specified jacket may be used for equipment and round duct insulation, provided that it meets all insulation characteristics requirements stated above and maintains same R-value as specified.

2.04 JACKETS

A. Jacket puncture resistances shall be based on ASTM D-781 test methods. Vapor barrier permeance ratings shall be based on ASTM E-96 Procedure A.
B. Type D-1 Jacket:
   1. Heavy-duty, fire retardant material with glass fiber reinforcing. Jackets shall have neat, white Kraft finish or white vinyl finish suitable for painting, with beach puncture resistance of 50 units minimum. Vapor barrier shall be adhered to inner surface of jacket. Permeance shall not exceed 0.02 perm. Owens Corning "ASJ", Johns Manville "AP".
C. Type D-2 Jacket:

   1. Glass fiber reinforced foil Kraft laminate with permeance not exceeding 0.02 perm and beach puncture resistance 25 units minimum. Owens Corning "FRK", Johns Manville "FSK".
D. Type P-1 Jackets:
   1. Heavy-duty, fire retardant material with glass fiber reinforcing and self-sealing lap. Jacket shall have neat, white Kraft finish or white vinyl finish suitable for painting, with beach puncture resistance of 50 units minimum. Vapor barrier shall be adhered to inner surface of jacket. Permeance shall not exceed 0.02 perm. Owens Corning "ASJ-SSL", Johns Manville flame-safe "AP-T".
E. Type V-1 Jacket:
   1. Fire retardant and UV resistant PVC in minimum 20 mil (0.02") thickness consisting of preformed fitting covers, preformed end terminations, and sheet material for straight runs of pipe. Material when installed according to manufacturer's instructions shall provide complete vapor barrier and readily cleanable surface while meeting Federal CGMP requirements.
   2. Jacketing system shall be equal to Johns Manville Zeston/Perma-Weld System. Similar product by PROTO will be acceptable.

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

A. Products shall be compatible with surfaces and materials on which they are applied, and shall be suitable for use at operating temperatures of systems to which they are applied.
B. Products shall be fire retardant, moisture resistant and mildew resistant and vermin proof.
C. Adhesives, mastic, sealants, and protective finishes shall be as recommended by insulation manufacturer for specified application.
D. Adhesives, mastic, sealants, and protective finishes, shall comply with VOC limits set forth in South Coast Air Quality Management District (SCAQMD) Rule 1168.
E. Glass fiber fabric reinforcing shall be 10 x 10 or 20 x 10 mesh.
F. Wire mesh reinforcing shall be 22 ga, 1” galvanized.

G. Insulation cement shall be ANSI/ASTM C195, hydraulic setting mineral wool.
H. Finishing cement shall be ASTM C449.
I. Butt joint and longitudinal joint adhesive for Type A insulation shall be Armstrong 520, Rubatex 373 or Manville 57.
J. Weather-resistant protective finish for Type A insulation shall be equal to Armstrong WB Armaflex finish.

2.06 METAL BANDS AND WIRES

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

PART 3 - EXECUTION

3.01 APPLICATION

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

Piping System

Service	Jacket Type	Insulation Type	Insulation Thickness According to Pipe Size				
			3/4" and less	1" - 1-1/4"	1-1/2" - 3"	4" - 6"	8" and Larger
Cooling Coil Condensate Drain	--	A	3/4"	3/4"	3/4"	3/4"	3/4"
Refrigerant Suction Lines and Hot Gas By-pass Line if Used	-	A	1"	1"	1"	1"	1"
Provide protective coating paint for exposed exterior piping.							
Heating Hot Water (to 200F)	P-1	R	1-1/2"	1-1/2"	2"	2"	2"
Domestic Potable Hot Water and Hot Water Return (105-140°F)	P-1	R	1"	1"	1-1/2"	1-1/2"	1-1/2"
	--	A	1"	1"	1-1/2"	NA	NA
Exposed piping in spaces with finished floors or ceilings.	Provide V-1 jacket in addition to insulation jacket specified in this schedule.						

Piping System

Service	Jacket Type	Insulation Type	Insulation Thickness According to Pipe Size				
			3/4" and less	1" - 1-1/4"	1-1/2" - 3"	4" - 6"	8" and Larger
Piping Penetrating Through Roof.	Provide Type 1" thick Type R insulation between pipe and roof flashing.						

Ductwork/Equipment System

Service	Jacket Type	Insulation Type	Insulation Thickness
OA Ducts Exposed	D-1 or D-2	R	2"

	Ductwork/Equipment System		
Service	Jacket Type	Insulation Type	Insulation Thickness
OA Ducts Concealed	D-2	F	2"
Mixed Air (Outside Air & Return Air Ducts & Plenum)	D-1	R	1-1/2"
Supply & Return Ducts Exposed	D-1	R	1-1/2"
Supply, Return and General Exhaust Ducts Concealed	D-2	F	2"
Fume Exhaust and Restroom Exhaust Ducts	n/a	NONE	n/a

3.02 INSTALLATION - GENERAL

A. All insulation installation methods shall be performed in accordance with the latest edition of National Commercial and Industrial Insulation Standards published by MICA (Midwest Insulation Contractors Association) and manufacturer's installation instructions, except as modified in this Section of specifications.

B. Install products with good workmanship, with smooth and even surfaces. Use full-length factory-furnished material where possible. Do not use scrap pieces.

C. Apply insulation only on clean, dry surfaces, after all rust and scale have been removed and testing of systems has been completed. Do not insulate any section of system that must be pressure tested until after it has been successfully tested. Any removal and reinstallation to correct system defects prior to end of guarantee period shall be accomplished at no expense to Owner.

D. Install insulating materials with necessary joints and terminations, to permit easy access and removal of equipment sections where inspection, service or repair is required, and to allow for expansion.

E. Where possible longitudinal joints in jackets shall face toward wall or ceiling.

F. Apply insulation to each pipe or duct individually. Common insulation applied to adjacent pipes or ducts will not be accepted.

G. Unless otherwise indicated, pipe and duct insulation shall be continuous through walls and floors.

H. Where multiple layers of insulation are used, stagger and secure each layer with metal bands.

I. Where penetrations occur through fire-rated walls, partitions, or floors, provide fire seal as specified in Section 20 0000 - General Mechanical Requirements and Section 20 0573 - Mechanical Systems Firestopping.

J. Insulate water piping within casework up to penetration of casework pipe chase at fixture stop. Insulate water piping within walls up to pipe penetration through the wall at fixture stop when serving wall-mounted fixtures. Termination of insulation shall be in neat and workman like manner with insulation jacket cap.

K. Insulate the following systems for complete vapor barrier protection:
   1. Refrigerant
   2. Cooling coil condensate drain
   3. All insulated ductwork

L. Apply Type A insulation for insulation and jackets requiring vapor barrier protection where specified insulations are cut for mounting sensors, control devices, parts of valves, devices or components which extend out from specified insulation to prevent condensation.

3.03 PIPING, VALVE AND FITTING INSULATION

A. Apply insulation to pipe, unions, flanges, fittings, valves and piping specialties with butt joints and longitudinal seams closed tightly. Valve insulation shall cover entire valve body including bonnets and packing nuts.

B. Laps on factory-applied jackets shall be 2" minimum width firmly cemented with lap adhesive, or shall be pressure sealing type lap.
C. Cover joints with factory furnished tape (3" minimum width) to match jacket. Cement firmly with lap adhesive.
D. Secure insulation, except insulation covered with vinyl jackets, additionally with staples.
E. Where staples are used, they shall be on 6" maximum centers. When used for systems requiring vapor barrier, cover lap and staples with finish coat of lagging adhesive.
F. Built-up insulation for fittings and valves shall be made with sectional insulation, wrapped firmly to thickness of adjoining pipe insulation, and bound with jute twine, or built up with insulating cement, and finished to smooth hard surface, and covered with minimum of 9 oz per sq yd rewettable glass cloth similar to Clairmont Diplag 60.
G. For valves and fittings requiring vapor barrier, apply 2 coats of vapor barrier mastic with glass fiber reinforcing fabric after application of insulating cement. For valves and fittings not requiring vapor barrier, apply 2 coats of weatherproof mastic with glass fiber reinforcing fabric after application of insulating cement. Apply coating in accordance with manufacturer's recommended procedure.
H. For finishing of insulated pipe fittings and valves where surface temperature of insulation is not higher than 125°F, one piece PVC fitting covers, minimum thickness of 20 mil, may be used. Fitting covers located in mechanical rooms within 8 ft above floor shall be 30 mil thickness. Johns Manville Zeston 2000 PVC, PROTO Fitting Covers, or similar by other manufacturers listed. Where fitting and valve insulation requires vapor barrier, seal joints of PVC covers with vapor barrier adhesives. Insulation type, R-value and density of insulation used at fittings shall match those of adjacent piping. Install insulation at pipe fittings and valves completely prior to applying PVC covers.
I. Where terminations of pipe insulation are required, insulation shall have tapered ends, built up and finished as specified for fittings.
J. For pipes 1-1/2" and smaller, install specified pipe insulation and jacket continuous through hanger or support locations. Install insulation protection shields to protect insulation from compressing.
K. For pipes 2" and larger, where manufactured pre-insulated pipe supports are used at hanger or support locations, extend insulation to insulated pipe supports. Where vapor barrier is required, this Contractor shall be responsible for continuity of vapor barrier at insulated pipe supports. Use 3" wide vapor barrier tape on hot and cold systems at pipe supports.
L. For pre-insulated pipe supports and insulation protection shields, refer to Section 20 0529 - Mechanical Supporting Devices.
M. For Contractor-fabricated anchors, secure insulation directly to pipe surface and extend insulation up anchor for distance of 4 times insulation thickness. For pre-insulated anchors, cover entire surface of anchors with Type A insulation. Where applicable, take special care to assure vapor seal at anchor.
N. Where mechanical grooved pipe connections are used in piping system, insulate couplings as specified for pipe.
O. Piping, fittings and valves not to be insulated:
    1. Valves furnished with removable insulation/jacket

3.04 DUCTWORK AND COMPONENTS

A. Apply duct insulation evenly over duct surface. Unless otherwise indicated, insulation and jacket shall run continuously between duct and duct supports. Maintain insulation thickness specified over duct reinforcing members.
B. For support points of rectangular or oval ducts supported by trapeze hangers, place weight-supporting insulation at bottom of duct over trapeze. Weight supporting insulation inserts shall be minimum 6" long with same thickness as insulation specified and shall be Type G or H insulation. Size inserts based on compression strength and weight being supported.

C. For support points of round ducts smaller than 16" diameter, weight-supporting insulation is not required for either rigid or flexible glass fiber insulation.
D. For support points of round ducts 16" diameter and larger, place weight-supporting insulation between duct and strap or trapeze. Weight-supporting insulation shall be minimum 6" long with same thickness as insulation specified and shall be Type G or H insulation. Size inserts based on compression strength and weight being supported.
E. Secure flexible glass fiber insulation (Type F) to underside of horizontal rectangular or oval ductwork 24" in width or greater and on vertical sides of horizontal and vertical ductwork with weld pin fasteners not over 18" on center and within 3" of butt joint or edge.
F. Secure rigid glass fiber insulation (Type R) to all sides of horizontal and vertical rectangular or oval ductwork with weld pin fasteners. Install pins or fasteners as required to secure, but not less than 12" on center for underside and sides of ducts and 24" on center for top of ducts, and within 3" of butt joint or edge.
G. Clip pins fastened to ductwork with adhesives are not allowed. Where weld pin fasteners are used, install them without damage to interior galvanized surface. Clip pins neatly back to each fastener.
H. Where insulation is required for ductwork, provide insulation over entire ductwork system, including system components such as filters, mixing air chambers, sound attenuators, air measuring stations, reheat coils, etc. For fire dampers, smoke dampers and combination F/S dampers in ductwork requiring insulation, install insulation and jacket to wall and apply vapor barrier sealant to prevent condensation.
I. Provide insulation over supply air diffusers, grilles and unlined boots after termination point of flexible ducts or rigid duct insulation to prevent from sweating.
J. Where vapor barrier jackets are specified, pins shall be jacketed over with matching material. Where staples are used for systems requiring vapor barrier, cover lap and staples with finish coat of lagging adhesive.
K. Insulation without factory jacket shall be cut and mitered to suit surface. Build up voids, seams and joints with insulating cement, cover with glass fabric as specified herein and finish to smooth surface.
L. For other than factory-applied vapor barrier jackets, apply 2 coats of vapor barrier mastic with glass fiber reinforcing fabric, after application of insulating cement. For surfaces not requiring vapor barrier jackets, apply 2 coats of weatherproof mastic with glass fiber reinforcing fabric after application of insulation cement. Apply coating in accordance with manufacturer's recommended procedure.
M. D-1 jackets:
    1. Butt together joints and seams firmly.
    2. Cover all joints, seams, punctures and breaks in jacket with glass fiber fabric, 4" minimum width, and finish with 2 coats of vapor barrier mastic.
N. D-2 jackets:
    1. Butt together joints and seams firmly.
    2. Cover all joints, seams, punctures and breaks in jacket with glass fiber fabric, 4" minimum width, and finish with 2 coats of vapor barrier mastic.

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

A. Longitudinal overlap shall be at least 2" wide with vapor barrier sealant.
B. Secure jacketing with 3/4" wide 0.015" stainless steel or 3/4" wide 0.020" aluminum bands and wing seals on maximum 18" centers.

END OF SECTION

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SECTION 211314
AUTOMATIC FIRE SPRINKLER SYSTEM

PART 1 - GENERAL

1.01 DESCRIPTION

A. This Section specifies materials and methods for the following systems.
   1. Sprinkler
B. Extend piping to 5 feet outside the building wall and connect to the site fire system.
C. Research indicates there is no documentation or indication that microbiologically influenced corrosion (MIC) exists in the area of the project.
D. NFPA 13's seismic requirements are not part of this project.
E. This is not a Factory Mutual Global (FMG) protected property.
F. Engineer of Record:
   1. This is a performance-based specification. Affiliated Engineers is the Engineer of Record.
      a. The Engineer has prepared Signed-and-Sealed Drawings and Specifications.
      b. Provide engineering design, system layout, and hydraulic calculations.
      c. Do not Sign-and-Seal fabrication drawings or hydraulic calculations.
      d. The Contract Documents establish the requirements and parameters for system design and installation.

1.02 RELATED WORK

A. Section 20 0000 - General Mechanical Requirements
B. Section 20 0520 - Excavation and Backfill
C. Section 20 0529 - Mechanical Supporting Devices
D. Section 20 0553 - Mechanical Systems Identification
E. Section 28 3116 - Multiplexed Fire Detection and Alarm Systems

1.03 QUALITY ASSURANCE

A. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): "The articles listed in FAR 25.104(a) that are acquired as construction materials."
B. Codes and Standards:
   1. This installation shall conform to the following:
      a. NFPA 13, Installation of Sprinkler Systems (2016 Edition)
      b. NFPA 24, Installation of Private Fire Service Mains and Their Appurtenances (2016 Edition)
      c. NFPA 45, Fire Protection for Laboratories Using Chemicals (2015 Edition)
      d. NFPA 72, National Fire Alarm Code (2016 Edition)
      e. NFPA 101, Life Safety Code (2018 Edition)
      f. Underwriters Laboratories (UL) Fire Protection Equipment Directory
      g. Florida Building Code (2020 Edition)
C. Contractor Installation Program:
   1. Provide journeyman sprinkler fitter(s) for installation and supervision.
   2. Provide fire protection installer licensed in the State of Florida for installation of fire protection systems.
   3. Submit pre-qualification evidence of at least three projects of comparable size successfully completed with their Bid.
D. Electrical Coordination
   1. All relays, wire, conduit, pushbuttons, pilot lights, and other devices required for power side or the control of electrical equipment shall be furnished by Division 26 and Division 28 Contractors, except as specifically noted elsewhere in this Specification.

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

1.04 DELIVERY, STORAGE, AND HANDLING

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

1.05 SUBMITTALS

A. Pre-qualification documents
B. Product Data:
   1. Pipe
   2. Valves
   3. Tamper switches
   4. Flow switches
   5. Sprinklers
   6. Fire department connections
   7. Pressure gauges
   8. Material Safety Data Sheet (MSDS) for corrosion inhibitive paint
C. Shop Drawings:
   1. Fabrication Drawings
D. Calculations:
   1. Hydraulic Calculations
E. Submit to Local Authority for Review:
   1. Product data sheets
   2. Fabrication drawings
   3. Hydraulic calculations
F. Review Letters:
   1. Local Authority review letter
G. Reports:
   1. Pipe Pressure Test Reports
H. Certifications:
   1. NFPA Exterior Piping Certifications
   2. NFPA Sprinkler Certifications

3. Performance testing for double check backflow preventer assembly.

I. Closeout Documents:
1. NFPA 25, Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems

PART 2 - PRODUCTS

2.01 MATERIALS

A. Materials and Equipment:
1. Materials and equipment in system shall be new and current products of manufacturer regularly engaged in production of such materials and equipment.
2. Where two or more pieces of equipment are required to perform interrelated functions, they shall be products of same manufacturer.

B. Approval Guides:
1. Products shall be UL Listed in the latest publication of the UL Fire Protection Equipment Directory or approved in the latest Factory Mutual Research Corporation Approval Guide for service intended.

2.02 PIPE

A. Below Ground:
1. Pipe: Ductile iron, Class 52, American Water Works Association (AWWA) C151, minimum 350 psi working pressure, with standard cement mortar lining, AWWA C104, American National Standards Institute (ANSI) A21.4
2. Fittings: Ductile iron or grey iron, mechanical joint, 350 psi working pressure, AWWA C153, cement mortar lined, AWWA C104
3. Encasement: Polyethylene encasement, 8 mil thick, AWWA C105

B. Above Ground:
1. Carbon Steel, 2” and smaller:
a. Pipe: Carbon steel pipe, Schedule 40, American Society for Testing of Materials (ASTM) A795 or A53
b. Fittings:
1) Malleable iron, threaded, Class 150, 300 psi Cold Water Pressure (CWP) rating, ASME B16.3
2) Cast iron, threaded, Class 125, 175 psi CWP rating, ANSI B16.4
3) Cast iron, flanged, Class 125, 175 psi CWP rating, ANSI B16.1
4) Carbon steel butt weld, ASTM A234 Grade WPB/American Society of Mechanical Engineers (ASME) B16.9, standard weight, seamless
5) Ductile iron or malleable iron, roll grooved for mechanical coupling, 175 psi CWP rating, malleable iron conforming to ASTM A47.
a) Acceptable manufacturers: Anvil Gruvlok, Tyco Grinnell, Victaulic, Viking, or equal
b) Fitting, gasket, and coupling shall be furnished by same manufacturer.
c. Joints:
1) Threaded, tapered pipe threads, ANSI B1.20.1
2) Flanged, cast iron, 175 psi CWP rating, ANSI B16.1, square head machine bolts with semi-finished hexagon nuts, ASTM A183, neoprene gasket
3) Welded, welding electrodes shall be Lincoln or equal with coating and diameter as recommended by manufacturer for type and thickness of work being done.
4) Mechanical:
a) Flexible mechanical, malleable iron, ASTM A47, equal to Victaulic Style 75
b) Rigid mechanical, ductile iron, ASTM A-536, equal to Victaulic Style 009N
c) Wet systems gasket: Grade E EPDM gasket per UL 157 and UL 213

d) Dry systems gasket: Victaulic “FlushSeal” or equal
e) Rigid or zero flex type couplings shall be provided when operating pressures cause piping to move out of place or sway on hangers. Flexible couplings may be used where pipe is braced or clamped into rigid position.

2. Carbon Steel, larger than 2”:
   a. Pipe: Carbon steel pipe, Schedule 10, ASTM A795, A53, or A135
   b. Fittings:
      1) Carbon steel butt weld, ASTM A234 Grade WPB/ASME B16.9, Schedule 10, seamless
      2) Ductile iron or malleable iron, roll grooved for mechanical coupling, 175 psi CWP rating, malleable iron conforming to ASTM A47.
         a) Acceptable manufacturers: Anvil Gruvlok, Tyco Grinnell, Victaulic, Viking, or equal
         b) Fitting, gasket, and coupling shall be furnished by same manufacturer.
   c. Joints:
      1) Welded, welding electrodes shall be Lincoln or equal with coating and diameter as recommended by manufacturer for type and thickness of work being done.
      2) Mechanical:
         a) Flexible mechanical, malleable iron, ASTM A47, equal to Victaulic Style 75
         b) Rigid mechanical, ductile iron, ASTM A-536, equal to Victaulic Style 009N
         c) Wet systems gasket: Grade E EPDM gasket per UL 157 and UL 213
         d) Dry systems gasket: Victaulic “FlushSeal” or equal
         e) Rigid or zero flex type couplings shall be provided when operating pressures cause piping to move out of place or sway on hangers. Flexible couplings may be used where pipe is braced or clamped into rigid position.
3. Flexible sprinkler hose fittings for fire protection service shall be manufactured by FlexHead Industries, Inc., 56 Lowland Street, Holliston, MA 01746; Telephone: (800) 829-6975. No substitutions allowed. Product shall be FMRC Approved for its intended use pursuant to FM 1637 – Approval Standard for Flexible Sprinkler Hose with Threaded End Fittings. Product shall be UL Listed for its intended use pursuant to UL 2443 – Standard for Flexible Sprinkler Hose with Fittings for Fire Protection Service. For seismic projects, product shall be seismically qualified for use pursuant to ICC–ES AC-156 – Acceptance Criteria for Seismic Qualification by Shake-Table Testing of Nonstructural Components and Systems. Provide high pressure fittings where pressures exceed 175 psi water working pressure. Model numbers on high pressure fittings must include the “H” suffix.
   a. FlexHead Flexible Hose Assemblies and End Fittings:
      1) Composition: 100% Type 304 Stainless Steel
      2) Shall be fully welded non-mechanical fittings, braided, leak-tested with minimum 1” true-bore internal corrugated hose diameter
      3) Flex hose assembly length shall be limited to a maximum of 4 ft.
      4) Straight Hose Assembly Lengths: 4 ft length, Model #2048
      5) Elbow Hose Assembly lengths: 4 ft length, Model #2048E
   b. FlexHead Ceiling Bracket:
      1) Composition: Type G90 Galvanized Steel
      2) Type: Direct attachment type, having integrated snap-on clip ends positively attached to the ceiling using tamper-resistant screws
      3) Flexible hose attachment: Removable hub type with set screw
4. Provide metal pipe’s exposed threads with corrosion inhibitive paint, equal to Rust-Oleum.

5. Provide pipe identification system with flow directional arrows on fire protection pipe. For additional information about pipe identification, refer to Section 20 0553 – Mechanical Systems Identification.
6. Plain end couplings (Roust-A-Bouts, Plainloks or similar couplings) are not allowed on either new or existing sprinkler systems.
7. Adjustable drop nipples are not allowed on either new or existing sprinkler systems.
8. Shop welded joints:
    a. Welding electrodes shall be Lincoln or equal with coating and diameter as recommended by manufacturer for type and thickness of work being done.

2.03 UNDERGROUND RESTRAINT

A. Acceptable manufacturers: EBAA Iron, Inc., Smith-Blair, or equal
B. Mechanical Joints Utilizing Setscrew Retainer Glands
    1. Mechanical joint restraint device for nominal pipe sizes 3” through 12” per AWWA C151, shall consist of multiple gripping wedges incorporated into a follower gland meeting the applicable requirements of AWWA C110/A21.10, body, wedges and wedge actuating components shall be cast from grade 65-45-12 ductile iron material in accordance with ASTM A536, minimum working pressure rating of 350 psi, includes torque limiting breakaway nuts, allows for a minimum of 3° of deflection, and includes fusion-bonded epoxy coating per AWWA C213.
    2. Mechanical restraint coupling gasket shall be furnished by same manufacturer.
C. Pipe Clamps and Tie Rods
    1. Clamps, rods, and washers shall be sized per the requirements listed in NFPA 24.
        a. Clamps shall be made of steel, used to prevent joint separation through use in combination with rod clamp washers, rod couplings, and heavy hex nuts.
        b. Rods shall be carbon steel per ASTM A193 GR B7, using rolled threads for improved physical characteristics, greater thread accuracy, and smooth surface finish.

2.04 UNDERGROUND PENETRATION MODULAR SEAL

A. Acceptable manufacturers: GPT Industries, Roxtec, or equal
B. Modular sealing device consisting of sealing elements, pressure fittings, and hardware preassembled from manufacturer.
    1. Sealing elements: EPDM rubber that adjusts to the outside diameter of the pipe to ensure proper fitment and sealing.
    2. Pressure resistant to a minimum of 20 psig (40 ft. of head).
    3. Bolts and nuts: 316 stainless steel per ASTM F593
C. Basis of Design: GPT Industries Link-Seal, Roxtec Model RS, or equal

2.05 VALVES

A. Gate Valve:
    1. Acceptable manufacturers: Kennedy, Milwaukee Valve Co., Mueller, Nibco, Stockham, Victaulic, or equal
    2. Outside screw and yoke (OS&Y) gate valve, bronze body and trim or cast iron body bronze mounted and rated for 175 psi, non-shock water working pressure, Nibco F-607-OTS or equal.
B. Vertical Post Indicator Valve:
    1. Acceptable manufacturers: Kennedy, Mueller, Nibco, Stockham, Victaulic, or equal
    2. Non-rising stem (NRS) gate valve, ductile iron body, resilient wedge, epoxy coated interior and exterior, includes indicator post flange and flange screw, rated for 300 psinon-shock cold working pressure, Nibco F-609-RWS or equal.
    3. Cast iron post with lockable lever operator for use with non-rising stem gate valve, 1” square valve stem extension rod, UV-stabilized Lexan window containing cast aluminum

signage reading “OPEN” and “SHUT”, Kennedy Model 2495A, Nibco NIP-1AJ, Victaulic Series 774, or equal.

C. Check Valve:
   1. Acceptable manufacturers: Globe Fire Sprinkler, Reliable, Tyco Fire Products, Victaulic, Viking, or equal
   2. Iron body, bronze seat, stainless steel clapper with a replaceable rubber seal, Globe Fire Sprinkler Model RCV, Tyco Fire Products CV-1F, Viking Model G-1, or equal.
D. Check Valve (Anti-Water-Hammer type)
   1. Acceptable manufacturers: Anvil Gruvlok, Reliable, Tyco Fire Products, Victaulic, Viking, or equal
   2. Ductile iron conforming to ASTM A536, Grade 65-45-12, rust inhibiting coating, sizes 2” to 5” consisting of stainless steel clapper conforming to ASTM A-167 and for sizes 6” to 8” consisting of ductile iron clapper conforming to ASTM A-536, Anvil Gruvlok Series 7800 or equal.
E. Ball Valve:
   1. Acceptable manufacturers: Milwaukee Valve Co., Mueller, Nibco, Stockham, Victaulic, or equal
   2. Bronze body and stem, full port design, brass ball with chrome plated finish, conforms to MSS SP-110 standard, Nibco Model KT-585-70-UL or equal.
F. Globe/Drain Valve:
   1. Acceptable manufacturers: Milwaukee Valve Co., Mueller, Nibco, Stockham, Victaulic, or equal
   2. Bronze body, stem, bonnet, and packing nut; non-asbestos packing; nitrile seat disc; stainless steel handwheel screw or nut; Nibco Model KT-65-UL for valve sizes 1/2” to 1”, Nibco Model KT-211-W-UL for valve sizes 1-1/4” to 2”, or equal.
G. Butterfly Valve:
   1. Acceptable manufacturers: Globe Fire Sprinkler, Kennedy, Milwaukee Valve Co., Mueller, Nibco, Stockham, Tyco Fire Products, Victaulic, or equal
   2. Globe Fire Sprinkler Model GL300 for valve sizes 1” to 2-1/2”, or equal.
   3. Globe Fire Sprinkler Model GLR300 2-1/2” to 8”, Kennedy Valve Co. Fig. G300 for sizes 2-1/2” to 6”, Victaulic FireLock Series 705 for valve sizes 2-1/2” to 8”, or equal.
H. Double Check Backflow Prevention Assembly (DCBP):
   1. Acceptable manufacturers: Ames, Apollo, Cla-Val, Febco, Watts, or equal
   2. Weighted clapper double check valve assembly including 2 supervised outside screw and yoke (OS&Y) gate valves
   3. Assembly shall be double check valve assembly for cross connection devices.
   4. Certified in accordance with ASSE 1015 and AWWA C510
   5. Double check valve shall be selected based on minimal pressure drop to allow maximum available pressure to sprinkler system.
I. Test and Drain Valves:
   1. Acceptable manufacturers: AGF, Globe Fire Sprinkler, Victaulic, or equal
   2. AGF TESTanDRAIN, Globe Fire Sprinkler Model UTD, Victaulic Style 720 TestMaster II, or equal.
   3. Test and drain valve shall include integral pressure relief valve. Pressure relief valve shall be set to operate at 175 psi or 10 psi in excess of the maximum system pressure, whichever is greater.
J. Riser Manifold:
   1. Acceptable manufacturers: Globe Fire Sprinkler, Tyco Fire Products, Victaulic, Viking, or equal

2. Ductile iron or fabricated steel pipe body; threaded or grooved connections; rated to 175 psi non-shock water working pressure; includes test and drain valve with integral pressure relief valve kit, flow switch without optional cover tamper kit, and pressure gauge; Globe Fire Sprinkler Model UM, Tyco Fire Products Model RM-1, or equal.

K. Universal Manifold Check Assembly:
   1. Acceptable manufacturers: Globe Fire Sprinkler or equal
   2. Ductile iron construction, incorporating a control valve, check valve, flow switch, test & drain assembly, adjustable pressure relief valve, and pressure gauges in one compact body/footprint, manufactured for right- and left-hand orientations, rated for use at the maximum service pressure of 300 psi, and UL Listed and FM Approved. The test & drain assemble shall contain an adjustable pressure relief valve, with a range of 175 psi to 310 psi, and a universal test orifice of K2.8. Globe Fire Sprinkler Model UMC or equal.

L. Air Release Valve:
   1. Acceptable manufacturers: Engineered Corrosion Solutions, Potter Electric Signal Co., or equal
   2. Automatic float type air vent, ball valve with tamper switch, Y-type strainer, and single set of normally closed dry contacts rated 24VAC/DC at 2 Amps, UL 2573 Listed, FM Approved “Automatic Air Release Valve for Sprinkler Systems”, rated to 175 psi non-shock water working pressure, Potter Electric Signal Co. Model PAAR-B or equal.
   3. Air release valve shall be installed in an accessible location to permit operation, maintenance, and visual inspection of the status of the valve.

M. Provide identification sign (enamel on metal) for valves per NFPA requirements. For additional information, refer to Section 20 0553 – Mechanical Systems Identification.

N. Valves in galvanized piping shall be bronze.

2.06 TAMPER SWITCH

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

B. Outside screw and yoke (OS&Y) supervisory switch, NEMA 4 enclosure, provided with 2 sets of SPDT (Form C) contacts rated at 2.5 Amps at 30 VDC and 15 Amps at 125/250 VAC. Provide without optional cover tamper kit. For areas identified as hazardous locations, provide “EX” Model. Potter Electric Signal Co. OSY series or equal.

C. Control valve supervisory switch, NEMA 4 enclosure, provided with 2 sets of contacts rated at 2.5 Amps at 30 VDC and 15 Amps at 125/250 VAC. Provide without optional cover tamper kit. For areas identified as hazardous locations, provide “EX” Model. Potter Electric Signal Co. PIBV series or equal.

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

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

2.07 FLOW SWITCH

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

B. Vane type waterflow switch for use in wet sprinkler systems, minimum 300 psi service pressure rating, 10 gpm minimal flow rate to activate alarm, and 2 sets of SPDT (Form C) contacts. Provide without optional cover tamper kit. Potter Electric Signal Co. VS series or equal.

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

2.08 SPRINKLERS

A. Manufacturers:
   1. Unless otherwise noted below, shall be manufactured by Globe Fire Sprinkler, Reliable, Tyco Fire Products, Viking, or equal.

B. Automatic, having temperature and pressure rating suitable for location.

C. Light hazard occupancies shall utilize quick-response type sprinklers.

D. Architect will review deviations from specified styles for approval prior to installation.
E. Provide the following type of sprinklers
    1. Unfinished areas such as mechanical spaces:
        a. Standard Coverage, Brass Upright or Pendent, ordinary temperature class (155°F), Globe Fire Sprinkler Model GL-QR, Tyco Fire Products Model TY-FRB, Viking Microfast, or equal.
        b. Extended Coverage, Brass Upright or Pendent, large orifice, ordinary temperature class (155°F), Globe Fire Sprinkler Model GL-ECOH, Tyco Fire Products Model EC-11/14, Viking ECOH-ELO, or equal, designed and installed per its listing
    2. In areas with ceilings.
        a. Standard Coverage, Concealed Pendent, ordinary temperature class (155°F), Globe Fire Sprinkler Model GL-QR/INCH, Tyco Fire Products Model RFII, Viking Mirage, or equal adjustable sprinkler with 139°F temperature class cover plate, mounted flush with ceiling. Cover plate color shall match ceiling color and shall be factory-painted (i.e. by manufacturer).
        b. Standard Coverage, Semi-Recessed, ordinary temperature class (155°F), Globe Fire Sprinkler Model GL-QR, Tyco Fire Products TY-FRB, Viking Microfast, or equal. Sprinkler and escutcheon finish shall be standard bright white.
    3. In areas where ceiling conditions do not permit installation of pendent sprinkler or finished area where sidewall sprinkler provides better coverage of hazard.
        a. Standard Coverage, standard bright white finish, ordinary temperature class (155°F), Globe Fire Sprinkler Model GL-QR/SW, Tyco Fire Products Model TY-FRB, Viking Microfast horizontal (HSW) or vertical (VSW) sidewall with Viking Microfast Model F-1 adjustable escutcheon, or equal.
        b. Extended Coverage, standard bright white finish, ordinary temperature class (155°F), Globe Fire Sprinkler Model GL-QR/ECLH/SW, Tyco Fire Products Model TY-FRB or equal designed and installed per its listing
    4. In areas requiring coverage of exterior areas and projections.
        a. Standard Coverage or Extended Coverage, white finish dry horizontal sidewall, intermediate temperature class (200°F), adjustable recessed chrome escutcheon, Globe Fire Sprinkler Model GL-QR/DRY, Tyco Fire Products Model DS-1 or equal.
F. Submit samples for examination and approval when appearance is different than sprinkler specified.
G. Temperature class of sprinklers shall vary if installed close to heat sources, under skylights or in special hazard areas as defined on contract drawings. Refer to NFPA 13 for requirements.
H. Spare Sprinkler Cabinets:
    1. Shall be complete with required number of spare sprinklers of each type and temperature rating per NFPA 13.
    2. Shall be provided with at least one sprinkler wrench for each type of sprinkler installed.
    3. Provide multiple cabinets to meet this requirement.
    4. Coordinate cabinet locations with Owner's representative.

2.09 FIRE DEPARTMENT CONNECTION (FDC)

A. Acceptable Manufacturers: Badger-Powhatan, Croker, Elkhart Brass, Guardian Fire Equipment, Potter-Roemer, Tyco Fire Products
B. Flush Fire Department Connection: Potter-Roemer 5023-D-F, cast brass body, drop clappers, faceplate, two 2-1/2” snoots, pin-lug hose thread swivels, pin-lug plugs with chains, integral sillcock, polished chrome plated finish, AUTOSPKR lettering.

2.010 BALL DRIP

A. Acceptable manufacturer: Potter-Roemer, Reliable, Tyco Fire Products, or equal

B. Provide bronze ball drip for fire department connection (FDC) inside of building and pipe to nearest floor drain or discharge to exterior.
C. Exterior discharge location must be coordinated with Architect and Owner.

2.011 HANGERS

A. Acceptable manufacturers: Afcon, Anvil, Eaton, Pentair, Tolco, or equal
B. Concrete expansion hangers, when provided, are to be Hilti, Illinois Tool Works (ITW), Powers Fasteners, or equal. Concrete hangers shall be rated for cracked concrete conditions.
C. Hanger rods shall comply with Manufacturer Standardization Society (MSS) standards and manufacturer's published load rating.
D. Provide hanger rod, hanger rod attachments, pipe stands, bolts, U-bolts, nuts, studs and washers with electroplated zinc coating or with hot-dipped galvanized finish.
E. Riser clamps shall be electroplated zinc coated or have a hot-dipped galvanized finish and shall not protrude more than 2" beyond edge of hole, Anvil Fig. 261 or equal.

2.012 PRESSURE GAUGES

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

2.013 DIELECTRIC FITTINGS

A. Acceptable manufacturers: Epco Sales, Lochinvar, Watts Regulator Co., Wilkins, or equal
B. Dielectric unions 2" and smaller; dielectric flanges 2" and larger; with iron female pipe thread to copper solder joint or brass female pipe thread end connections, non-asbestos gaskets, and pressure rating of not less than 175 psig at 180°F.

PART 3 - EXECUTION

3.01 DESIGN CRITERIA

Flow Test: TBD

A. Contractor shall provide an up to date flow test prior to preparation of installation drawings and hydraulic design calculations.

B. Hydraulically calculated system shall be designed to a minimum of 10% below available water flow curve.

C. Systems that are hydraulically calculated must include 1.2 factor for design area.

D. Basis of Design:
   1. Office areas and general building spaces shall be hydraulically designed to provide minimum density of 0.10 gpm per sq ft over most hydraulically remote 1500 sq ft. Maximum spacing shall not exceed 225 sq ft per head.
   2. Laboratory areas, including corridors between labs separated from office areas by doors and firewalls, shall be hydraulically designed to provide minimum density of 0.15 gpm per sq ft over most hydraulically remote 1500 sq ft. Maximum spacing shall not exceed 130 sq ft per head.
   3. Chemistry labs shall be hydraulically designed to provide minimum density of 0.20 gpm per sq ft over most hydraulically remote 1500 sq ft. maximum spacing shall not exceed 130 sq ft per head.
   4. Mechanical equipment areas shall be hydraulically designed to provide minimum density of 0.15 gpm per sq ft for most remote 1500 sq ft. Maximum spacing shall not exceed 130 sq ft per head.

5. General storage areas and chemical transfer area shall be hydraulically designed to provide minimum density of 0.15 gpm per sq ft over most hydraulically remote 1500 sq ft. Maximum spacing shall not exceed 130 sq ft per head.

E. Hose Streams:
   1. Light Hazard Occupancy: 100 gpm inside/outside hose allowance
   2. Ordinary Hazard Occupancy: 250 gpm inside/outside hose allowance

3.02 INSPECTION

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

3.03 INSTALLATION

A. Install hydraulically designed sprinkler system and associated accessories according to requirements of NFPA 13 and as shown on drawings.
B. Install pipe, fittings, couplings, and valves according to requirements of manufacturer.
C. Keep materials within listed temperature range to assure jointing in accordance with manufacturer's requirements.
D. Pipe and fittings shall be of corresponding materials when assembled.
E. Underground Pipe:
   1. Underground pipe shall be restrained against movement at changes in direction per the requirements of NFPA 24. Restraint shall be provided by using thrust blocks or one of the following methods:
      a. Mechanical joint restraint utilizing setscrew retainer glands
         1) Mechanical joint restraint shall require conventional tools and installation procedures per AWWA C600, while retaining full mechanical joint deflection during assembly as well as allowing joint deflection after assembly.
         2) Proper actuation of the gripping wedges shall be ensured by use of torque limiting twist off nuts.
      b. Pipe clamps and tie rods
      c. Locking mechanical or push-on joints
      d. Bolted flange joints
   2. Thrust blocks shall be of concrete, of a mix not leaner than one part cement, two and one-half parts sand, and fire parts stone.
   3. Wherever possible, thrust blocks shall be located so that the joints are accessible for repair.
   4. Pipe clamps and tie rods shall not be installed where the pipe penetrates building walls or floors.
   5. Threaded sections of rods shall not be formed or bent.
   6. Except for fittings, valves, glands, and other accessories having an epoxy-coated finish, all rods, nuts, bolts, washers, clamps, and other restraining devices shall be cleaned and thoroughly coated with a bituminous or other acceptable corrosion-retarding material after installation.
   7. Provide metallic bond at each joint of ductile iron and cast iron pipe. Bond wire shall be type RHW-USE size 1/0 neoprene-jacketed copper conductor shaped to stand clear of joint.
   8. Polyethylene encasement shall be installed for ductile iron pipe. Refer to AWWA C105-10 for material standards and installation procedures.
F. Above Ground Pipe:
   1. Provide pipe identification system with flow directional arrows on fire protection pipe in accordance with manufacturer’s installation instructions. For additional information, refer to Section 20 0553 – Mechanical Systems Identification.

2. Coat exposed threads with corrosion inhibitive paint, equal to Rust-Oleum. Apply paint per manufacturer's instructions.

G. Provide readily removable fittings at end of cross-mains. Minimum size of flushing connection shall be 2".
H. Provide test connection for each flow switch.
I. Discharge test connections inside building to receptacles provided as part of plumbing system or to standpipe's drain riser.
J. Drain line detailed adjacent to standpipe/sprinkler risers shall be considered as part of Sprinkler System from combination test/auxiliary drain valve for each zone or sub-zone shown on plans to plumbing receptacle.
K. Provide auxiliary drains at low points of systems per requirements of NFPA 13.
L. Identify valve with brass tag denoting which flow switch is being tested, when test valves are located remote from flow switch.
M. Clamp-on or saddle type fittings (i.e. mechanical tees) are not allowed. Outlet fittings inserted into holes drilled into piping or pipe-o-lets are not allowed.
N. Provide reducing fittings or provide shop fabricated weld-o-lets to change pipe sizes in sprinkler/standpipe systems. No bushings or grooved reducing couplings, such as Victaulic Style 750, are allowed.
O. Feed sprinklers, installed in finished ceilings, with FlexHead, swing joint, or return bend arrangement for final positioning in ceiling grid pattern during construction phases.
P. All arm-over and flexible sprinkler fittings shall be taken from the sides or top of the branch line. No arm-overs or flexible sprinkler fittings shall be connected to the bottom of the branch line.
Q. Sprinklers are required to be installed in the center of ceiling tiles.
R. Install tamper switch on each shutoff valve.
S. Install sprinklers as recommended by manufacturer. Sprinklers shall be set level and at locations to avoid interference with spray pattern of sprinkler. When ducts and lights are obstructions to sprinkler distribution, provide additional sprinklers beneath obstruction.
T. Make joints of threaded pipe by cutting pipe square and reaming inside.
U. Use joint compound sparingly.
V. Install joints for mechanical coupled pipe according to manufacturer's recommendations. Use manufacturer's gasket lubricant sparingly.
W. Pipe grooving shall be per coupling manufacturer's instructions.
X. Welded joints shall be made in fabrication shop. No welding allowed at project site.
Y. Hangers, Bracing, and Restraint of System Piping:
    1. Provide hangers and associated parts to support piping in perfect alignment without sagging or interference, to permit free expansion and contraction, and meet requirements of NFPA 13 and manufacturer's installation instructions.
    2. Select and size building attachments per Manufacturer Standardization Society (MSS) standards and manufacturer's published load rating.
    3. Coordinate hanger support installation to group piping of all trades.
    4. Hang pipe from building members using either concrete inserts for concrete construction or beam clamps for steel construction. Installation shall comply with manufacturer's installation instructions. Expansion type inserts may be used for branch piping.
    5. Restraining clips/clamps are required in locations where vibration may be a concern. Refer to Section 23 0550 – Vibration Isolation, for additional information regarding restraining clips/clamps.
    6. Suspend hangers by means of electroplated zinc or hot-dipped galvanized finish hanger rods. Perforated band iron and flat wire straps (strap iron) are not allowed.

7. Mains parallel to joists shall not be supported from a single joist. Mains parallel to joists shall be supported by trapeze hanger and be positioned equally between two joists. Trapeze hangers shall be positioned to load joists at panel points only.
8. Support pipe from top flange of beams.
9. Where joists are used, locations of pipe supports shall be approved by the structural engineer prior to installation.
10. Do not support equipment or piping from metal roof deck.

Z. Install pressure gauges as required in manufacturer's installation instructions, and as required per NFPA standards.

AA. Generally install capped tees in lieu of couplings for future connections.

3.04 CLEANING

A. Flush sprinkler system to purge cutting oil, debris and metal fines.

B. Ensure underground feed pipe has been flushed per NFPA 24 to clear out construction debris, prior to connecting aboveground fire protection system to it.

C. Clean systems after installation is complete.

D. Clean piping both internally and externally to remove dirt, plaster dust, or other foreign materials. When external surfaces of piping are rusted, clean and restore surface to original condition. Replacement of heavily soiled and deteriorated materials shall be done at the Contractor's expense.

E. Clean equipment as recommended by manufacturers. Thoroughly clean equipment of stains, paint spots, dirt, dust, and any other foreign materials. Remove temporary labels not used for instruction or operation.

3.05 TESTING

A. Refer to testing paragraph of Section 20 0000 – General Mechanical Requirements.

B. Coordinate fire pump test with Division 26 and Division 28 contractors.

C. Perform all NFPA required acceptance tests.

D. Test sprinkler system as entire system or partial system. System shall be hydrostatically tested at not less than 200 psi or 50 psi above static pressure in excess of 150 psi for 2 h. No leakage allowed. Replace defective joints with new materials. No caulking of defective joints allowed. Re-test system after defective joints are replaced, until satisfactory results are obtained.

E. Hydrostatically test piping between the exterior fire department connection (FDC) and the check valve in the fire department inlet pipe in the same manner as the balance of the system.

F. Pipe shall not be concealed until satisfactorily pressure tested.

G. Conduct drain test. Record static pressure and residual pressure per NFPA 13.

H. Owner's representative or engineer may witness tests. Contractor shall notify Owner and Engineer a minimum of 3 days in advance to allow for participation.

I. Log of tests shall be kept at job site and shall identify:
1. Who performed test
2. Time of test
3. Date of test
4. Section of system tested
5. Results of test
6. Completed Contractor's Material and Test Certification form(s) from NFPA 13
7. Operate flow switches to test that signals are transmitted to Fire Alarm Control Panel.

J. Include test for tamper switches.

END OF SECTION

SECTION 221118
WATER DISTRIBUTION SYSTEM

PART 1 - GENERAL

1.01 DESCRIPTION

A. This Section covers interior domestic cold water, domestic hot water (120-140°F), domestic hot water return, cold soft water (CSW), nonpotable cold water and trap filler lines to a point 5 ft outside building wall.

B. All components shall comply with NSF-61 and NSF-372 to be compliant with requirement for lead content of ≤0.25% maximum weighted average.

1.02 RELATED WORK

A. Section 20 0513 - Motors
B. Section 20 0520 - Excavation and Backfill
C. Section 20 0529 - Mechanical Supporting Devices
D. Section 20 0553 - Mechanical Systems Identification
E. Section 20 0700 - Mechanical Systems Insulation
F. Section 22 2114 - Plumbing Specialties

1.03 QUALITY ASSURANCE

A. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): “The articles listed in FAR 25.104(a) that are acquired as construction materials.”

B. Order pipe with each length marked with manufacturer's name or trademark and type of pipe; with each shipping unit marked with purchase order number, metal or alloy designation, temper, size, and supplier's name.

C. Installed material not meeting specification requirements must be replaced with material that meets these Specifications without additional cost to Owner.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Promptly inspect shipments to ensure material is undamaged and complies with specifications.

B. Cover pipe to prevent corrosion or deterioration while allowing sufficient ventilation to avoid condensation. Do not store materials directly on grade. Protect pipe, tube, and fitting ends from damage. End caps shall remain in place. Protect fittings, flanges, and unions by storage inside or by durable, waterproof, above ground packaging.

C. Offsite storage agreements will not relieve Contractor from using proper storage techniques.

D. Storage and protection methods must allow inspection to verify products.

1.05 SUBMITTALS

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

B. Shop Drawings on items specified herein.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Materials as specified shall be new unless otherwise noted.

B. Materials shall be provided from list of approved manufacturers. Home Market, Generic Broker, or Wholesaler's house brands are not acceptable.

2.02 PIPE, FITTINGS, AND JOINTS

A. Underground 2-1/2" and Smaller:
   1. Copper:
      a. Pipe: Copper tube, Type K, soft (annealed) temper in coils, ASTM B88
      b. Fittings:
         1) Cast copper alloy, solder joint, pressure rated, ANSI B16.18
         2) Wrought copper, solder joint, pressure rated, ANSI b16.22
      c. Joints: Lead free (<0.2%) solder, ASTM B32, flux, ASTM B813
      d. Joints: Where joints are permitted, brazed, silver solder, BCuP-5 Type, AWS.A5.8, 1250°F melting point minimum.
      e. Pre-insulated with polyurethane insulation and PVC jacket.

B. Underground 3" and Larger:
   1. Ductile Iron:
      a. Pipe: Ductile iron, Class 52, AWWA C151, with standard cement mortar lining, AWWA C104
      b. Fittings:
         1) Ductile iron or grey iron, mechanical joint, cement mortar lined, Class 250, AWWA C110
         2) Ductile iron, mechanical joint compact fittings, Class 350, AWWA C153
      c. Joints: Joint shall be restrained type equal to EBAA Iron Megalug 15MJ00TD restraint system for mechanical joint for ductile iron pipe, AWWA C151/A21.51 and AWWA C150/A21.50. Joints shall be designed to accommodate deflection after assembly up to 3°.
      d. Encasement: provide 8 mil tube or sheet polyethylene encasement of iron pipe and pipe fittings, AWWA C105
   2. Polyvinyl Chloride (PVC):
      a. Pipe:
         1) PVC pressure pipe, DR 18, Class 150, AWWA C900; integral bell and elastomeric gaskets, ASTM D3139
         2) PVC pressure pipe, Schedule 80, ASTM D1785, AWWA C900
      b. Fittings:
         1) Ductile iron or grey iron, mechanical joint, cement mortar lining, AWWA C104
         2) Ductile iron, mechanical joint compact fittings, Class 350, AWWA C153
         3) PVC, Schedule 80, socket pattern
      c. Joints:
         1) Elastomeric gaskets, ASTM C3139
         2) Primer, ASTM F656; solvent cement, ASTM D2564

C. Above Ground:
   1. Copper (2-1/2" and Smaller):
      a. Pipe: Copper tube, Type Lhard drawn, ASTM B88
      b. Fittings:
         1) Cast copper alloy, solder joint, pressure rated, ANSI B16.18
         2) Wrought copper, solder joint, pressure rated, ANSI B16.22
         3) Copper, press fit joint, EPDM O-ring, ANSI B16.51, 0° - 250°F, maximum 200 psig. Propress by Viega, ApolloPress by Apollo Flow Controls or Pressystem by Nibco.
      c. Joints:

1) Lead free (<0.2%) solder, ASTM B32, flux, ASTM B813
2) Press fit joint, EPDM O-ring, made with electro-hydraulic crimping tool and jaw correct for pipe size.

d. Nipples: Red brass pipe, threaded
e. Exposed tubing and fittings in kitchen and areas subject to chemical cleaning shall have chrome plated finish.

2.03 UNIONS AND FLANGES

A. General:
1. Unions, flanges and gasket materials to have pressure rating of not less than 150 psig at 180°F.

B. Copper (3" and Smaller):
1. Wrought copper union, Nibco Figure 633-W. Mueller Brass equal.

C. Copper (4" and Larger):
1. Cast red brass flanges, alloy 844, ASTM B584, Class 150, Standard bolt pattern, ANSI B16.24 with neoprene gasket

D. Copper (3" and Larger):
1. Ductile iron flange adapters, ASTM A 536, coated with copper-colored enamel for use with grooved end pipe and fittings, flat face, manufactured for engaging directly into roll grooved copper tube and fittings and bolting directly to flanged components with ANSI Class 125 and 150 bolt hole patterns, EPDM gasket. Victaulic Style 641.

2.04 VALVES

A. Shutoff Valves:
1. Ball Valves (2-1/2"and smaller):
a. Acceptable manufacturers: Apollo, Hammond, Milwaukee, Nibco, Stockham and Watts with indicated features and equal to model listed. Note that not all manufacturers make all sizes. Basis of design valves have threaded or soldered ends. Equivalent valves with press ends are acceptable when press fit joints and fittings are allowed.
b. Full Port, 2 Piece: Bronze body, ASTM B584, stainless steel ball and stem, teflon seats, stem extension with length according to installed system insulation thickness, 600 psi CWP pressure rating, Apollo Series 77CLF-240-01 or approved equal.
c. Full Port, 3 Piece: Bronze body, ASTM B584, stainless steel ball and stem, teflon seats, stem extension with length according to installed system insulation thickness, 600 psi CWP pressure rating, Apollo Series 82LF-240 or approved equal.
d. Insulated Handle: For insulated systems to prevent condensation on valve body with thermal and vapor seal, equal to Apollo Therma Seal.

2. Butterfly Valves (3" and larger):
a. Acceptable Manufacturers: Apollo, Hammond, Kitz, Milwaukee, Nibco, and Stockham with indicated features and equal to model listed. Note that not all manufacturers make all sizes or styles.
b. Grooved Type:
1) Cast brass body, aluminum-bronze disc, stainless steel stem. Disc shall be offset from stem centerline to provide full 360 degree seating. Elastomeric seal, copper tubing sized grooved ends, 300 psi CWP pressure rating, manual level or gear operator with handwheel for 3" to 6", Victaulic Series 608N.
2) Ductile iron body, electroless nickel-plated ductile iron disc, blowout proof 416 stainless steel stem. Disc shall be offset from stem centerline to provide full 360 degree seating. Seat and seal material shall be pressure responsive EPDM, TFE lined fiberglass bearings, grooved ends, 300 psi CWP pressure rating, manual

lever lock handle or gear operator with handwheel, 3” to 12”, Victaulic Vic 300 Masterseal.

3) Stainless steel body and disc, ASTM A351 Grade CF8M, stainless steel stem. Disc shall be offset from stem centerline to provide full 360 degree seating. Seat and seal material shall be EPDM, grooved ends, 300 psi CWP pressure rating, manual lever lock handle or gear operator with handwheel, 3” to 8”, Victaulic Series 861.

3. Gate Valves:
   a. Acceptable Manufacturers: Apollo, Crane, Hammond, Kennedy, Milwaukee, Nibco, and Stockham with indicated features and equal to model listed. Note that not all manufacturers make all sizes.
   b. Size 2-1/2” and Larger: Nickel iron body and wedge, stainless steel trim, outside screw and yoke (OS&Y), 125 psi steam pressure rating, bolted bonnet, flanged pipe ends, Hammond IR1913-HI or approved equal.

B. Swing Check Valves:
   1. Size 2” and Smaller:
      a. Bronze body, ASTM B62, Y pattern, Buna-N resilient disc, horizontal swing, 200 psi CWP rating, Apollo 163S-LF series or approved equal.
   2. Valves 2-1/2” and Larger:
      a. Nickle iron body, horizontal swing, stainless steel or nickel iron disc, stainless steel replaceable seat, 200 psi CWP rating, Nibco F-918-13 or approved equal.

C. Spring Check Valves:
   1. Valves 2” and Smaller:
      a. Bronze body, ASTM B584, in-line lift type with spring, Buna-N or PTFE disc, 250 psi CWP rating, Nibco 480-Y-LFApollo 61LF-500 series or approved equal.
   2. Valves 2-1/2” and Larger:
      a. Cast iron body, wafer type, Buna-N seat, aluminum bronze disc, in-line type with stainless steel spring, 250 psi CWP rating, Mueller 103MAT or approved equal.

D. Balancing Valves:
   1. Circuit Setter:
      a. Acceptable Manufacturers: Bell and Gossett, Watts or approved equal

      2” and Smaller: Shall be of lead-free bronze construction with glass and carbon-filled TFE seat rings and have differential pressure read-out ports across valve seat area. Read-out ports to be filled with internal EPT insert and better connection with check valve. Valve bodies to have 1/4” NPT tapped drain/purge port. Valves to have memory stop feature and calibrated nameplate to assure specific valve setting. Valve to be leak-tight at full-rated working pressure and temperature (300 psi/250°F). B&G Circuit Setter Model CBor approved equal.
   2. Thermostatic Balancing Valve
      a. Acceptable Manufacturers: ThermOmegaTech or approved equal
      b. Stainless steel body, piston and spring, NSF 61 certified, set to fully open at 110F and close at 120F.

2.05 DIELECTRIC FITTINGS

A. Dielectric unions 2” and smaller; dielectric flanges 2-1/2” and larger; with iron female pipe thread to copper solder joint or brass female pipe thread end connections, non-asbestos gaskets and pressure rating of not less than 175 psig at 180°F. Watts Regulator Company, Lochinvar, Wilkins or Epco Sales, Inc.

B. Copper-silicon casting, UNS C87850, threaded or grooved end. UL classified in accordance with NSF-61 for potable water service. Victaulic Style 647

2.06 WATER HAMMER ARRESTORS

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

2.07 IN-LINE CENTRIFUGAL PUMPS FOR TEMPERATURE MAINTENANCE OF POTABLEHOT WATER

A. Manufacturers: Armstrong, Aurora, Bell and Gossett, Deming, Ingersoll-Rand, Taco, Weinman, or Worthington
B. Pumps shall be pipeline mounted, single suction type with cast iron casing, bronze fitted with working pressure of 125 psi and operating temperature of 200°F continuous.
C. Impellers shall be plastic and shall be directly hung from motor shafts without using flexible couplings.
D. Pump shafts shall be ceramic, steel or stainless steel, sealed and gasketed from pumped fluid.
E. Pumps shall be furnished with mechanical carbon/silicon carbide seals.
F. Bearing assemblies and motor shall be permanently oil lubricated and maintenance free.
G. Pump shall be controlled by aquastat located in return pipe at pump with 100°F to 240°F operating temperature with 5°F to 30°F adjustable differential, remote bulb, UL listed similar to Honeywell L6006A1012.
H. Refer to Section 26 2913 - Enclosed Controllers.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install pipe and fittings in accordance with reference standards, manufacturer's recommendations and recognized industry practices.
B. Maintain piping system in clean condition during installation. Remove dirt and debris from assembly of piping as work progresses. Cap open pipe ends where left unattended or subject to contamination.
C. Include connections to plumbing fixtures, to equipment by others, and to equipment requiring water. Provide proper backflow and back siphonage protection to safeguard potable water system from contamination.
D. Lay out water system so as to conform to intent of drawings. Coordinate piping with building features and work of other trades. Install water piping plumb and square with building. Plans indicate, general routing, provide additional offsets as required. Install piping with necessary swing joints and offsets to allow for expansion.
E. Install shut-off valves on branch lines near mains to avoid long dead-leg branches when valves are closed.
F. Install shut-off valves where indicated and at base of risers to allow isolation of portions of system for repair.
G. Do not install water piping within exterior walls.
H. Provide drain valves at base of risers and at low points of trapped piping 2” and larger where trapped water volume exceeds 5 gallons.
I. Install pressure reducing valves where indicated on drawings. Provide pressure gauges on both inlet and outlet sides of valve. Flush strainer and adjust to outlet pressure as scheduled.
J. Provide protective sleeve covering of elastomeric pipe insulation where copper or steel piping is embedded in masonry or concrete.
K. Provide dielectric fittings between dissimilar piping materials.

L. Do not route piping through transformer vaults or above transformers, panelboards, or switchboards, including required service space for this equipment, unless piping is serving this equipment.
M. Install valves and piping specialties, including items furnished by others, as specified and/or detailed. Provide access to valves and specialties for maintenance. Make connections to equipment, fixtures and systems installed by others where same requires piping services indicated in this Section.
N. Install water pipe using proper pipe and fittings. Use reducing fittings for changes in pipe size.
O. Install trap filler lines to slope to drain tailpiece without trapping.

3.02 UNDERGROUND WARNING TAPE

A. Provide warning tape for exterior buried utilities per Section 20 0553.

3.03 COPPER TUBING

A. Copper tubing shall be installed per Copper Development Association guidelines in addition to methods specified herein.
B. Soldered Copper Joints:
   1. Use non-acidic and lead free flux on cleaned pipe and fittings for soldered joints.
   2. Cut tube square, remove burrs from exterior of tube and ream interior of tube before assembly.
   3. Fill joints with solder by capillary action. Solder shall cover joint periphery. Wipe joint clean.
   4. Apply heat carefully to prevent damage to pipe, fittings and valves.
   5. Follow manufacturer's recommendations when heating valves and equipment for soldered connections.
C. Brazed Copper Joints:
   1. Cut tube square, remove burrs from exterior of tube and ream interior of tube before assembly.
   2. Joints shall be cleaned and polished before brazing.
   3. Flux of any type shall not be used.
   4. Apply heat carefully to prevent damage to pipe, fittings and valves. Disassemble valves where possible to prevent damage to seats during brazing.
D. Press Fit Copper Joint:
   1. Cut tube square, remove burrs from exterior of tube and ream interior of tube before assembly.
   2. Tubing shall be clean and dry before inserting into fittings.
   3. Insert pipe fully into fitting and mark on pipe at shoulder of fitting.
   4. Check fitting alignment against mark on pipe to ensure pipe is fully engaged.
   5. Crimp joint with pressing tool approved by fitting manufacturer.
E. Grooved Copper Joints:
   1. All grooved end piping products shall be supplied by single manufacturer. Grooving tools shall be supplied by same manufacturer as grooved fittings and components.
   2. Install rolled groove copper pipe and fittings using equipment specifically for copper tube by mechanical coupling manufacturer.
   3. Use only those couplings and gaskets so designated for copper tube.
      a. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified.
      b. Gaskets shall be supplied by the grooved coupling manufacturer.
   4. Flaring of tube and fitting ends to IPS dimensions is not permitted.
   5. Grooved end shall be clean and free from indentations, projections, and roll marks in area from pipe end to groove for proper gasket sealing.

6. Factory-trained field representative shall provide on-site training for contractor's field personnel in proper use of grooving tools, application of groove, and installation of grooved piping products. Factory trained representative shall periodically review product installation. Contractor shall remove and replace any improperly installed products.

3.04 SPRING LOADED CHECK VALVES

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

3.05 WATER HAMMER ARRESTORS

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

3.06 DIELECTRIC UNIONS AND FLANGES

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

3.07 CLEANING

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

3.08 TESTING

A. Refer to Testing paragraph of Section 20 0000 - General Mechanical Requirements.
B. Water test system may be applied to system in its entirety or in sections. Test piping with water to pressure of 160 psi for 2 h. No decrease in pressure allowed. Provide pressure gauge with shutoff and bleeder valve at highest point of system tested. Inspect joints in system under test.
C. Defective work or material shall be replaced or repaired as necessary and inspection and test repeated. Repairs shall be made with new materials. No caulking of threaded joints or holes will be allowed.
D. Do not conceal pipe until satisfactorily tested.
E. Testing with air will not be allowed.

3.09 BALANCING

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

3.010 DISINFECTION

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

3.011 BACTERIOLOGICAL TESTS

A. Take representative water samples and test to ensure bacteriologically safe water supply system. Include HPC (Heterotrophic Plate Count) test and test for presence of Pseudomonas aeruginosa as well as regular coliform bacteria test. HPC test maximum containment level of 500 organisms/ml. Perform bacteriological tests shortly before Owner's acceptance of building. If tests fail, make corrections and retest.
B. When connecting to existing water supply of unknown quality, sample for analysis and comparison with finished water system analysis shall be taken prior to making new connection. This will allow isolating source of contamination from within scope of work or pre-existing water supply. Final conditions shall meet criteria specified above for areas within scope of work.

END OF SECTION

SECTION 221314
SANITARY WASTE AND STORM DRAINAGE SYSTEMS

PART 1 - GENERAL

1.01 DESCRIPTION

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

1.02 RELATED WORK

A. Section 20 0513 - Motors
B. Section 20 0520 - Excavation and Backfill
C. Section 20 0529 - Mechanical Supporting Devices
D. Section 20 0700 - Mechanical Systems Insulation
E. Section 22 2114 - Plumbing Specialties
F. Section 22 4000 - Plumbing Fixtures

1.03 QUALITY ASSURANCE

A. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): “The articles listed in FAR 25.104(a) that are acquired as construction materials.”
B. Order piping with each length marked with manufacturer's name or trademark and type of pipe; with each shipping unit marked with purchase order number, metal or alloy designation, temper, size, and supplier's name.
C. Installed material not meeting specification requirements must be replaced with material that meets these specifications without additional cost to Owner.

1.04 DELIVERY, STORAGE, AND HANDLING

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

1.05 SUBMITTALS

A. Manufacturer's technical data for the following:
    1. Pipe and fittings
    2. Joints
    3. Cleanouts
    4. Floor drains and floor sinks
    5. Roof drains
    6. Downspout nozzles
    7. Air gap fittings
    8. Discharge check valves
    9. Discharge isolation valves
    10. Traps
    11. Sump pumps

PART 2 - PRODUCTS

2.01 MATERIALS

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

2.02 PIPE, FITTINGS, AND JOINTS

A. Interior Underground 15” and Smaller:
   1. Cast Iron:
      a. Pipe: Hub and spigot pipe, service weight, ASTM A74, NSF certified or CISPI marked.
      b. Fittings: Hub and spigot fittings, service weight, ASTM A74, NSF certified or CISPI marked. Joints: Neoprene rubber compression gaskets, ASTM C564
   2. Polyvinyl Chloride (PVC):
      a. Pipe:
         1) Schedule 40, CLASS 12454 (PVC 1120), ASTM D1785
      b. Fittings: Socket fitting, DWV patterns, ASTM D3311. Fabricated fittings 10” and larger shall be per ASTM F1866.
      c. Joints: Primer, low VOC, ASTM F656; solvent cement, low VOC, ASTM D2564

B. Pressurized Underground 3” and Smaller:
   1. Polyvinyl Chloride (PVC):
      a. Pipe: Schedule 40, Class 12454 (PVC 1120), ASTM D1785
      b. Fittings: Socket pattern pressure fittings, ASTM D2466
      c. Joints: Primer, low VOC, ASTM F656; solvent cement, low VOC, ASTM D2564

C. Pressurized Underground 3” and Larger:
   1. Polyvinyl Chloride (PVC):
      a. Pipe: DR 18, Class 150, AWWA C900, with integral bell
      b. Fittings:
         1) Ductile iron or grey iron mechanical joint cement mortar lined fittings, class 250, awwa c110
         2) Ductile iron mechanical joint compact fittings, class 350, awwa c153
      c. Joints: Elastomeric gaskets, ASTM C3139

D. Interior Above Ground:
   1. Cast Iron:
      a. Pipe: Hubless cast iron pipe, ASTM A-888, CISPI 301, NSF certified or CISPI approved.
      b. Fittings: Hubless cast iron fittings, ASTM A-888, CISPI 301, NSF certified or CISPI approved.
   2. Polyvinyl Chloride (PVC):
      a. Pipe: Schedule 40, Class 12454 (PVC 1120), ASTM D1785
      b. Fittings: Drain, waste and vent (DWV) pattern fittings, ASTM D2665; socket fitting patterns, ASTM D3311. Fabricated fittings 10” and larger shall be per ASTM F1866.
      c. Joints: Primer, low VOC, ASTM F656; solvent cement, low VOC, ASTM D2564

E. Pressurized Interior Above Ground:
   1. PVC (3” and smaller):
      a. Pipe: Schedule 40, Class 12454 (PVC 1120), ASTM D1785
      b. Fittings: Socket pattern pressure fittings, ASTM D2466
      c. Joints: Primer, low VOC, ASTM F656; solvent cement, low VOC, ASTM D2564

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

2.03 VALVES

A. Pump Discharge Check Valves:

1. Acceptable Manufacturers: Hammond, Milwaukee, Nibco and Stockham with indicated features and equal to model listed
2. Size 2" to 4", Horizontal Installation:
   a. Cast iron body, swing check, bronze disc and ring, brass pin, Class 125, threaded ends, Nibco T-918-B
3. Size 2-1/2" and Larger, Vertical Installation:
   a. Cast iron body, swing check, bronze disc to 4" and cast iron disc with bronze disc face rings or bronze disc for 5" and up, lever and spring operator, brass pin, Class 125, flanged ends, Nibco F-918-BLS
4. Size 4" and smaller:
   a. Acceptable manufacturers: Chemtrol, Ipex, Spears, or approved equal
   b. PVC body, swing check, EPDM seals, flanged ends. Spears 4423-(size)

B. Pump Discharge Isolation Valves:
1. Ball Valves:
   a. Acceptable Manufacturers: Apollo, Hammond and Nibco with indicated features and equal to model listed
   b. Size 2" to 3":
      1) Full Port, 2 Piece: Bronze body, ASTM B584, stainless steel ball, teflon seats, stem extension, 600 psi CWP pressure rating, Apollo Series 77-240 or approved equal.
2. Size 2" and smaller:
   a. Acceptable manufacturers: Chemtrol, Ipex, Spears, or approved equal
   b. True union, full port ball valve, CPVC body, ASTM D1784, EPDM o-rings, Teflon seats, socket ends. Ipex VX series

2.04 CLEANOUTS

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

2.05 FLOOR DRAINS

A. Josam, Mifab, Smith, Wade, Watts or Zurn, equal to number listed herein or in Drains and Cleanout Schedule.

B. Floor drains shall be in accordance with ANSI A112.21.1. Provide with caulked or no-hub connection. Floor drains shall have internal seepage collar for embedding in floor construction and weep holes to provide adequate drainage to drain pipe. Include trap primer connection where indicated on drawings.

2.06 ROOF DRAINS AND OVERFLOW DRAINS

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

B. Roof drains and overflow drains shall have cast iron body with adjustable collar, cast iron flashing ring, gravel stops, 10” diameter cast iron dome strainer, and cast iron underdeck clamp.

C. Expansion joints shall be cast iron joint with bronze pipe sleeve and neoprene gasket. J.R. Smith 1710.

2.07 AIR GAP FITTINGS

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

2.08 DOWNSPOUT NOZZLES

A. Acceptable Manufacturers: Josam, Smith, Wade or Zurn equal to number listed

B. Downspout nozzles shall be polished bronze body, wall flange and threaded inlet, equal to J.R. Smith #1770-PB.

2.09 TRAPS

A. Same material as pipe or fittings unless specified or scheduled with fixtures. Refer to Section 22 4000 - Plumbing Fixtures. Provide 17 ga brass, chrome plated traps for exposed traps.

2.010 ELEVATOR SUMP PUMPS

A. Acceptable manufacturers: Aurora/Hydromatic; Liberty, Stancor, Inc., Weil

B. Pump shall be submersible type constructed of epoxy coated cast iron shell, cast iron volute, two vane enclosed recessed vortex non-clog bronze impeller, stainless steel shaft, stainless steel fasteners, upper sleeve and lower ball bearing factory sealed grease lubricated, and ceramic mechanical seal.

C. Pump shall be hermetically sealed, capacitor start, built-in thermal overload protection sized for no-overloading entire pump curve.

D. Pump shall be of capacity and electrical service as indicated in the equipment schedules on the drawings.

E. Pump controls shall include:
   1. Single on/off UL listed float switch
   2. Oil sensor to terminate operation on oil
   3. Alarm with dry contact to BAS

F. Pump accessories shall include:
   1. Discharge check valve
   2. Full port ball valve
   3. Union for each pump

PART 3 - EXECUTION

3.01 INSTALLATION - GENERAL

A. Install pipe and fittings in accordance with reference standards, manufacturer's recommendations and recognized industry practices.

B. Connect piping to fixtures, each piece of equipment, and drains. Install required piping as shown on drawings.
C. Grade horizontal lines with minimum of 1/8” per ft, except piping 2” diameter or smaller which shall be run at 1/4” per ft slope.
D. Grade horizontal lines with minimum of 1/4” per ft, except piping 4” diameter or larger which may be run at 1/8” per ft slope with approval of local authority.
E. Install piping parallel with building lines and at heights, which do not obstruct any portion of window, doorway, stairway, or passageway, except, as may be shown on plans. Install overhead piping as high as possible.
F. Grade vent pipe for complete drainage by gravity to soil or waste pipes. Vent terminations shall be set true and level. Locate vent piping at least 10 ft away from window, door or intake openings. Coordinate closely with roofing contractor to prevent damage to roofing membrane. Flashing shall be in accordance with requirements of roofing manufacturer.
G. Where interferences develop, offset or reroute piping as required to clear interferences. Coordinate locations of plumbing piping with piping, ductwork, conduit and equipment of other trades to allow sufficient clearances. Consult drawings for exact location of pipe spaces, ceiling heights, door and window openings, or other architectural details before installing piping.
H. Provide protective sleeve covering of elastomeric pipe insulation, where piping and/or fittings are embedded in masonry or concrete.
I. Maintain piping in clean condition internally during construction.
J. Mitered ells, notched tees, and orange peel reducers are not allowed. Bushings are not allowed on threaded piping.
K. Do not route piping through transformer vaults or above transformers, panelboards, or switchboards, including required service space for this equipment, unless piping is serving this equipment.
L. Set cleanouts true and level and protect properly throughout construction.
M. Set floor drains true and level and protect properly throughout construction. Weep holes shall be filled with removable material and kept free from concrete and other debris during construction. Weep holes shall be cleaned out for final working order. Provide safing for floor drains installed in elevated slabs.
N. Trap each fixture and piece of equipment requiring sanitary drainage connections. Trap seals shall be standard depth, except when deep seals are required by code. Traps shall be set true and level and located within limits of code requirements. Traps shall not be used as separator, interceptor or other type of device to retain solids. Traps shall be provided with thread type approved cleanout plugs when specified. Protect traps during construction and seal off to prevent stones, debris and other foreign matter from entering before use. Locate running traps for full accessibility with double cleanout.
O. Provide plugs or caps for pipe openings during construction to prevent debris from entering pipe. Temporary plug shall be plastic cap or equivalent.

3.02 UNDERGROUND WARNING TAPE

A. Provide warning tape for exterior buried sewers per Section 20 0553.

3.03 POLYVINYL CHLORIDE (PVC) PIPE

A. Pipe Joints:
   1. Install in accordance with ASTM D2855 "Making Solvent Cemented Joints with PVC pipe and Fittings". Saw cut piping square and smooth. Tube cutters may be used if fitted with wheels designed for use with PVC pipe that do not leave raised bead on pipe exterior. Support and restrain pipe during cutting to prevent nicks and scratches. Bevel ends 10-15 degrees and deburr interior. Check dry fit of pipe and fittings. Reject materials, which are out of round or do not fit within close tolerance. Use heavy body solvent cement for large diameter fittings.

2. Maintain pipe, fittings, primer and cement between 40°F and 100°F during application and curing. Apply primer and solvent using separate daubers (3” and smaller piping only) or clean natural bristle brushes about 1/2 size of pipe diameter. Apply primer to fitting socket and pipe surface with scrubbing motion. Check for penetration and reapply as needed to dissolve surface to depth of 4-5 thousandths. Apply solvent cement to fitting socket and pipe in amount greater than needed to fill gap. While both surfaces are wet, insert pipe into socket fitting with quarter turn to bottom of socket. Solvent cement application and insertion must be completed in less than 1 minute. Minimum of 2 installers is required on piping 4” and larger. Hold joint for 30 seconds or until set, whichever is longer. Reference manufacturer's recommendations for initial set time before handling and for full curing time before pressure testing.

B. Install plastic pipe and fittings as recommended by manufacturer. Include adequate offsets or expansion joints to allow for pipe expansion.
C. Do not install plastic pipe in plenum space.

3.04 CAST IRON PIPE

A. No-hub Piping: Place gasket on end of one pipe of fitting and clamp assembly on end of other pipe or fitting. Firmly seat pipe or fittings ends against integrally molded shoulder inside neoprene gasket. Slide clamp assembly into position over gasket. Tighten fasteners to manufacturer's recommended torque.
B. Hub and Spigot Piping: Clean pipe end, bell, gasket seat and gasket of dirt or debris. Coat end of pipe and gasket with gasket lubricant. Insure pipe is supported off ground so lubricant does not pick up dirt. Push spigot end into end of gasket bell with levered pipe joining tool recommended by pipe manufacturer. Large diameter exterior mains may be joined by pushing end of pipe section with backhoe against wood blocking over pipe end. Insert to fully seated position or to reference mark on pipe.
C. Install cast iron pipe and fittings as recommended by CISPI in their publication "Installation of Cast Iron Soil Pipe and Fittings".
D. Support piping at every coupling. Locate hanger within 18” of coupling.
E. Installations with multiple joints within a 4 ft developed length shall be supported at every second joint.
F. Secure base of risers with thrust restraints to prevent joint separation. Restraint shall be in accordance with CISPI recommendations.
G. Brace horizontal piping 5” and larger to prevent horizontal movement. Install bracing at every branch connection and every change of direction in accordance with CISPI recommendations.

3.05 TESTING

A. Refer to Testing paragraph of Section 20 0000 - General Mechanical Requirements.
B. Gravity Systems:
   1. Water test may be applied to system either in its entirety or in sections. Piping shall be tightly plugged and submitted to 10 ft head of water located at highest point. Provide separate standpipe above highest point being tested or extend system to obtain required 10 ft head of water. Head shall be maintained for at least 30 minutes before inspection starts.
C. Pressurized Systems:
   1. Water test system may be applied to system in its entirety or in sections. Test piping with water to pressure of **[**25 psi**] [**50 psi**]** for 2 h. No decrease in pressure allowed. Provide pressure gauge with shutoff and bleeder valve at highest point of system tested. Inspect joints in system under test.
D. Defective work or material shall be replaced or repaired as necessary and inspection and test repeated. Repairs shall be made with new materials. No caulking of threaded joints or holes will be allowed.

E. Do not backfill pipe until successfully tested.
F. Testing with air will not be allowed.

END OF SECTION

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SECTION 221600
NATURAL GAS PIPING

PART 1 - GENERAL

1.01 DESCRIPTION

A. This Section specifies natural gas piping and accessories to 5 ft outside building wall.

1.02 RELATED WORK

A. Section 20 0520 - Excavation and Backfill
B. Section 20 0529 - Mechanical Supporting Devices
C. Section 20 0553 - Mechanical Systems Identification

1.03 QUALITY ASSURANCE

A. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): “The articles listed in FAR 25.104(a) that are acquired as construction materials.”
B. Order piping with each length marked with manufacturer's name or trademark and type of pipe; with each shipping unit marked with purchase order number, metal or alloy designation, temper, size, and supplier's name.
C. Installed material not meeting specification requirements must be replaced with material that meets these Specifications without additional cost to Owner.

1.04 DELIVERY, STORAGE, AND HANDLING

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

1.05 SUBMITTALS

A. Manufacturer's technical data for the following:
   1. Pipe and fittings
   2. Joints
   3. Valves
   4. Regulators
B. Shop Drawings on items specified herein.

1.06 NATURAL GAS SERVICE

A. Gas service, meters and regulating equipment will be installed by gas company on inlet side of meters.

PART 2 - PRODUCTS

2.01 MATERIALS

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

2.02 BELOW GROUND PIPE, FITTINGS AND JOINTS

A. 2” and Smaller:
   1. Pipe: Thermoplastic polyethylene tubing, PE 2406 or PE3408, ASTM D3350, SDR-11, rated for 80 psig working pressure at 73°F, ASTM D2513
   2. Fittings: ASTM D2683, socket fusion. Use transition fitting at joints between polyethylene tubing and steel with protective coating. Transition fittings shall have socket joint on polyethylene tubing side and plain beveled end on steel side.

3. Joints: Socket fusion
4. Trace Wire: No. 12, copper 600 V, THHN insulation

B. Anodeless Gas Riser:
1. Acceptable manufacturers: Elster Perfection, Gastite, Georg Fischer, Lyall, or approved equal
2. Manufactured polyethylene to carbon steel transition fitting, requiring no cathodic protection for buried carbon steel pipe, socket, or butt fusion connection for polyethylene pipe, plain beveled end for carbon steel pipe, electrostatically applied epoxy coating on carbon steel pipe, CSA listed

2.03 ABOVE GROUND PIPE, FITTINGS AND JOINTS (UNDER 2 PSIG)

A. 4”and Smaller:
1. Pipe: ASTM A53, Grade A or B, Type E, or ASTM A106, Grade B, standard weight, (Schedule 40), carbon steel
2. Fittings: ASTM A197/ANSI B16.3 Class 150, black malleable iron, threaded
3. Joints: Threaded

2.04 ABOVE GROUND PIPE, FITTINGS AND JOINTS (2 PSIG)

A. 2” and Smaller:
1. Pipe: ASTM A53, Grade A or B, Type E, or ASTM A106, Grade B, standard weight, (Schedule 40), carbon steel
2. Fittings: ASTM A105/ANSI B16.11, 3000 lb forged steel, socket weld
3. Joints: Welded

2.05 UNIONS

A. Steel Pipe, 2” and Smaller:
1. Malleable iron, ground brass seat, 150 psi steam working pressure; Anvil 2125 or equivalent
2. Forged steel, spiral wound gasket seats, ASTM A105, ANSI B16.5

2.06 FLANGES

A. Steel Pipe, 2-1/2” and Larger:
1. ANSI 150 lb class forged steel flanges, ASTM A105/ANSI B16.5. Standard bolt pattern, ANSI 150 lb class 1/8” thick gasket, Type 304 stainless steel, spiral wound metal with graphite filler.

2.07 VALVES

A. Plug Valves:
1. Acceptable Manufacturers: DeZurik, Homestead, Key Port, Milliken and Resun equal to manufacturer's Figure number listed
2. 2” and Smaller:
a. Cast iron body, threaded, permanently lubricated bearings, bronze plug, corrosion resistant Hycar plug seal, Buna stem seal packing, lever actuator, 175 psi CWP, UL Listed. Key Port Figure 425S.
3. 2-1/2” through 4”:
a. Cast iron body, flanged, permanently lubricated bearings, electroless nickel plated cast iron plug, corrosion resistant Hycar plug seal, Buna stem seal packing, lever actuator, 175 psi CWP, UL Listed. Key Port Figure 425F.

B. Vented Gas Pressure Regulators:
1. Acceptable Manufacturers: Fisher, Rockwell, Sensus, or American meeting capacity and performance listed
2. Valves shall be capable of supplying flow rates and pressures of respective equipment as indicated on the drawings.

3. Provide manufacturer recommended regulators.

C. Non-Vented Gas Pressure Regulators:
1. Acceptable Manufacturers: Maxitrol 325 with VLimiter, Pietro Fiorentine “Gas Governor”, or approved equal.
2. 2” and Smaller: Cast iron or cast steel body, plated steel spring, threaded, external vent limiter, 2 psi maximum inlet pressure, listed in compliance with ANSI Z21.80.
3. Valves shall be capable of supplying flow rates and pressures of respective equipment as indicated on the drawings.
4. Provide manufacturer recommended regulators.

PART 3 - EXECUTION

3.01 GENERAL

A. Install gas piping according to requirements of this Section, local gas utility, NFPA 54 National Fuel Gas Code, AGA pamphlets and as shown on drawings.
B. Piping through roof to be run through approved roof penetration with flashing and counter flashing.
C. Install buried/underground polyethylene gas piping with trace wire taped to pipe along its entire route. Secure wire to pipe to prevent movement during backfilling. Extend trace wire to valve boxes and service entrance.
D. Transition from polyethylene piping to steel piping shall occur below grade. Provide cathodic protection and corrosion protection pipe wrap for underground steel pipe.
E. Install underground polyethylene gas piping exterior to building according to pipe manufacturer's recommendations and to meet local gas utility company's installation standards.
F. Manufacturer's representative shall instruct workmen in proper techniques for installation of underground polyethylene gas piping and provide certification to Owner that instructions have been given and proficiency been demonstrated by Contractor for installation of that piping system. Joints must be made by "Qualified" personnel proficient in joining methods of ASTM D2513 thermoplastic gas pressure pipe.
G. Grounding to gas piping is prohibited.
H. Gas piping shall be installed with dirt legs adjacent to equipment and with drain tees and plugs at low points.
I. Gas piping in plenum ceilings shall have welded joints.
J. Install gas piping above ground in buildings. Gas piping shall not be installed below building floor or footings.
K. Pitch horizontal piping downward at 1” per 60 ft in direction of flow toward risers or appliances. Install minimum of 4” deep dirt leg at bottom of each vertical run and at each appliance. When installing mains and branches, cap gastight each tee or pipe end, which will not be immediately extended. Take branch connections to main from top or side of main.
L. Coat underground piping with corrosion resistant tape equal to Tapecoat H-30 and cathodically protected as specified herein. Repair breaks in tape coating caused by installation process.
M. Make threaded joints by cutting pipe square and reaming inside. Threads shall be cut so exposed threads do not exceed 3 in number. Protect exposed threads against corrosion. Use only joint compounds approved for gas piping.
N. Do not route piping through transformer vaults or above transformers, panelboards, or switchboards, including the required service space for this equipment, unless piping is serving this equipment.

3.02 UNDERGROUND WARNING TAPE

A. Provide warning tape for exterior buried gas lines per Section 20 0553.

3.03 PRESSURE REGULATORS

A. Install regulators in accordance with manufacturer's instructions.

B. Regulator shall be accessible for maintenance and protected from fire and mechanical damage. Regulator shall be supported from structure by brackets and supports.
C. Vent(s) from vented pressure regulators or pressure safety valves shall be piped to outside. Terminate vent with protection screen and return bend. If above ground vent terminates in area subject to snow accumulation, terminate line at least 5 ft above grade. Coordinate vent routing with other trades to point of termination. Size vents in accordance with regulator manufacturer's requirements for regulator flow rate and length of run.
D. Provide unions on both sides of regulators for removal and maintenance.
E. Provide gas cock for pressure verification.

3.04 WELDER QUALIFICATIONS

A. Welding procedures, welders, and welding operators for building service piping to be in accordance with certified welding procedures of National Certified Pipe Welding Bureau and Section 927.5 of ASME B31.9 Building Services Piping or AWS 10.9 Qualification of Welding Procedures and Welders for Piping and Tubing.
B. Before metallic welding is performed, submit Welding Procedure Specification together with Procedure Qualification Record as required by Section 927.6 of ASME B31.9 Building Services Piping.
C. Before polyethylene fusion welding is performed, submit certification that welders to be used on this project have successfully demonstrated proper welding procedures in accordance with Code of Federal Regulations, Title 49, Part 192, Section 192.285.
D. Before welding is performed, submit Standard Welding Procedure Specification together with Procedure Qualification Record as required by Section IX of ASME Boiler and Pressure Vessel Code.
E. Welded joints shall be made in conformance with latest provision of Code for Pressure Piping, ANSI Standard B31-8 - Gas Transmission and Distribution Systems. Welds to be made by qualified welders experienced in piping work. Welding, piping fabrication, etc. shall be in accordance with ASME Code, State Codes, and Welding Manual of Mechanical Contractors Association of America.
F. Architect or Engineer reserves right to test work of welder employed on Project, at Contractor's/Owner's expense. If work of welder is found to be unsatisfactory, welder shall be prevented from doing further welding on project and defective welds replaced at no additional cost to Owner.

3.05 TESTING

A. Test above ground steel gas piping with dry compressed air at 50 psi for 2 h. Soap test of each joint shall be done to detect leaks during 2 h period. No loss of pressure allowed during test period. No piping shall be concealed until successfully tested.
B. Test underground polyethylene gas piping at 50 psi with dry air for 2 h. No loss in pressure allowed. Defective joints shall be cut out, pipe repaired, and retested. No piping may be backfilled until successfully tested.
C. Types and extent of non-destructive examinations required for pipe welds are as shown in Table 136.4 of ASME Code for Pressure Piping, ANSI/ASME B31.1 - Power Piping. If requirements for non-destructive examination are to be other than that stated above, degree of examination, and basis for rejection shall be matter of prior written agreement between fabricator, or Contractor and purchaser.
D. Local regulating and governing agencies may require periodic testing of seismic valve’s ability to shut-off gas flow during seismic event. Follow procedures specified by local governing agency for test.

3.06 CLEANING

A. Before actuation of gas system, flush system with dry nitrogen to ensure clean system free of oil and construction debris.

END OF SECTION

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SECTION 222114
PLUMBING SPECIALTIES

PART 1 - GENERAL

1.01 DESCRIPTION

A. This Section covers material specialties for piping systems.

B. All components installed on water systems defined in Section 22 1118 shall comply with NSF-372 to be compliant with requirement for lead content of <0.25% maximum weighted average.

1.02 RELATED WORK

A. Section 22 0594 - Domestic Water Systems Balance

B. Section 22 1118 - Water Distribution System

C. Section 22 1314 - Sanitary Waste and Storm Drainage Systems

1.03 SUBMITTALS

A. Manufacturer's technical data for the following:

1. Thermometers
2. Pressure gauges
3. Pressure relief valves
4. Strainers
5. Backflow preventers
6. Flexible connections
7. Air vents
8. Trap primers
9. Flashings
10. Safings

B. Shop drawings on items specified herein.

C. Certificates: Submit performance testing certificates for reduced pressure backflow preventers and double check backflow preventers.

PART 2 - PRODUCTS

2.01 MATERIALS

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

2.02 THERMOMETERS

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

B. Thermometers shall be 9” die cast aluminum case and frame, double strength glass window, adjustable angle stem, permanently stabilized glass tube with mercury free indicating fluid, readable scale with gradations from 30°F to 240°F. Provide brass extension neck sockets of appropriate length. Trerice Series No. A400 (old catalog number BX91400).

2.03 THERMOMETER SOCKETS AND TEST WELLS

A. Brass construction with threaded connections suitable for thermometer bulbs and control sensing devices, well length suitable for pipe diameter with extended neck as required to suit pipe insulation. Trerice 5550 Series.

B. Test wells for stainless steel piping shall be same material as piping.

2.04 PRESSURE GAUGES

A. Manufacturers: Ashcroft, Marsh, Marshalltown, Miljoco, Taylor, Trerice, U.S. Gauge, Weiss, and Winters, equal to Trerice number listed

B. Pressure gauge shall be 4-1/2” die cast aluminum case, double strength glass window, readable dial scale with gradations from 0 to 200 psi, phosphor bronze bourdon tube, brass socket. Provide shutoff valve with pressure gauge, Trerice Series No. 600.

C. Gauge accuracy shall meet ASME B40.1 Grade 1A (1% full scale).
D. Pressure gauges shall be calibrated for the following pressure ranges:
   1. Domestic Water: 0 to 160 psi at 2 psi increments
E. Pressure Snubbers:
   1. 1/4” or 1/2” size, matching gauge size, 1000 psig WP. Brass for copper or carbon steel pipe, stainless steel for stainless steel pipe.

2.05 PRESSURE RELIEF VALVE

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

2.06 STRAINERS

A. Manufacturers: Apollo, Hoffman, Keckley, Metraflex, Mueller, Watts, Wheatley or Zurn
B. Strainers shall be comparable to regulator or control valve specified. Strainers shall be "Y" type for liquid service to 300 lbs WOG at 210°F, with 20 mesh stainless steel screen. Body material shall be compatible with installed piping, stainless steel, or FDA approved, heat fused, epoxy coated interior.

2.07 BACKFLOW PREVENTERS

A. Reduced Pressure Zone Backflow Preventers (RPBP):
   1. Manufacturers: Apollo, Cla-Val, Febco, Watts or Zurn, equal to model listed
   2. 3/4” through 2”: Lead free cast copper silicon body, resilient check valve seats, shut-off valves, Y-pattern strainer with bronze body and stainless steel screen, drain line air-gap fitting, bronze test cocks, certified in accordance with ASSE 1013 and AWWA C511, equal to Watts number LF919-S
   3. 2-1/2” through 10”: Lead free body, stainless steel housing, EPDM elastomers, butterfly isolation valves, drain air-gap fitting, bronze test cocks, certified in accordance with ASSE 1013 and AWWA C511, equal to Watts number 957
B. Dual Check Backflow Preventers (DBP):
   1. Ice Makers: Watts LF7 or 7C, all bronze construction, union connection, 150 psig pressure rating, 180°F temperature rating, ASSE 1024. Provide chrome finish where installed exposed in spaces with finished floors, walls and ceilings.
   2. Coffee Machines: Watts SD-3, 316 SS construction, NPT connection, 200 psig pressure rating, 110°F temperature rating, ASSE 1022, strainer.
   3. Lab fitting: All bronze construction with stainless steel trim, lead free construction, union connections, 150 psi pressure rating, 180°F temperature rating, and conforming to ASSE Standard 1024 / CSA B64.6. Watts series LF7R or approved equal.

2.08 TRAP PRIMERS

A. Manufacturers: Precision Plumbing Products, Portland, OR.
B. Electronic trap primer manifold, cabinet mounted; with 24 h timer, vacuum breaker, solenoid valve and hydraulic shock arrestor. Control wiring shall be 120 V single phase 3 wire connection for 120 V solenoid and 24 h timer. Box includes manual on/off switch and 2 amp fuse. Provide assembly without factory installed valve. Plumbing Contractor shall install a 3/4” ball valve as specified in Section 22 1118 - Water Distribution System. Cabinet shall be 14” x 16” x 3-1/2” deep, 16 ga box with 14” x 16” hinged prime coated door. Model No. PTS-4, PTS-6, PTS-8, PTS-10 or PTS-12.

2.09 IN-LINE TRAP SEALER

A. Manufacturers: Mi-Gard by Mifab, Quad Close Trap Seal by Jay R. Smith, Sure Seal by Rector Seal, Trap Guard by Proset or ZShield by Zurn

B. Inline trap sealer shall be ABS plastic housing and neoprene rubber diaphragm or Elastomeric PVC material with self-closing bottom. In-line trap sealer shall conform to ASSE 1072.

2.010 FLEXIBLE CONNECTIONS

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

2.011 AIR VENTS

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

2.012 FLASHINGS

A. Elastomer Membrane Roofing:
   1. Pipe clamps, Fernco Series 1056 flex coupling with Series 300 stainless steel clamps.
B. Built-Up Roofing:
   1. 4 lb/ft^2 sheet lead, to 18" beyond drain perimeter.
   2. Preformed lead vent collar, 4 lb/ft^2 sheet lead, to 18" beyond vent perimeter; 18" minimum square base flange.
   3. Nobleflex roof drain flashing of Chloraloy and 20 lb/ft^2 asphalt saturated roofing felt bonded together.

2.013 SAFINGS

A. 4 lb/ft^2 sheet lead, to 18" beyond edge of drain on all sides.
B. Chlorinated polyethylene (CPE) as manufactured by Noble Company under trade name Chloraloy 240.
C. Polyvinyl Chloride (PVC) shower pan line, 40 mil thickness, ASTM D4551.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Provide thermometers where indicated on drawings. Thermometers shall be easily read from floor or maintenance platforms. Calibrate thermometers to insure accuracy.
B. Install pressure gauges where indicated on drawings. Gauges shall be easily read from floor or maintenance platforms. Provide extensions as required to make gauges easily readable. Calibrate gauges to insure accuracy.
C. Install backflow preventers as indicated on drawings. Flush debris from strainers. Certified tester shall test reduced pressure zone backflow preventers to verify that functions are operational. Route vent line to adjacent hub drain.
D. Install strainers for equipment including pumps, meters, backflow preventers, reducers and regulators, and as shown on drawings.
E. Install trap primer units as recommended by manufacturer and as indicated for priming drain traps. Ensure positive air gap to protect against backflow.
F. Install in-line check valves where specified or as indicated on drawings.
G. Install flexible connections for base mounted pumps and other vibrating equipment.
H. Install air vents at high points in water systems where air may collect.
I. Safing:
   1. Install safing for floor drains. Extend safing to 18" from edge of drain. Safing shall be clamped to floor drain body and pitched to drain to weep holes. Floor drains installed in unexcavated areas do not require safing.
   2. Where core drilled floor drain installation into existing floor slab has been approved by A/E, drain strainer inlet shall be grouted in place with non-shrink epoxy concrete approved by Structural Engineer. Refer to detail Section 22 0690 - Plumbing Details.

3. Install safings for showers. Concrete floor shall be smooth and free of dirt. Seal joints per manufacturer's recommendations and turn up sides minimum of 6” above curb or maximum water level. Safing shall clamp into drip pan of floor drain and be secured by flashing clamp to assure drainage into weep holes of drain body. Inside vertical corners of showers shall have 12” strips 6 ft above floor, extend 6” in each direction and bottom to overlap pan 3”.
4. Membrane roofing material, preformed elastomer pipe pots, and flashing seams are provided by Roofing Contractor for pipe penetrations and drain flashing. Plumbing Contractor shall provide drain flashing clamps and stainless steel strap clamps for piping penetrations. Coordinate with General Contractor to facilitate sealing drain flashing and pipe penetrations.

J. Flashing:
1. Coordinate flashings on roof closely with Roofing Contractor. Install flashings as required to insure proper vapor barrier and as directed by Architect.
2. Install flashing for roof drains and overflow drains. Flashing shall extend minimum of 18” beyond edge of drain and shall be clamped into drain body.
3. Use premolded flashing assembly for roof penetration of medical air intake piping. Install 1” of insulation between flashing and outside of pipe.
4. Use premolded flashing assembly with hood for roof penetrations of medical vacuum exhaust piping. Set bottom of hood at 24” above finished roof.
5. Roof penetrations for corrosive or acid vent systems shall be preformed EPDM vent pot with flex coupling pipe clamp collar.

3.02 TESTING

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

END OF SECTION

SECTION 223314
WATER HEATING EQUIPMENT

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 20 0529 - Mechanical Supporting Devices
B. Section 20 0553 - Mechanical Systems Identification
C. Section 22 1118 – Water Distribution System
D. Section 22 2114 - Plumbing Specialties

1.02 QUALITY ASSURANCE

A. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): “The articles listed in FAR 25.104(a) that are acquired as construction materials.”
B. Water heating equipment shall conform to State and Local Codes, meet national standards, and be certified by respective organization and bear its stamp.

1.03 SUBMITTALS

A. Shop drawings on items specified herein.

PART 2 - PRODUCTS

2.01 MATERIALS

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

2.02 ATMOSPHERIC GAS FIRED TANK TYPE WATER HEATER

A. Manufacturers: A.O. Smith, Bock, Bradford White, Lochinvar, Rheem, Ruud, State
B. Water heater shall be high efficiency atmospheric gas fired water heater. Water heater design shall bear “CSA Design Certified” mark, have 5 yr tank warranty and have 1 yr parts warranty.
C. Burner shall be cast iron or stainless steel with thermostat adjustment of 90°F to 180°F. Controls shall be arranged for emergency shut off in event of pilot failure.
D. Tank shall be glass lined steel ASME rated for 150 psig. Tank shall have removable magnesium anode rod, pressure and temperature relief valve, drain valve, boiler-type hand-hole cleanout, draft hood, polyurethane insulation, painted steel jacket, inlet and outlet thermometers, and gas pressure regulator set for operation at 14” WC natural gas.
E. Refer to Water Heater Schedule for water heater capacity required.

2.03 THERMAL EXPANSION TANK

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

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install water heaters as recommended by manufacturer. Provide final connections as required. Coordinate water heater location with other Contractors.
B. Initial start up and balancing service shall be provided by representative of manufacturer.

END OF SECTION

SECTION 22 4000
PLUMBING FIXTURES

PART 1 - GENERAL

1.01 DESCRIPTION

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

1.02 RELATED WORK

A. Section 22 1118 - Water Distribution System
B. Section 22 1314 - Sanitary Waste and Storm Drainage Systems
C. Section 22 1600 - Natural Gas Piping
D. Section 22 6114 - Laboratory Compressed Air System
E. Section 22 6653 - Corrosion Resistant Waste and Vent System

1.03 QUALITY ASSURANCE

A. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): “The articles listed in FAR 25.104(a) that are acquired as construction materials.”

1.04 SUBMITTALS

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

PART 2 - PRODUCTS

2.01 MATERIALS

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

2.02 MANUFACTURERS

A. Plumbing fixtures shall be provided from list of approved manufacturers. Home Market, Generic Broker, or Wholesaler’s house brands are not acceptable.
B. Water closets, urinals, and lavatories: American Standard, Kohler, or Zurn equal to number listed
C. Water Closet Seats: Bemis, Beneke, Centoco, Olsonite or Zurn equal to number listed
D. Flush Valves: Delaney**,** Sloan or Zurn equal to number listed
E. Stainless Steel Sinks: Advance Tabco, Elkay or Just equal to number listed
F. Electric Water Coolers: Elkay, Halsey-Taylor, Haws, Oasis, or Sunroc equal to model listed
G. Service Sinks: American Standard, Eljer, or Kohler equal to number listed
H. Mop Basins (Janitor Sinks): Fiat, Mustee, Stern-Williams, or Zurn equal to number listed

I. Emergency Eyewashes and Showers: Acorn, Bradley, Encon, Guardian, Haws, or Speakman, equal to number listed
J. Manual Faucets: Chicago Faucet, Delta HDF, Kohler or Moen Commercial, equal to number listed
K. Sensor Activated Faucets: Bradley, Chicago Faucet, Kohler, Sloan, TOTO or Zurn equal to model listed
L. Fixture Traps: Engineered Brass Company, Kohler, McGuire, or Zurn equal to number listed
M. Insulated Traps and Supplies: McGuire or True-Bro equal to model listed
N. Supplies and Stops: Chicago Faucet, Kohler, McGuire or Zurn equal to number listed
O. Shower Valves and Mixing Valves: Acorn, Leonard, Powers or Symmons equal to number listed

2.03 CARRIERS AND SUPPORTS

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

2.04 WATER CLOSETS AND URINALS

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

2.05 WATER CLOSET SEATS

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

2.06 PROTECTIVE PIPE INSULATION COVERS

A. Manufactured plastic wraps for covering plumbing fixture hot and cold water supplies, trap and tailpieces shall comply with Americans with Disabilities Act (ADA) requirements.

2.07 PLUMBING FIXTURES

A. Refer to schedule on drawings for detailed fixture selection criteria not contained herein.

2.08 LABORATORY FIXTURES

A. Refer to schedule on drawings for detailed fixture selection criteria not contained herein.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install plumbing fixtures as recommended by manufacturer. Caulk around fixtures mounted on irregular surfaces such as tile or stone with silicone sealant, same color as fixture.
B. Support fixtures with proper carrier for each use. Insure that carrier is solidly anchored to prevent rocking whatever piping is used. Anchor bolts in carrier foot shall extend 3” minimum into concrete slab.
C. Fixture carriers shall be suitable for securing each plumbing fixture in place solidly, yet allowing its removal when necessary. Carriers shall be capable of mounting "Barrier Free" fixtures at suitable heights.
D. Rough in and test water closet carriers with plastic coupling. Before installing fixture, remove plastic coupling and install steel coupling.

E. Install each fixture with trap easily removable for servicing and cleaning. Install fixture stops in readily accessible location for servicing.
F. Install barrier free fixtures in compliance with local code and Federal ADA Accessibility Guidelines. Install barrier free lavatory traps parallel and adjacent to wall and supplies and stops elevated to 27” above finished floor to avoid contact by wheelchair users.
G. Return fixture waste and supply piping into wall as high as practical under fixture. Provide accessible shutoff in fixture supply. Protect "barrier free" supply and drain piping with white colored wrap neatly trimmed to prevent contact with hot or sharp surfaces by user.
H. Coordinate with Electrical Contractor for electronic sensor wiring necessary to install "sensor" operated fixtures. Provide "shockstops" at supplies to solenoid activated fixtures.
I. Provide individual supplies to fixtures and rough-in fixture piping with adequate support to prevent movement fore, aft and laterally. Provide additional blocking as required.
J. Install flush valves for barrier-free water closets with operator handle facing wide side of toilet stall.
K. Provide unions at water connections to drinking fountains and electric water coolers.

3.02 LABORATORY BENCH AND CUP SINKS

A. Set sink, faucet, eyewash, drain and tailpiece.
B. Make final waste, vent and water connections to fixture.
C. Purified water outlets do not require fixture stops.

3.03 LABORATORY CASEWORK OUTLETS

A. Set fixtures in predrilled casework.
B. Make final connection of fixture to service piping.

3.04 FUME HOODS

A. Set cup sink, faucet, drain and tailpiece.
B. Make final connections to service piping or pre-piped hood. Vent piping for cup sink will not be pre-piped.

3.05 PROTECTION

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

3.06 CLEANING

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

END OF SECTION

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SECTION 226114
LABORATORY COMPRESSED AIR SYSTEM

PART 1 - GENERAL

1.01 DESCRIPTION

1.02 RELATED WORK

A. Section 20 0513 - Motors
B. Section 20 0529 - Mechanical Supporting Devices

1.03 QUALITY ASSURANCE

A. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): “The articles listed in FAR 25.104(a) that are acquired as construction materials.”

1.04 SUBMITTALS

A. Shop drawings on items specified herein.

1.05 PRODUCT DELIVERY

A. Deliver pipe and equipment properly packaged to protect against shipping and handling damage.
B. Installed pipe shall be sealed during construction to prevent construction debris from entering piping system.

PART 2 - PRODUCTS

2.01 MATERIALS

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

2.02 PIPE AND FITTINGS

A. Above Ground
    1. Copper
        a. Pipe:
            1) Copper tube, Type L, hard temper, cleaned and capped, ASTM B819, marked "MED" or similar in accordance with ASTM
        b. Fittings: Wrought copper, solder joint, pressure rated, cleaned and bagged, ANSI B16.22
        c. Joints: Brazed, silver solder, BCu-3 or BCuP-5 type, AWS A5.8, 1250ºF melting point minimum.

2.03 UNIONS

A. Copper 3” and smaller:
    1. Wrought copper union, Nibco 633-W

2.04 VALVES

A. Ball Valves:
    1. Acceptable manufacturers: Apollo, Nibco, Watts
    2. 3” and Smaller:
        a. Full port, 2-piece, bronze body, chrome plated bronze ball, teflon seats, blowout-proof stem, and threaded or soldered joint, Watts FBV or FBVS
        b. Full port, 3-piece, bronze body, stainless steel ball, PTFE seats, stainless steel trim, blow-out proof stem, 6” tube extension, oxygen cleaned and bagged, quarter turn handle, 600 psi CWP; Nibco CS-595-YX-66-EC Series, Apollo 82 240 Special Female through 2”
B. Check Valves
    1. Acceptable manufacturers: Apollo, Nibco, Watts

2. 2” and smaller:
    a. Spring loaded, bronze or bronze/stainless steel body, 316 stainless steel spring, straight through flow, shipped bagged and oxygen clean. Apollo Ball-Cone Model 62-100-57.

2.05 PRESSURE REGULATORS

A. Manufacturers: Cashco, Fisher, Jordan or approved equal
B. Bronze body and spring case, direct acting valve, manual adjustment screw with top nut, stainless steel trim, resilient valve seat, cleaned for oxygen service. Cashco Model D Series or approved equal, Jordan Mark 68G Series. Refer to schedule on drawings for performance criteria.

2.06 AUTOMATIC DRAIN DEVICE

A. Acceptable manufacturers: Jorc or approved equal
B. Automatic condensate removal device with zero air loss during condensate discharge. Drain device shall have Viton seals and shall have 120 V power connection.
C. Basis of design is Jorc “Smart Guard Ultra” capable of up to 3600 scfm at up to 230 psig at 34-112°F.

2.07 OIL-LESS RECIPROCATING AIR COMPRESSOR (AC-1)

A. Manufacturers: Atlas Copco, Ingersol-Rand, Powerex, Quincy, Squire-Cogswell
B. Air compressor shall be duplex air cooled, oil less reciprocating unit. Compressor shall be tank mounted and shall be factory wired, piped, and tested prior to delivery to jobsite.
C. Compressors shall operate in lead/lag/alternate configuration. Panel for compressor control shall be included with package.
D. Each compressor shall be provided with following components:
    1. 10 micron inlet filter
    2. Air intake silencer
    3. Discharge air check valve
    4. Manual compressor isolation valve
    5. Air cooled aftercooler
    6. 230 or 460 V, 3 Ph motor meeting efficiencies listed in 20 0513
    7. Capacity of 80 cfm at 100 psig
    8. Control panel:
        a. Fused disconnect switches
        b. Magnetic across-the-line starters with thermal overload protection
        c. Automatic pump start and stop
        d. Automatic pump lead/lag controls
        e. Automatic alternator, controlled by time clock
        f. 120 volt control transformer
        g. Compressor discharge pressure gauge
        h. Power indicator
        i. Pump running indicators
        j. High temperature shut-down switch
        k. Individual hand-off-auto switches
        l. Motor overload alarm.
E. Basis of design: Refer to schedule on drawings for detailed fixture selection criteria not contained herein.

2.08 REFRIGERATED AIR DRYER

A. Manufacturers: Arrow by McIntire, Deltech, Hankinson, Zeks
B. Air dryers shall be refrigerated units piped in parallel. Air dryers shall be factory wired, piped and tested prior to delivery to jobsite.

C. Air dryers shall be provided with following components:
   1. Simplex inlet coalescing filter with automatic drain device
   2. Simplex outlet particulate filter
   3. Hot gas bypass
   4. Air cooled condensing unit
   5. Capacity of 80 scfm at 40°F dewpoint discharge air
   6. 120 V, 1 Ph power connection
   7. NEMA 4 control panel with following features:
      a. Power indicator
      b. Compressor on indicator
      c. High air temperature alarm
      d. Locally mounted dewpoint indicator
      e. High humidity alarm
      f. Extra set of dry contacts for alarm monitoring to Building Automation System

D. Basis of Design: Refer to schedule on drawings for detailed fixture selection criteria not contained herein.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install compressed air piping as shown on drawings and details.
B. Provide low point drain valve at bottom of risers. Pipe mains shall not be trapped between connection at riser and last branch take-off. Branch take-offs to rooms or individual spaces shall be from top of main.
C. Cut copper tube square and ream before assembly. Keep piping capped during construction to prevent intrusion of construction debris.
D. Support piping drops through finished ceiling from structure above to prevent any lateral or up/down movement. Other outlet drops shall be supported from walls, columns, or workbenches using appropriate hangers, anchors, or Unistrut.
E. Install unions on equipment side of shutoff valves for items such as: air dryers, receiver, compressors, filters, and similar equipment requiring periodic replacement or maintenance.
F. Install vented valve for lock-out/tag-out at connection to equipment. Vented valve shall meet OSHA requirements for disabling power source and bleeding downstream energy.
G. Install temporary plugs and caps on openings during construction phase.

3.02 COPPER TUBING

A. Copper tubing shall be installed per Copper Development Association guidelines in addition to methods specified herein.
B. Brazed Copper Joints:
   1. Brazed joints shall be ASTM Grade 4 or 5 and have melting point at approximately 1250ºF. Solder impurities shall not exceed 0.15%.
   2. Tubing shall be delivered to site with original mill caps in place.
   3. Cut tube square, remove burrs from exterior of tube and ream interior of tube before assembly.
   4. Joints shall be cleaned and polished before brazing.
   5. Flux of any type shall not be used.
   6. Apply heat carefully to prevent damage to pipe, fittings and valves. Disassemble valves where possible to prevent damage to seats during brazing.
   7. Purge tube with nitrogen during brazing procedure. Provide manual shut-off valve and check valve as required for purge gas.

3.03 AIR COMPRESSORS

A. Provide wiring necessary for controls and automation systems interface.

B. Air compressor package with components and accessories shall be furnished by one manufacturer. Install components according to manufacturer's recommendations. Consult manufacturer-furnished piping diagrams for interconnecting piping of system components.
C. Verify that all compressor functions are properly functioning.
D. Adjust compressor stop, start, staging, and alternation functions.
E. Verify that the automatic drain valve is properly functioning.

3.04 TESTING

A. Refer to testing paragraph of Section 20 0000 - General Mechanical Requirements.
B. Air piping shall be tested at 150 psig for 2 h prior to connection of laboratory fixtures. Soap test each joint to detect leaks during test period. No loss of pressure allowed during test period. Defective joints shall be cut out and replaced. Air piping shall be re-tested at 100 psig for 8 h after final connection of laboratory fixtures.
C. Air compressor equipment shall be delivered pre-assembled and tested by equipment manufacturer.
D. Verify proper signal transmission for each condition specified to Building Automation Controller.

3.05 CLEANING

A. All pipe, fittings and valves will be cleaned by manufacturer. On- or off-site cleaning of any components by Contractor is not allowed. Any components, which have become contaminated, will not be used on any clean systems. They may be used in laboratory vacuum or any water system using copper pipe or fittings.
B. Before system is placed into use, flush piping with product air to remove foreign particles.

3.06 WARRANTY

A. Manufacturer shall warrant air compressor package and components complete, for period of 2 yrs from date of start-up.

END OF SECTION

SECTION 226653
CORROSION RESISTANT WASTE AND VENT SYSTEM

PART 1 - GENERAL

1.01 DESCRIPTION

A. This Section specifies pipe, fittings, equipment and methods for corrosion resistant waste and vent piping system installed to 5 ft outside the building wall.

1.02 RELATED WORK

A. Section 20 0529 - Mechanical Supporting Devices

1.03 QUALITY ASSURANCE

A. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): “The articles listed in FAR 25.104(a) that are acquired as construction materials.”

1.04 SUBMITTALS

A. Shop drawings on items specified herein.
B. Submit Manufacturer's technical data for the following:
   1. Pipe and fittings
   2. Joints
   3. Floor drains
   4. Cleanouts

PART 2 - PRODUCTS

2.01 MATERIALS

A. Use new materials unless otherwise noted.

2.02 PIPE

A. Underground:
   1. Chlorinated Polyvinyl Chloride (CPVC):
      a. Pipe: Schedule 40, ASTM D1784, and ASTM F2618
      b. Fittings: Drain, waste, and vent (DWV) pattern, ASTM D3311
      c. Joints: Solvent cement, ASTM F493
      d. Manufacturers: Charlott “ChemDrain”, Spears “LabWaste”
B. Above Ground:
   1. Chlorinated Polyvinyl Chloride (CPVC)
      a. Pipe: Schedule 40, ASTM D1784, and ASTM F2618
      b. Fittings: Drain, waste, and vent (DWV) pattern, ASTM D3311
      c. Joints: Solvent cement, ASTM F493
      d. Manufacturers: Charlotte “ChemDrain”, Spears “LabWaste”

2.03 ADAPTERS

A. Provide where indicated and as necessary; glass to plastic compression coupling, plastic to metal mechanical joint, or glass to metal mechanical joint and/or compression coupling.
B. Plastic to plastic 1” through 4”: Fernco Proflex 3000 Series shielded coupling with neoprene gasket, stainless steel shield, and stainless steel clamping bands.
C. Stainless Steel to Polypropylene (1” to 10”): 316L stainless steel shielded coupling with EPDM inner gasket, and 316 stainless steel fasteners. Teekay Type IV stepped transition coupling or approved equal.
D. Submit adapter fittings for approval prior to installation.

2.04 CLEANOUTS

A. Corrosion resistant materials similar to piping materials. Refer to Cleanouts in 22 1314 Sanitary Waste and storm drainage.

2.05 FLOOR DRAINS

A. Refer to Drain Schedule.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install piping neat and orderly; accomplish changes of direction using proper pipe fittings. Connect to sinks, cup sinks, floor drains, and other devices as shown on drawings. Conceal piping unless noted to be exposed in reagent rack. Piping within casework shall be coordinated with casework supplier.
B. Pitch vent piping to waste line. Install horizontal waste piping with minimum pitch of 1” in 4 ft; except piping 3” and larger may pitch 1” in 8 ft. Make changes in direction of flow by use of drainage pattern fittings.
C. Set floor drains level and at low points. Protect weep holes from filling with concrete. Clamp safing to drain body for proper drainage.
D. Install cleanouts as shown on drawings. Locate cleanout access cover so that snake of100 ft can be properly used.
E. Provide caps and plugs on open pipe ends during construction phase to prevent construction debris from entering pipe.
F. Provide necessary transition fitting and couplings required when changing from one piping material to dissimilar material.

3.02 PLASTIC PIPING

A. Install plastic pipe and fittings as recommended by respective manufacturer. Fuse plastic pipe joints with surrounding temperature above freezing using equipment supplied by pipe manufacturer. Adhere to instructions for fusing as published by manufacturer. Instructions for fusing shall be kept on site.
B. Install mechanical joints in accordance with instructions from pipe/fitting manufacturer. Use materials of same manufacturer, especially made for mechanical jointing. Use pipe and fittings with factory cut groove, except pipe may be grooved in field using equipment and methods as recommended by manufacturer of pipe. Use hangers on each side of mechanical couplings.

3.03 TESTING

A. Refer to Testing paragraph of Section 20 0000 - General Mechanical Requirements.
B. Water test may be applied to system either in its entirety or in sections. Piping shall be tightly plugged and submitted to 10 ft head of water located at highest point. Provide separate standpipe above highest point being tested or extend system to obtain required 10 ft head of water. Head shall be maintained for at least 30 minutes before inspection starts.
C. Defective work or material shall be replaced or repaired as necessary and inspection and test repeated. Repairs shall be made with new materials. No caulking of threaded joints or holes will be allowed.
D. Do not backfill pipe until successfully tested.
E. Testing with air will not be allowed.

3.04 CLEANING

A. After successful pressure test, clean and flush piping system to eliminate debris in drainage system.

END OF SECTION

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SECTION 226714.13
PLASTIC PIPING FOR HIGH PURITY SERVICE

PART 1 - GENERAL

1.01 DESCRIPTION

A. This Section covers requirements for procurement, installation, inspection, and sanitization of piping, fittings, valves, and specialties for High Purity Water (HPW) service: Deionized Water (DI) and Reverse osmosis water (RO).

B. High purity piping is defined as piping downstream of reverse osmosis unit (RO). Refer to Section 22 1118 (Water Distribution System) for piping prior to the RO unit.

1.02 RELATED WORK

A. Section 20 0529 - Mechanical Supporting Devices

B. Section 22 6720.13 - High Purity Water System

1.03 QUALITY ASSURANCE

A. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): “The articles listed in FAR 25.104(a) that are acquired as construction materials.”

1.04 SCOPE OF WORK

A. Contractor shall be responsible for procurement, installation, inspection, and sanitization of piping system.

B. Contractor shall provide personnel trained and experienced in installation of selected manufacturer's piping system. If personnel are not experienced at start of installation, piping manufacturer's representative shall train Contractor prior to installation. Training certification and experience record is required.

C. Contractor shall submit documentation on components proposed for system and shall obtain approval prior to purchase or fabrication of those components.

D. Contractor shall inspect system and provide documentation to demonstrate that system is installed according to Specification, is leak free, and has been sanitized according to procedure.

1.05 BASIS OF DESIGN

A. Service: HPW water
   1. Scope: Piping downstream of storage tank
   2. Process Fluids: water with resistivity of 1.0 megohm; 1% peracetic acid solution
   3. Operating Pressure/Temp. 100 psig at 80°F
   4. Piping System
      a. Design Pressure: 150 psig at 100°F for components
      b. Material: LXT PVC as specified below.
         1) Joining method: Solvent weld
         2) Elastomer: EPDM

1.06 SUBMITTALS

A. Submit the following items prior to purchase:
   1. Product Data:
      a. Pipe, fittings, & joints
      b. Identification of joining method and fusion equipment
      c. Valves
      d. Specialty items
      e. Instrumentation
   2. Reports: Detailed Sanitization Procedure (see Part 3.1).

3. Certifications: Training certification for installation personnel

B. Provide the following documentation with system delivery:
   1. Pressure Test Report
   2. Sanitization Records

1.07 DELIVERY

A. Pipe, fitting, and components shall be furnished with plastic end-caps/plugs to prevent contamination and damage.
B. Pipe, fittings, and components shall be handled and shipped so as to protect from contamination and damage.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Low-Extractable PVC: Harvel LXT, Spears LXT or approved equal.
B. PP: Asahi, Georg Fischer, Sani-Tech, Simtech

2.02 GENERAL

A. Piping, fittings, and valves that are to be heat fused shall be products of same manufacturer.
B. Piping, fittings, valves, gaskets and accessories shall be compatible with Design Conditions in Part 1.5 as stated above.
C. Dimensions of end connections for valves shall be compatible with pipe and fittings.
D. Materials in contact with water shall be FDA approved for sanitary product contact surfaces.
E. Pipe and fittings shall be permanently identified with production lot and wall thickness or pressure rating.
F. Piping, fittings, valves, and components shall be manufactured in dedicated equipment in clean environments and bagged.

2.03 PIPE, FITTINGS, & JOINTS

A. Low-Extractable Polyvinyl Chloride (LXT PVC):
   1. To insure uniform installation fit, piping system components shall be products of one manufacturer.
   2. Pipe and Fittings: Low-extractable PVC specifically compounded for high purity water application, Schedule 80, socket pattern fittings.
   3. Joints:
      a. Low-extractable PVC solvent cement, specifically compounded for high purity water application and low-extractable PVC pipe.
      b. Breakable Joints: Tri-Clamp with Viton Sanitary gasket.
      c. Connections at equipment (only)
         1). Flange adapter with PVDF coated steel flange ring with boltholes per ANSI B16.5, Class 150 pattern.
         2). For mating with FRP flange, flat gasket shall be Garlock "Stress Saver", PTFE, or approved equal.
         3). For mating with stainless steel flange, flat gasket shall be Garlock Gylon 3545.
B. Polypropylene (PP)
   1. Material: pigmented polypropylene, conforming to ASTM D-4101
      a. Acceptable manufacturers: Asahi “PP-Pure”, Georg Fischer “PROGEF Standard”, or Simtech “Alpha Plus”.
   2. Fused joints
      a. Socket Fusion
   3. Mechanical Joints
      a. Tri-Clamp or sanitary union

b. Mechanical joints to be used only where indicated on P&ID. Use in other locations requires prior approval.

4. Connections at equipment (only)
   a. Flange adapter with Georg Fischer V-Flange ring with bolt holes per ANSI B16.5, Class 150 pattern
   b. For mating with FRP flange, flat gasket shall be Garlock "Stress Saver", PTFE, or approved equal
   c. For mating with stainless steel flange, flat gasket shall be Garlock Gylon 3545 or Georg Fischer Sygef HP Gasket.

2.04 VALVES

A. General
   1. Valve type shall be as indicated on flow diagram.
   2. Valves shall be same material and manufacturer as piping.
   3. Valves shall conform to Basis of Design in Part 1.5 above.

B. LXT PVC Valves:
   1. General
      a. Manufacturers: same as selected tubing.
      b. Body: Low-extractable PVC.
      c. Design Conditions: as per Part 1.5 above.
   2. Ball Valves: True union type, full port, Viton seals, Teflon seats.
   3. Sampling valves: Same as ball valves.
   4. Self Contained Pressure Regulating Valves
      a. PTFE, EPDM backed, diaphragm and Viton O-rings.
      b. Relief valves to be George Fisher V85 or equal.
      c. Retaining (back pressure) valves to be George Fisher V86, Jordan Steriflow Mark 95.
      d. Reducing valves to be George Fisher V82 or equal.
      e. Sizing is per Equipment Schedule.
   5. Check Valves: Ball check valves, Viton seals, PVC ball.

C. PP Valves
   1. Diaphragm Valves
      a. Weir type, self-draining, PTFE diaphragm backed by EPDM, non-rising stem, position indicator, stroke limit stops.
      b. Size 2” and smaller: Georg Fischer Type 515, Simtech DVA or DVS series
      c. Zero static valve: Georg Fischer Type 319
   2. Ball Valves
      a. True union type, full port, Viton seals, Teflon seats
      b. Georg Fischer Type 546, Simtech TBL series
   3. Sampling valves
      a. Zero static tee diaphragm valves, 1/2”
      b. Millipore Sanitary ESP sampling valve YY20040H0, 1/4” Halar, NPT
      c. Millipore Sanitary ESP sampling valve YY20040S0, 1/4” stainless steel, NPT
   4. Self-Contained Pressure Regulating Valves
      a. PTFE, EPDM backed diaphragm and Viton O-rings
      b. Retaining (back pressure) valves to be Plast-O-Matic RVDT, Georg Fischer 586, or Jordan Steriflow Mark 95.
      c. Reducing valves to be Georg Fischer 582, Jordan Steriflow Mark 96, or Plast-O-Matic RVDT.
      d. Sizing is per Section 22 6720.13.

D. Check Valves

a. 2” and smaller: Ball check valves, Viton seals, PP ball, Georg Fischer Type 561, Simtech BCQ Series
b. 3” to 4”:
    1) Ball check valve, Viton seals, PP ball, Simtech BCQ series
    2) Flanged insert valve (FIV), PTFE, with Viton seats, Check-All Style FP

2.05 SPECIALTY ITEMS

A. Faucet Connections
    1. Tubing for connection to lab faucets shall be polypropylene, or PFA tubing, 3/8” OD; 0.062” wall, rated to at least 150 psig at 80°F. Polypropylene tubing shall be made from virgin copolymer conforming to FDA requirements for food contact.

2.06 INSTRUMENTATION

A. Instrumentation Specifications are covered in Section 22 6720.13.

PART 3 - EXECUTION

3.01 GENERAL

A. Install and inspect piping and accessories as per Contract Documents and recommendations of equipment manufacturers.
B. Provide installation personnel who are trained and experienced with assembly of selected piping in high purity systems.
C. Provide diaphragm valves or type of valves as indicated on drawings.
    1. Inspect delivered components to verify conformance to specification and to check for evidence of damage or contamination. Do not use suspect materials.
D. Maintain high level of cleanliness during handling and installation.
    1. Prior to starting work, identify areas that will be used for storage and fabrication, and take measures to prevent contamination from adjoining areas.
    2. Handle and store tubing, fitting, and components in a manner that prevents impact damage, excessive stress, and contamination.
    3. Maintain manufacturer's protective packaging in place until immediately prior to use.
    4. Keep openings on assemblies sealed during fabrication to prevent contamination prior to final installation.
E. Install piping using minimum number of joints.
F. Monitor and inspect installation process to ensure:
    1. Conformance with this Specification.
    2. Compliance with manufacturer’s requirements.
    3. Piping is supported as specified.

3.02 INSTALLATION

A. LXT Joint Fabrication
    1. Perform joining in strict accordance with manufacturer's recommended procedures. Cut piping in strict accordance with manufacturer's recommended procedures.
    2. Clean components prior to fusion conscientiously and in strict compliance with Manufacturer's recommendations for high purity services.
    3. Form joints by solvent welding in accordance with appropriate parts of ASTM D-2855, using solvent cement conforming to ASTM F-493 and to NSF International for use on potable water systems.
    4. Use union joints only where indicated on drawings or where necessary to connect to accessories and equipment. Verify that o-ring is correctly indexed prior to tightening. Tighten hand tight only; do not use tools. Tighten flanged connections in strict accordance with manufacturer's recommendations.
    5. Use threaded connections only if no other option for connecting to equipment.

B. PP Joint Fabrication
   1. Perform joining in strict accordance with manufacturer's recommended procedures with manufacturer's specified equipment.
   2. Fabricate in clean area. Provide ventilation to room isolated from areas where grinding or welding of metals is occurring.
   3. Cut piping in strict accordance with manufacturer's recommended procedures.
   4. Clean components prior to fusion conscientiously and in strict compliance with manufacturer's recommendations for high purity services.
   5. Form joints using socket fusion with equipment made specifically for this use by manufacturer of this material.
   6. Label joints for traceability.
   7. Use equipment capable of generating records of operating conditions for each joint. Record operating conditions of fusing equipment for each joint.
   8. Use sanitary union or Tri-clamp joints only where indicated on drawings or where necessary to connect to accessories and equipment. Verify that gasket is correctly indexed prior to tightening. Tighten hand tight only; do not use tools.
   9. Provide ANSI flanged joints only for connecting to equipment that does not have Tri-Clamp fittings available. Tighten flanged connections in strict accordance with manufacturer's recommendations. Threaded joints are not acceptable.

C. Configuration
   1. Install tubing so that there are no undrainable pockets.
   2. Orient diaphragm valves per manufacturer's instructions to ensure complete drainage.
   3. Install check valves and orifice plates in vertical sections. If installation in horizontal is required, provide eccentric valve or plate and orientate properly.
   4. Provide low point drains and high point vents in compliance with drawings and Engineering review of isometric drawings.
   5. Rough or sharp edges must not be in contact with pipe.
   6. Erect tubing without spring or force. Connect to equipment such that stress is not transferred to equipment.
   7. Install all tee connections so as to minimize dead leg. Distance from sealing point on branch to inside of main line wall shall be less than 2 feet.
   8. Route lines so as to accommodate thermal expansion where required. Provide supports appropriate for thermal expansion. Install supports so that movement of piping due to thermal expansion is not impeded.

D. In-Line Devices
   1. Locate and orient in-line specialty items and instrumentation so as to allow for access after insulation is installed, including:
      a. Access for maintenance and calibration.
      b. Viewing of gauges by operating personnel.
      c. Clearance for removal of regularly replaced components (filter elements, UV lamps, etc.)
      d. Convenient operator access to sample valves and insertion of sampling container.
   2. Install in-line specialty items and instruments such that they are free draining.
      a. Install restriction orifices in vertical section of pipe. Provide orifice that is eccentric drilled and orientate with hole at low point if orifice must be installed in horizontal pipe.
      b. Install in-line specialty items and instruments in strict accordance with manufacturer’s instructions.
      c. Install sensors for conductivity and resistivity in run of a horizontal tee with flow exiting upward branch.

d. Provide length of straight pipe upstream and downstream of flowmeters. As specified by manufacturer.
e. Install pressure regulators and backpressure regulators with at least 10 pipe diameters of straight pipe upstream and downstream of regulator.
f. Install sanitary orifice plates in sanitary unions or in Tri-Clamp joints as indicated on drawings. Clearly tag orifice location.
g. Securely support relief valves and relief discharge lines.

E. Penetrations
1. Fire-Rated walls:
a. Provide firestopping per division 07.

3.03 USE POINT CONNECTIONS

A. Faucets
1. Install a reducing tee in distribution line with 1/2” outlet and fuse 1/2” diaphragm valve directly on tee outlet.
2. Connect outlet of valve to faucet with 3/8” polypropylene or PFA tubing.
3. Use shortest length of tubing as possible.

B. Equipment
1. Install a reducing tee in distribution line with outlet size indicated on distribution drawing. Fuse 1/2” diaphragm valve directly on tee outlet.
2. Install piping per size from valve to equipment.

3.04 TESTING

A. Inspection
1. Visually inspect all joints and verify that they comply with manufacturer’s criteria for a properly formed joint.

B. Hydrotest
1. Execute all pressure testing safely.
a. Do not pressurize plastic piping with gas.
b. Isolate equipment or instrumentation that cannot to be exposed to test pressure.
c. Notify personnel with access to system that testing is to take place. Tag each use point to indicate that valve is not to be used.
d. Ensure that air is completely vented from system to avoid a hazardous condition.
e. Pressurize system gradually.
f. Provide controls to prevent pressure from exceeding specified test pressure.
2. Ensure that cleanliness of system is not compromised.
a. Provide water for testing and flushing that has quality equal to or better then service water.
b. When performing preliminary testing of sections of system, after test is complete flush all water out of system and ensure that it drains completely. Close all openings in system after draining.
3. Execute final acceptance test on completed piping system.
a. Do not insulate or conceal piping until testing is complete.
b. Test system in sections or as a whole, but all joints need to be covered in test.
c. Ensure that air is completely vented from system.
d. Pressurize gradually and hold system at 100 psig for 4 hours. An initial pressure decrease will occur due to pipe elongation after pressurization. After 4 hours, pressure loss will stabilize, and pressure must then hold at test pressure without a loss of 1% over period of one hour to pass test.
e. Monitor pressure with gauge located near bottom of system that is readable to at least plus or minus 1 psi.

f. Note if pressure drops more than 1% over test period and determine source of leakage.
   1) Cut out and reinstall defective joints.
   2) Hand tighten wing nuts on sanitary clamps if required. If leakage continues, install new gasket. Do not tighten using tools.
   3) Retest.

4. Provide written certification that includes identification of portion of system tested, date, time, test criteria, test medium and pressure, duration, and name and title of person responsible for test.

3.05 SANITIZING/FLUSHING

A. General

1. Perform sanitization after inspection, documentation, and acceptance of system. If chemical sanitation is not required then this procedure will be used for flushing, without addition of sanitant.
2. Prior to sanitization, slowly fill system with water while venting air from system. Continue to check that all air has been vented after water is recirculating.
3. Adjust any pressure regulators to their preliminary setpoints.
4. Perform sanitization immediately prior to placing system in operation and coordinate with Owner's representative.
5. Safety:
   a. Follow manufacturer's safety recommendations for handling of chemicals.
   b. Disconnect power to UV lights prior to sanitization.
   c. Provide controls to ensure that system remains within pre-established sanitization conditions and that system pressure does not exceed Design Conditions in Part 1.5 above.
   d. Ensure that proper chemicals are used and that they are handled safely.
   e. Notify personnel with access to system that sanitation is being performed. Prior to cleaning, tag each use point to indicate that valve is not to be used.
6. Provide all equipment, fittings, and supplies necessary to execute sanitization.
7. Prepare a procedure which identifies:
   a. Recirculation circuits and sampling points.
   b. Measures required to confine sanitizing solution.
   c. Step-by-step procedure (including any modifications to piping or controls).
   d. Sign-off matrix.
8. Isolate equipment or instrumentation that is not to be exposed to sanitant.
   a. Bypass ion exchange beds.
   b. Turn off UV lights.
   c. Record all changes made to system that are required to execute test.
9. Record execution of procedure including Owner sign-off.

B. Procedure for peracetic acid

1. Makeup solution of 1% Minncare with water that is less than 70°F. Water shall be equivalent to service water quality or deionized water (minimum 1 megohm) that has passed through a 1.0 micron filter. Fill entire system with solution. All gas must be vented, and system set up for recirculation so that all parts will be exposed to solution.
2. Recirculate at flow rate of at least 3 fps. Draw samples at points of use and at other key sample points to confirm presence and concentration of peracetic acid solution using test strips. Monitor system temperature to ensure that is does not rise above 75°F.
3. Confirm that there is solution throughout system, and then continue to recirculate for at least 3 h. Draw off water for at least one minute at each use point.

4. After recirculation with peracetic acid solution flush system with product quality water for at least 45 minutes, rotating draw off from all use points.
5. Test water with peracetic acid solution residual test strips at key sample points to ensure less than 1 ppm is achieved.
6. Continue to flush for 30 minutes. Draw off water for at least 1 minute at each use point.
7. Return system to its original configuration. Verify that all modifications that were made to piping or controls were restored. Prepare system for normal operation.

END OF SECTION

SECTION 22 6720.13
HIGH PURITY WATER SYSTEM

PART 1 - GENERAL

1.01 DESCRIPTION

A. This Section specifies the system for production and distribution of High Purity Water (HPW).
B. Complete specification of the system is defined by:
   1. This Section
   2. Sections listed under Related Work below
   3. Equipment layout on drawings

1.02 SCOPE

A. Contractor's Scope of Work includes:
   1. Subcontracting with an acceptable water treatment equipment vendor (Vendor) and managing Vendor’s scope of work and performance. Coordinating:
      a. Size of equipment and skids with delivery schedule to ensure that equipment can be moved into place.
      b. A drawing showing layout of equipment positioned in Owner’s area.
      c. Identification of all field installation of piping and wiring interconnections required between Vendor’s equipment.
   2. Installation of Vendor’s equipment and providing utilities to equipment.
      a. Providing piping and wiring interconnections between Vendor equipment as required.
   3. Providing distribution piping.
   4. Coordination of startup and system Turnover with Owner to ensure system is always actively managed.
B. Vendor’s Scope of Work includes furnishing:
   1. A complete system, as defined in this document.
   2. Detailed drawings and instructions to Contractor for installation for field piping and wiring interconnections required between Vendor’s equipment and components.
   3. Documentation
   4. Sanitization of system
   5. On-site support checkout, startup, and testing
   6. Demonstration that system meets quality and operational requirements
   7. On-site training
   8. Operation of system until turnover to Owner

1.03 RELATED WORK

A. HPW system shall meet requirements of following Sections:
   1. Section 20 0513 - Motors
   2. Section 20 0529 - Mechanical Supporting Devices
   3. Section 20 0553 - Mechanical Systems Identification
   4. Section 22 6714.13 - Plastic Piping for High Purity Service
   5.

1.04 QUALITY ASSURANCE

A. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): “The articles listed in FAR 25.104(a) that are acquired as construction materials.”

1.05 BASIS OF DESIGN

A. Vendor is responsible for providing system that consistently and reliably delivers water of the following quality to the supply of distribution loop piping.

1. If Vendor believes that system design specified herein will not meet the quality standards, Vendor shall notify Engineer.

B. Water Quality Requirements
1. System shall provide water meeting specifications of American Society of Testing and Materials (ASTM) Type II Reagent Grade Water per ASTM D1193. Specification is:
   a. Conductivity: ≤ 1.0 micro siemens/cm (25°C)
   b. Resistivity: ≥ 1.0 megohms - cm (25°C)
   c. pH: NA
   d. TOC: ≤ 50 micrograms/liter
   e. Sodium: ≤ 5 micrograms/liter
   f. Chlorides: ≤ 5 micrograms/liter
   g. Total silica: ≤ 3 micrograms/liter
   h. Microbial Level: none

C. Supply Water Quality
1. Vendor is responsibility for confirming validity of supply water analysis and notifying Engineer if quality is significantly different than stated below.
2. Minimum temperature of supply water: 60°F
3. Minimum pressure of supply water: 50 psig
4. Maximum pressure of supply water: 80 psig

D. Capacity Requirements
1. System shall produce 300 gallons per day of water of quality stated above.
2. Individual equipment shall comply with capacity and efficiency requirements stated below.

E. Size Requirements
1. Equipment shall be located in area shown on drawings referenced in Part 1.1. Location and sizes of equipment shown in those areas are preliminary.
2. Contractor shall work with Vendor to determine equipment layout and submit an accurate drawing indicating positions of equipment in the area.
3. Layout shall ensure:
   a. Selected equipment and skid sizes will be able to pass through available building opening and passageways or must be delivered prior to completion of that area of building.
   b. Proper access to HPW equipment and instrumentation for operations and maintenance.
   c. Compatibility with floor drains shown on drawings.
   d. Clearance for removal of regularly replaced components (filter elements, UV lamps, etc.)
   e. Access to tank manway and components on top of tank.

F. Site Conditions
1. Seismic Zone: None
2. System location: Mechanical room 119
3. Electrical classification: non-hazardous

1.06 DOCUMENTATION

A. The following documents shall be furnished as follows:

	Submit for Approval	Upon Delivery	Turn Over Package
Production flow rates; flows to drain	X		

	Submit for Approval	Upon Delivery	Turn Over Package
Piping and Instrumentation Diagram (P&ID)	X	X	As built
Pump Curves with Operating Points	X		X
Utility Loads	X		X
Drawing of system in facility space	X		
Instructions for Rigging, Storage, and Anchoring		X	
Instructions for extended storage of system, if necessary		X	
Detailed Equipment drawings	X	X	X
Equipment List	X		X
Descriptions of equipment and components.	X		X
Instrument List	X		X
Instrument Cut sheets	X		X
I/O List	X	X	X
Calibration Certifications		X	X
Operational and control description and functions	X		
Functional Specification	X	X	As built
Loop Diagrams		X	X
Control Schematics		X	X
Control Panel wiring drawings		X	As built
Component Cut Sheets	X		X
PLC Program Printout and Disk File			As built
OIT Configuration		X	As built
Electrical single line diagrams	X	X	X
Schematic wiring diagrams		X	X
Electrical panel drawings		X	X
Sanitization Procedure	X	X	
Acceptance Test Procedures		X	
Acceptance Test Report			X
Water sampling results			X
O & M Manuals		X	As built
Training Program Outline		X	
Service Agreement Proposal		X	

1.07 WATER TREATMENT EQUIPMENT VENDORS

A. Acceptable Vendors: Burt Process Equipment, Crossbow-Water, Evoqua Water Technologies, Stilmas Americas, Therma Corporation, US Water Services, Veolia, Wigen Water Technologies, Culligan, or approved equal

1.08 DELIVERY

A. Vendor shall provide complete instructions on handling, rigging, anchoring, and on-site reassembly with unit.
B. Vendor is responsible for packaging to ensure unit arrives undamaged and uncontaminated.
   1. Nozzles shall have covers which protect the face from damage and seal system from contamination.
   2. Parts shipped loose shall be boxed and properly identified with durable, waterproof shipping tags attached with stainless steel wire or plastic tie strips. Parts shall be match marked for easy reassembly at site.

PART 2 - PRODUCTS

2.01 GENERAL

A. For equipment that is skid mounted:
   1. Size of skid must be compatible with building dimensions and/or delivery must be coordinated with construction schedule to ensure that skid can be moved into building and set in place.
   2. Skid size and dimension must be compatible with room layout.
   3. Skids shall conform to AISC Manual of Steel Construction.
   4. Skid construction shall comply with local and state code seismic requirements.
   5. Single connection for each utility and for drain shall be provided.
   6. Frame to be stainless steel or carbon steel with 2 coats epoxy paint.
   7. Frame shall adequately support system components at their operating weights.
   8. Surfaces that allow water to pool on part of frame are not permitted.
   9. Skids shall be designed so that they may be lifted by both forklift truck and overhead crane.
   10. Vendor shall inform contractor of field work required to assemble and interconnect skids.

2.02 WATER SOFTENER

A. Unit shall be comprised of **duplex** alternating**,** water softener tank, complete with piping, automatic brass control valves, controller, pressure gauges, sample valves, resin, gravel, outlet "Y" strainer, dry-brine tank, and brine eductor. Unit shall be preassembled, prewired, and hydrostatically tested. Media shall be packaged separately.
B. Design Criteria
   1. Each tank shall be sized to handle the service flow rate with the following criteria:
   2. Service flow: 8.0 gpm
   3. Volumetric Flow Rate: less than 3 gpm/ft^3 at service flow rate
   4. Velocity: greater than 2.5 gpm/ft^2
   5. Normal hardness leakage: Less than 1 ppm as $CaCO_3$
   6. Endpoint effluent hardness: Less than 5ppm as $CaCO_3$
   7. Back wash flow rate: 4 6 gpm/ft^2
   8. Type: Resin: Amberlite IR-120-Na (Rohm and Haas) or equal
   9. Regenerant Chemical: saturated NaCl
   10. Regenerant Quantity: 15 lb/ft^3 maximum
   11. Regeneration Rate: 0.5 to 0.63 gpm/ft^2
   12. Method of Chemical Introduction: Eductor
   13. Capacity: 30,000 grams/ft^3 (as $CaCO_3$) at max salt dosage
C. Mechanical
   1. Softener vessel
      a. Material: Fiberglass or epoxy coated carbon steel

b. Pressure Rating/Test: 100/150 psig
c. Temperature Rating: 120°F
d. ASME Code Stamped: No
e. Floor Support: Structural base
f. Piping Connections: threaded
g. Vessel internal distributors shall be PVC or ABS.
1) Inlet Distributor (Top): Top inlet baffle
2) Underdrain Distributor (Bottom): Hub radial with PVC laterals.
h. Access ports shall be provided in top head for control valve connection, media loading and removal.

2. Piping: Per referenced pipe section.
3. Y-Strainer: Bronze or PVC body with 20 mesh screen

D. Brine Tank:
1. Description: Dry-brine system with elevated grid plate
2. Quantity: 1
3. Material: Polyethylene
4. Salt Dose: 6-15 lb/ft^3 of softener resin

E. Controls
1. Motor-driven control valve shall stage each softener through regeneration steps. Regeneration shall be initiated by signal from alternator controller.
2. Regeneration frequency shall be based on throughput volume, totalized at common effluent.

F. Electrical: 120VAC, 1 Ph, 60 Hz power supply
G. Pressure gauges shall be provided before and after unit.
H. Sample valve shall be provided after unit.

2.03 CARBON FILTER

A. Unit shall be comprised of a carbon filter, complete with piping, fully automatic brass motor driven multi-port control valve, pressure gauges, sample valves and media. Unit shall be preassembled, prewired, and hydrostatically tested. Media shall be packaged separately.
B. Vendor to determine the service exchangeability of carbon filter
C. Service Flow: 2.4 gpm
D. Design Criteria
1. Each bed shall be capable of handling the service flow rate with the following criteria:
2. Flow Rate Criteria: less than 7 gpm/ft^2 at design flow rate
3. Chlorine Removal: 0.0 ppm at carbon effluent
4. Chloramine Removal 0.0 ppm at carbon effluent
5. Clean Bed Pressure Drop: less than 5 psig at design flow rate

E. Mechanical
1. Vessel
a. Material: Fiberglass
b. Pressure Rating/test: 100/150 psig
c. Temperature Rating: 120°F
d. ASME Code Stamped: No
e. Internal distributors:
1) Material: PVC or ABS
2) Inlet Distributor (Top): Top inlet baffle
3) Underdrain Distributor (Bottom): Hub radial with laterals
f. Access: ports in top head for control valve connection and media loading/removal.

2. Media: Acid washed Activated Carbon, Fine Gravel, Medium Gravel.
3. Piping:

a. As per referenced pipe Section.

F. Controls: Backwash frequency controlled by seven-day time clock. Operator shall have option to select day-of-week and time-of-day for backwash to occur.
G. Electrical: 120 VAC, single phase, 60 Hz
H. Pressure gauges shall be provided before and after unit.
I. Sample valve shall be provided after unit.

2.04 CARBON FILTER – SERVICE EXCHANGABLE

A. Description: service exchangeable activated carbon cylinder.
B. Design Flow: 2.4 gpm
C. Design Criteria
1. Flow Rate Criteria: less than 7 gpm/ft^2 at service flow
2. Clean Bed Pressure Drop: less than 5 psig at service flow rate
D. Mechanical
1. Vessel:
a. Material: Fiberglass
b. Pressure rating/test: 150 psig
c. Temperature rating: 120°F
d. ASME Code Stamped: No
e. Piping Connections: Threaded
2. Hoses: Polypropylene
3. Carbon: New virgin activated carbon

2.05 REVERSE OSMOSIS (RO) UNIT

A. RO unit shall be skid mounted, fully automatic, single pass system. Unit shall be preassembled, prewired, and hydrostatically and functionally tested.
B. Design Conditions
1. Design flow: 1.0 gpm permeate
2. Feedwater Temp: 60°F
C. Design Criteria
1. Max Average Permeate Flux/Element: 18 gfd (Gallons/ft^2/day)
2. System Recovery: 50%
3. Minimum Salt Rejection: 96% at stated recovery
4. RO Membranes:
a. Type: Polyamide thin-film composite
b. Manufacturer: Filmtec (Dow) or approved equal
c. Minimum Salt Rejection: 98%
D. Instrumentation
1. The following instruments shall be provided:
a. Flow indicator on permeate
b. Flow indicators on reject on reject
E. Mechanical
1. Frame:
a. System shall be supported by epoxy-coated frame, and designed to provide easy access for servicing, maintenance, and monitoring of operation.
b. Piping shall be neatly arranged and supported on frame.
c. Frame shall be designed for seismic zone indicated in Part 1.1 and shall offer maximum support and protection for system components.
2. RO Prefilter: 5 micron absolute, sized for max 3 psi pressure drop at maximum RO flow.
3. Valves:

a. Automatic, pneumatically actuated, non-metallic, or stainless steel valve shall be provided in feed line.
b. High pressure valves, including pump discharge throttling valve, reject throttling needle valve and reject recycle throttling needle valve shall be 316 stainless steel.
c. Actuated flush valve shall be provided on a by-pass around reject throttle valve.
d. Sample valves shall be provided on feed, product, and reject lines. Individual sample valve on product tubing of each pressure vessel shall be provided for analyzing system performance.
e. Reject and reject recycle needle valves shall be mounted in close proximity to their respective flow rate indicators for ease of field adjustment.

4. Pressure gauges shall be furnished to monitor RO inlet pressure, pump suction pressure, membrane feed pressure, membrane reject pressure and RO product pressure.
5. Pressure Vessels:
   a. Manufacturer: Advanced Structures, Inc. or approved equal
   b. Material: FRP
   c. Rating: 400 psig
6. Piping:
   a. Piping shall be designed for minimal removal during membrane loading.
   b. Nozzles shall be provided for connection of temporary lines for cleaning and sanitizing RO membranes and vessels.
7. Material and connections:
   a. Feed and Reject Pipe: Per referenced pipe section
   b. High Pressure Pipe: 316L stainless steel tubing
   c. Product Piping: Per referenced pipe section
   d. Pump: 316 stainless steel

F. Control System: Microprocessor or PLC based control system shall monitor and control operation of system and communicate with pretreatment equipment and distribution tank level as required. Skid mounted control panel shall house control system, operator interface controls, solenoids, IEC motor starter(s), step down transformer, high voltage disconnect. Control system shall be fully programmed, and integrity tested at factory prior to shipment.
   1. System shall provide the following functions
      a. On start-up, inlet valve should open prior to initiation of pump to completely fill the system with water.
      b. Upon shutdown of pump, actuated flush valve shall open for 3 minutes. After 3 minutes, flush valve and inlet valve shall close.
      c. Provide one discrete general fault signal for use.
   2. Panel shall include:
      a. Lights, pushbuttons, and switches for status and control of system
      b. Conductivity monitor for feed and permeate
      c. Elapsed run time indicator
      d. Alarm horn
      e. System power switch
      f. Nameplates for device identification
      g. Automatic reject flush indicator and controls
   3. Alarm conditions shall Include:
      a. Low feed pressure
      b. High and High High permeate conductivity
   4. Unit Shutdowns include:
      a. Low feed pressure
      b. Pretreatment filters in backwash

c. Product storage tank full
d. High High permeate conductivity

5. Functional Specification
   a. Complete functional specification shall be provided which describes:
      1) operation of unit
      2) control loops
      3) interlocks
      4) alarms
      5) startup/shutdown sequences
      6) security

G. Electrical
   1. RO unit shall have a single connection for 480 V, 3 phase power. Transformers for devices requiring other voltage shall be provided integral to skid.

2.06 MIXED BED DI COLUMNS - EXCHANGABLE

A. Description: Service exchange, mixed resin, ion exchange beds. Beds contain 60% anion/40% cation resin mixture, premium grade.
   1. Design flow – Production: 2.4 gpm
   2. Design flow – Distribution: 25 gpm
   3. Design Criteria
      a. Volumetric Flow Rate: Less than 10 gpm/ft^3 at design flow
      b. Pressure Drop: Less than 3 psi per bed at design flow
      c. Cation Resin: Strong acid, hydrogen form
      d. Anion Resin: Strong base type 1, hydroxyl form
      e. Resin Capacity: 15,000 grains/ft^3
      f. Sodium Leakage: 0.1 ppm

B. Vendor shall provide beds in configuration shown on flow diagram in sufficient number to achieve design flow and criteria.

C. Mechanical
   1. Vessels: fiberglass reinforced plastic (FRP) with vinyl ester lining and connections
   2. Vessel Rating: 150 psig at 100°F
   3. Hoses: polypropylene
   4. Piping: as per referenced pipe Section

D. Instrumentation
   1. Locate conductivity indicator after first set of beds
      a. Setpoint 2.0 megohm
   2. Pressure gauges shall be provided before and after unit. Sample valve shall be provided after unit.

2.07 STORAGE TANK

A. Refer to Drawings for Equipment Schedule.
B. Description: polyethylene, cylindrical, atmospheric, closed top tank with flanged and covered manway.
C. Acceptable Manufacturers: Chemtainer, Polyprocessing, Snyder Tanks, or approved equal
D. Tank to be one piece, seamless construction of high density linear polyethylene.
E. Polyethylene to be FDA approved for food contact as per 21 CFR 177.1520. Resin complies with ASTM D-1998.
F. Design for at least 1.9 specific gravity. Temperature is 60° to 80°F.
G. Tank shall be air-tight
H. Cone or dish bottom shall be totally drainable.

I. Indoor location
J. Dished top head
K. Epoxy coated (2 coats) steel, or plastic support, so that bottom tank nozzle is at least 18” off of floor.
L. Nozzles:
   1. Nozzles shall be welded inside and outside.
   2. Nozzles shall be flanged and gusseted.
   3. Manway shall be flanged with gasketed, bolted cover. Standard lid is unacceptable.
   4. Vendor is responsible to ensure adequate number and size of nozzles
M. Quality Control:
   1. Vendor shall have active quality control program.
   2. Tank fabrication and all welds shall be inspected, and inspection shall be documented.
   3. Testing shall conform to ASTM D-1998.
   4. Tank shall be kept clean during and after fabrication consistent with use for high purity service.

2.08 STORAGE TANK VENT FILTER

A. Description: Cartridge filter housing and hydrophobic sterile filter element for vent filtration.
B. Acceptable Manufacturers: Pall, Millipore, Sartorius, or approved equal
C. Design Conditions
   1. Rating: 0.2 micron
   2. Pressure Drop: 0.2 psid maximum at 8 scfm
D. Filter Housing:
   1. Material: Polypropylene
   2. Pressure Rating: 50 psig minimum
   3. Gasket Material: Silicone
E. Filter Element:
   1. Quantity: per Vendor
   2. Grade: Pharmaceutical, 0.2 micron absolute, hydrophobic
   3. Material: PVDF/Polypropylene

2.09 DISTRIBUTION PUMPS

A. Vertical, multistage, stainless steel centrifugal, Grundfos CRN or approved equal
B. Grundfos model CRN or approved equal.
C. Design rating: Pumps shall be capable of delivering a maximum of 25 gpm at 175 ft and a minimum of 15 gpm at 175 ft.
D. Surfaces in contact with water shall be 316 stainless steel.
E. Nozzles shall be 150# ANSI flanges.
F. Seal shall be a single mechanical seal with a carbon rotating face and a tungsten carbide stationary seat.
G. Motor shall be TEFC, 460 V, 3 phase, VFD compatible
H. VFDs shall be provided for motors by HPW equipment Vendor.

2.010 INSTRUMENTATION

A. General
   1. Instrumentation shall be provided to enable reliable, safe, and efficient operation of the system, and to meet the functional requirements of this specification.
   2. Instrumentation shown on the drawings identified in Part 1.1 and in this specification shall be provided.
   3. Instruments shall be appropriate for water quality level.
      a. Instrument in contract with water downstream of the RO unit shall be of sanitary design. Pressure sensors shall have diaphragm seals.

4. Vendor shall ensure instruments are properly calibrated.

B. Production System
   1. Instruments integral to production system shall provide the required functionality with a high level of reliability.

C. Distribution system:
   1. Resistivity and temperature transmitters shall be Thornton or approved equal.
      a. Vendor shall provide calibration certification of installed unit.
      b. Sensors for conductivity/resistivity shall be installed in run of a horizontal tee with flow exiting the upward branch.
   2. Tank level transmitter shall provide continuous measurement of water level.
   3. Diaphragm seals shall be provided for all gauges and pressure transmitters on piping and equipment in distribution system. Alternatively, pressure gauges with 3A rating can be used.
   4. Thermowells shall be 316 stainless steel, 3A rated.
   5. Pressure regulators and backpressure regulators shall be installed with at least 10 pipe diameters of straight pipe upstream and downstream of regulator.
   6. Self contained backpressure regulator and gauge shall be provided on the end of the return line of the distribution loop.
      a. Specification as per referenced piping section
   7. Pressure Gauges shall have minimum 3.5” face.

D. Flow meter for recirculation line
   1. Description: Rotameter
   2. Manufacturer: Blue-White Series F-460 or approved equal
   3. Range: 1 to 10 gpm water
   4. Material:
      a. End Fittings: 316 SS
      b. Float and Rod: 316 SS
      c. Metering Tube: Acrylic
      d. O-Rings: Viton

2.011 CONTROL SYSTEM

A. General
   1. Controls shall be provided to enable reliable, safe, and efficient operation of the system, and to meet the functional requirements of this specification.
   2. Vendor shall provide:
      a. A dedicated control system to monitor and control the entire system
      b. Design of the control system, hardware, and software.
      c. Controls and instrumentation required to ensure proper operation of the equipment and to consistently and reliably produce and maintain the required water quality.
      d. Programming to accomplish the required functions. Programming shall be systematically tested, including challenge testing, and testing shall be documented.
      e. A functional Specification that completely describes the operation of the system and specifies the acceptable ranges for operating parameters.
   3. This specification is written for systems that have a dedicated PLC on RO unit; and would require second PLC for distribution system. Optionally, a single PLC that would control entire system would be acceptable and preferable.

B. Hardware
   1. PLC shall be an Allen Bradley MicroLogix or CompactLogix.
   2. HMI shall be Allen Bradley Color Panelview Plus 1000 Plus
   3. System shall have 20% spare processing capacity and space for cards that would provide an additional 20% I/O.

C. Functionality
   1. System shall automatically:
      a. Operate the production system
      b. Start and stop of flow from the production system into the storage tank based on tank level.
      c. Stop the flow from the production system into the storage tank if the resistivity falls below the acceptable value or if key production operating parameters are out of range.
      d. Adjust the speed of distribution pump to maintain constant flow rate at end of loop.
         1) Controls shall automatically switch operation of pumps at predetermined intervals.
      e. Stop the distribution pump[s] if tank is below Low-Low level.
      f. Turn UV light on and off
   2. System shall continuously monitor and provide alarms for:
      a. Tank levels
      b. Discrete alarm signals from RO, UV lights, and other equipment to ensure safe and proper operation of those units.
      c. Resistivity of water from the production system that is supplied to storage tank
      d. Distribution loop:
         1) Resistivity, on supply line
         2) Resistivity, flow, temperature on return
      e. Distribution pump running
      f. Faults from distribution pump VFD.
      g. Status of distribution pump.
   3. Control system shall provide:
      a. One discrete general fault output for connection to the BAS system corresponding to any alarm condition.
      b. An Alarm List.
      c. Capability of assigning multiple levels of alarms for all analog monitored parameters: low low, low, high, high high.
      d. Capability of providing a time delay for each alarm.
      e. Password protected, multilevel security to prevent change of primary operating parameters by unauthorized personnel.
   4. Alarms
      a. Vendor shall specify appropriate operating ranges and alarm setpoints for the production system.
      b. Alarm for the distribution system and preliminary setpoints shall be as follows:
         1) Storage Tank Level
            A) High high - approx. 95% capacity: provide alarm.
            B) Full - approx. 90% capacity
            C) Add - approx. 75% capacity
            D) Low low alarm - approx. 50% capacity: provide advisory message. This level indicates that makeup is inadequate.
            E) Low - approx. 5% capacity: shut down distribution pumps and provide alarm. Pumps shall not start under low low level conditions.
         2) Alarms shall only be active when pump has been in Automatic Mode for at least 1 minute.
   5. Operator Interface (Panelview) shall:
      a. Provide graphical displays that show process in flow diagram format
         1) summary screen[s]
         2) Several individual screens, dividing the system into logical parts, sufficient to clearly and logically display content.

b. Display:
1) all monitored parameters on the graphics
2) operation status of equipment
3) Active Alarms
4) Alarm History

D. Panels
1. NEMA 12 panel(s) shall be provided to contain controls, solenoids, operator interface, motor starters, step down transformers, and other devices required for system.
2. Panels shall be designed and listed in accordance with UL 508A.
3. Transmitters to be mounted in panels where feasible.
4. Power for transmitters and instrumentation shall be provided from panel.
5. Local horn and beacon for alarm conditions shall be provided. Provide alarm silence button.
6. Panels shall provide 20% minimum spare capacity of space, PLC chassis space, wireway space, and terminal blocks to allow for future expansion by adding I/O cards and associated cabling.

2.012 ELECTRICAL POWER

A. Vendor shall provide all panels, devices, wiring, local disconnects, VFDs and motor controls for the system.
1. A separate low voltage panel shall be provided for the PLC and HMI.
2. Panels shall be designed and listed in accordance with UL 508A.
3. An E-stop shall be provided.
4. Electrical components and installation shall conform to the NEC.
5. Equipment and installation shall conform to the latest requirements or state and local authorities having jurisdiction.
6. UL labeled equipment shall be provided to the full extent that UL labels are applicable.
7. Wiring shall comply with methods approved in NFPA 79.

B. Motors
1. NEMA Premier efficiency as per NEMA MG. 1-2003.
2. Service factor of 1.2 Shall not operate in service factor
3. TEFC
4. Conform to requirements of NEMA, IEEE, NSI, and NEC standards and shall be listed by UL for service specified.

C. Drops will be provided, under the electrical contractor’s scope of work, at the following locations:
1. Individual 110 VAC/1 ph/60 Hz drops to equipment prior to the reverse osmosis unit.
2. One 480 VAC/3 ph/60 Hz drop to panel on the reverse osmosis unit.
3. One drop 480 VAC/3 ph/60 Hz to a distribution system equipment panel.
4. Vendor shall provide for distribution of power from these panels to accommodate all of Vendor’s needs.
a. Vendor will be responsible for transforming power as required.
b. Vendor shall provide detailed instructions to Contractor covering any field wiring between Vendor equipment.
c. Vendor shall provide local disconnects.

PART 3 - EXECUTION

3.01 CONTRACTOR RESPONSIBILITIES

A. Coordinate delivery of tank and skids with building construction to ensure that tank can be moved into building and set in place.

B. Inspect delivered equipment and components for evidence of damage or contamination

C. Rig, handle, store, set, and anchor equipment as per Vendor's recommendations and in manner that prevents impact damage and excessive stress.
D. Maintain a high level of cleanliness during handling and installation.
    1. Prior to starting work, identify areas that will be used for storage and fabrication, and take measures to prevent contamination from adjoining areas.
    2. Keep openings on assemblies sealed during fabrication to prevent contamination prior to final installation.
E. Provide housekeeping pads as indicated on the drawings identified in Part 1.1.
    1. Determine final size of pads based on approved Vendor submittal drawings.
F. Install equipment level and plumb.
G. Interconnect Vendor equipment as required
    1. Install HPW piping in compliance with specification in "Related Work"
    2. Connect utilities.
H. Ensure that the system is ready for safe startup.
I. Provide tagging for equipment, piping, and valves.
J. Coordinate startup, balancing, testing and turnover of system with Owner and Vendor.
    1. Contractor shall be responsible for maintaining system in good working condition until final turn-over to Owner. Contractor may choose to actively operate system or place system in safe, non-operational state if significant time period is anticipated prior to Owner turn-over.
        a. Contractor shall monitor system to assure all parameters are within specified ranges if system remains in operation. Contractor shall perform routine maintenance to keep system in proper operating condition.
        b. Contractor shall be responsible for protecting system from damage or degradation if system is to be placed in non-operational state. Procedures and protective measures shall comply with manufacturer's recommendations for storage. System shall be drained and purged/dried with nitrogen to prevent corrosion. Contractor shall identify utility and other live system connections that should be isolated and locked out. Remove and store internal elements that can degrade if system is not operational. Provide written startup procedure for restoring system to operation.

3.02 VENDOR RESPONSIBILITIES

A. Provide a representative responsible for on-site activities:
    1. Verify that system is ready for startup.
        a. Inspect installation, interconnections, utility connections, vents, etc.
        b. Load media and filter elements as required.
        c. Conduct pre-startup check-out.
    2. Startup and test system.
        a. Verify proper operation in all operating modes.
        b. Adjust operation of equipment and controls to meet operational, water quality, and safety requirements, and update documentation as required.
        c. Test and balance distribution system and achieve stable operation at specified flow and pressure conditions.
        d. Adjust self contained backpressure regulator at end of distribution loop to maintain pressure at its upstream pressure gauge at the design setpoint value.
            1) Verify system flows are as per design values
    3. Sanitize system as per procedure.
    4. Demonstrate to the Owner or to the Commissioning Agent that system operates in accordance with requirements of this specification and per approved submittal documentation.
        a. Provide procedures that systematically verify that system operates as designed.
            1) Identification of acceptable ranges for all operating parameters.

b. Draw samples from at least 4 locations on the distribution loop and provide the results of analysis indicating that the water meets the bacteria level requirement.
   1) Arrange for the bacterial analysis to be performed by an independent testing laboratory, using standard methods, compliant with the requirements of the water quality standard in Part 1.5.
c. Calibrate resistivity and TOC monitors and provide calibration certification.

5. Maintain operational oversight of system until Owner's organization is able to assume responsibility for operation.
6. Provide Turn Over documentation as identified in Part 1.
   a. Documents shall include the final operational setpoints and information.
7. Provide training for Owner
   a. Provide a program that covers overview, operator training, and maintenance training.
   b. Operations training shall include:
      1) Start-up procedure
      2) Shutdown procedure
      3) Emergency operations
      4) Safety procedures and hazards
      5) Alarm conditions and actions
      6) Parameter adjustments
      7) Security

END OF SECTION

SECTION 230000
GENERAL HVAC REQUIREMENTS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Specification requirements defined in Division 20 of this Specification apply to, and are in addition to the work associated with equipment, systems, materials, and installation requirements specified in Division 23. Contractor shall provide the requirements specified in Division 20 to obtain complete systems, tested, adjusted, and ready for operation.

1.02 RELATED WORK

A. Section 20 0000 - General Mechanical Requirements
B. Section 20 0513 - Motors
C. Section 20 0514 - Variable Frequency Drives
D. Section 20 0529 - Mechanical Supporting Devices
E. Section 20 0553 - Mechanical Systems Identification
F. Section 20 0700 - Mechanical Systems Insulation

PART 2 - PRODUCTS

2.01 NOT APPLICABLE TO THIS SECTION.

PART 3 - EXECUTION

3.01 NOT APPLICABLE TO THIS SECTION.

END OF SECTION

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SECTION 230550
VIBRATION ISOLATION

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 20 0529 - Mechanical Supporting Devices
B. Section 23 2123 - Pumps
C. Section 23 3400 - Fans
D. Section 23 3314 - Ductwork Specialties (Duct Flexible Connections)
E. Section 23 7214 - Heat Recovery Equipment
F. Section 23 7323 – Factory Fabricated Custom Air Handling Units
G. Section 23 7400 – Packaged Rooftop Air Handling Units
H. Section 23 8126 - Split System Air Conditioners

1.02 DESIGN CRITERIA

A. Isolate all motor driven mechanical equipment, unless otherwise noted, from building structure, and from systems that they serve, to prevent equipment vibrations from being transmitted to structure. Unless specifically indicated, follow the latest edition of ASHRAE Application Handbook - Sound and Vibration Control, or manufacturer's recommendations for isolator selection whichever is more stringent.
B. Select and locate isolators to produce uniform loading and deflection. Use minimum of 4 isolators to support each piece of equipment.
C. Select vibration isolation devices based on the lowest operating speed of equipment.
D. Vibration Criteria:
   1. All rotating equipment shall operate at speeds less than 80% of their true critical speed. Unless otherwise required, equipment shall be balanced according to recommendations given in the following schedules.
   2. Vertical vibration of rotating equipment shall not be greater than levels indicated. Vibration shall be measured on equipment. If equipment has inertia base, allowable vibration level is reduced by ratio of equipment weight alone to equipment weight plus inertia base weight.
   3.

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

E. Following field installation, each fan and pump over 25 hp shall be balanced in accordance with the following maximum rms velocity levels:
   1. Fans: 0.15 inch/sec
   2. Pumps:
      0.16 inch/sec for 30 hp and smaller
      0.18 inch/sec for 40 through 60 hp
   3. Allowable field pump vibration values above are based on HI 9.6-2000, Figure 9.6.4.12.

1.03 SUBMITTALS

A. Submit Shop Drawings including, but not limited to, the following:
   1. Manufacturer's name

2. Isolator type and model number
3. Materials of construction and finish
4. Dimensional data
5. Load ratings (lbs)
6. Isolator free and operating heights
7. Static deflections
8. Isolation efficiency based on lowest operating speed
9. All other appropriate data

1.04 SUPERVISION, INSPECTION AND CERTIFICATION

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

PART 2 - PRODUCTS

2.01 MATERIALS

A. Materials used shall retain their isolation characteristics for life of equipment served. Elastomeric materials shall comply with ASTM D2240 and shall be oil-resistant industrial grade neoprene.
B. Isolators shall be treated to resist corrosion.
C. Isolation devices subject to weather shall have either hot-dip or cold-dip galvanized, cadmium plated, or neoprene coated finish after fabrication and be furnished with limit stops to resist wind.
D. Vibration isolator springs shall have minimum additional travel to solid equal to 50% of rated deflection.
E. Ratio of lateral to vertical stiffness of vibration isolators shall not be less than 0.8 or greater than 2.0.
F. Coordinate selection of devices with isolator and equipment manufacturer.

2.02 MANUFACTURERS

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

2.03 TYPE 1 MOUNTS (NEOPRENE PAD)

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

2.04 TYPE 2 MOUNTS (NEOPRENE MOUNTS)

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

2.05 TYPE 3 MOUNTS (UNHOUSED SPRING WITH NEOPRENE)

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

2.06 TYPE 4 MOUNTS (RESTRAINED SPRING WITH NEOPRENE)

A. Mason Type SLR, combination spring and neoprene with rib molded base similar to Type 3 above but shall have housing that includes vertical limit stops to prevent spring extension when weight is removed.
B. Installed and operating heights shall be the same. Maintain minimum clearance of 1/2" around restraining bolts and between housing and spring so as not to interfere with spring action. Limit stops shall be out of contact during normal operations. Use height saving brackets.

2.07 TYPE S BASES (STEEL BASE)

A. Mason Type WF, structural steel bases, rectangular in shape for all equipment other than centrifugal refrigeration machines and pump bases which may be "T" or "L" shaped. Pump bases for split case pumps shall include supports for suction and discharge base ells. Perimeter members shall be beams with minimum depth equal to 1/10 of longest base span between isolators, but not less than 4". Beam depth need not exceed 14" provided that deflection and misalignment is kept within acceptable limits as determined by manufacturer. Employ height saving brackets in all mounting locations to provide base clearance of at least 1" above floor or housekeeping pad.

2.08 TYPE I BASES (INERTIA BASE)

A. Mason Type K, or BMK rectangular or T shaped structural beam or channel concrete forms for floating foundations. Bases for split case pumps shall be large enough to provide support for suction and discharge base ells. Base depth need not exceed 12" unless specifically recommended by base manufacturer for mass, rigidity or component alignment. Base depth shall be a minimum of 1/10 of longest base span between isolators, but not less than 6". Forms shall include concrete reinforcement bars welded in place running both ways. Furnish forms with drilled steel members with sleeves welded below holes to receive equipment anchor bolts where anchor bolts fall in concrete locations. Employ height saving brackets in all mounting locations to maintain base clearance of at least 1" above floor or housekeeping pad.

2.09 TYPE 5 HANGERS (SPRING HANGER WITH NEOPRENE)

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

2.010 TYPE 6 HANGERS (PRECOMPRESSED SPRING HANGER WITH NEOPRENE)

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

2.011 TYPE T THRUST RESTRAINTS

A. Mason Type WB, horizontal thrust restraint consisting of spring element in series with neoprene pad as described for Type 3 mounts with the same deflection as specified for mountings or hangers. Spring element shall be contained within steel frame and designed so it can be preset for thrust at factory and adjusted in field for maximum of 1/4" movement at start and stop. Furnish thrust restraints complete with rods and angle brackets for attachment to both equipment and ductwork or equipment and structure. Attach horizontal restraints at centerline of thrust and symmetrically on either side of unit.

2.012 FLEXIBLE PIPING CONNECTORS

A. Flexible connectors shall be suitable for pressure, temperature and fluid involved, but not less than 215 psig working pressure at 250°F for 14” and smaller and 150 psi working pressure at 250°F for 16” and larger.

B. Flexible connectors shall be straight pipe configuration and shall not be used to replace pipe fittings such as elbows.
C. Where metal braided covered flexible connector is utilized, minimum live length of flexible connector shall be as follows.

Nominal Pipe Diameter (mm(in))	Minimum Live Length (mm(in))
65 mm(2-1/2”) and smaller	300 mm(12”)
80 mm(3”) and 100 mm(4”)	460 mm(18”)
130 mm(5”) and larger	600 mm(24”)

D. Water System:
   1. Connection to Rotating Equipment:
      a. Connectors shall consist of Kevlar or Nylon tire cord fabric reinforced with EPDM cover and liner. Solid steel rings or steel wire shall be used within raised face rubber flanged ends to prevent pullout. Furnish connectors with control rods only where recommended by connector manufacturer.
      b. 50 mm(2") and Smaller: Threaded connections, single sphere design similar to Mason SAFEFLEX SFU.
      c. 65 mm(2-1/2") and Larger: Floating steel flange connections, two sphere design with ductile iron or plated carbon steel reinforcing rings, similar to Mason SAFEFLEX SFDEJ. Single sphere design similar to Mason SAFEFLEX SFEJ, may be used for 350 mm(14") and larger.
   2. Connection to Non-rotating Equipment Mounted on Vibration Isolators:
      d. Seamless corrugated bronze or stainless steel flexible connector with braided cover for 50 mm(2") and smaller with threaded or flanged connections; seamless corrugated stainless steel flexible connector with braided cover for 65 mm(2-1/2") and larger with flanged connections.
E. Refrigerant System:
   1. Seamless corrugated bronze flexible connector with bronze wire braided cover and standard copper tube ends for copper piping. Seamless corrugated stainless steel flexible connector with braided cover for steel piping.
F. Compressed Air Systems:
   1. Seamless corrugated bronze flexible connector with bronze wire braided cover for copper piping and seamless corrugated stainless steel flexible connector with braided cover for steel piping. Connector ends shall be threaded, soldered, or flanged to match piping system valve ends.
G. Do not provide flexible piping connectors for compressed air piping.
H. Do not provide flexible piping connectors for gas piping

2.013 PERFORMANCE

A. Select vibration isolation devices to achieve either minimum 95% isolation efficiency or minimum static deflection and mounting requirements listed below, whichever is greater. Minimum static deflections listed below are not nominal but certifiable minimums with actual installed load. Unless otherwise indicated, apply requirements listed for floor mount for roof-mounted equipment.

TYPE OF EQUIPMENT	Ground Supported Slab		Floor Span							
			Up to20 ft		20 ft to 30 ft		30 ft to 40 ft		40 ft to 50 ft	
	Type	Min Defl. (in)	Type	Min Defl. (in)	Type	Min Defl. (in)	Type	Min Defl. (in)	Type	Min Defl. (in)

Pumps:										
Flexible Coupled (End suction and double suction/split case)										
Thru 40 hp	Bolt to pad		3-I	0.75	3-I	1. 5	3-I	1. 5	3-I	2.5
Inline	Support inline pumps by connected pipes if suspended or by pipe stands or support frame from floor as shown. No vibration isolation mounts are required. Provided spring hangers for connected piping as specified in this Section.									
Air Compressors:										
Tank Mounted Horizontal										
Thru 10 hp	3	0.75	3	0.75	3	1.5	3	1.5	3	2.5
15 hp and over	3-I	0.75	3-I	0.75	3-I	1.5	3-I	1.5	3-I	2.5
Tank Mounted Vertical and Base Mounted										
All sizes	3-I	0.75	3-I	0.75	3-I	1.5	3-I	1.5	3-I	2.5
Vacuum Pumps:										
Tank Mounted Horizontal										
Thru 10 hp	3	0.75	3	0.75	3	1.5	3	1.5	3	2.5
15 hp and over	3-I	0.75	3-I	0.75	3-I	1.5	3-I	1.5	3-I	2.5
Tank Mounted Vertical and Base Mounted										
All Sizes	3-I	0.75	3-I	0.75	3-I	1.5	3-I	1.5	3-I	2.5
Centrifugal Inline Fans:										
Suspended	Use Type 5 hangers with deflection from blower minimum deflection guide. Use Type 5-T for over 4” static pressure.									
Fan Coil Units:	Type 5 with minimum deflection of 0.5” for 600 cfm or less and 0.75” for over 600 cfm.									
Piping Connected to Rotating or Recipro-Equipment:	Use flexible piping connections, and Type 6 hangers for distance of 100 pipe diameters or 50 ft away from equipment, whichever is greater. Hangers shall have minimum deflection of 0.75” for pipe sizes 3” and smaller, 1.5” for pipe sizes 4” through 6” and 2.5” for pipe sizes 8” and larger. For piping less than 2” in diameter, neoprene or felt pad inserted between pipe or pipe covering and clamp or hanger may be used in lieu of Type 6 hangers. Where piping is floor-supported, above requirements shall apply, but use Type 3 mounts instead of hangers. Flexible piping connection shall not be used for unit heaters and in-line pumps that are supported by connected pipes. Type 6 hangers with 1” minimum deflection shall be applied within one foot of both sides of in-line pump and for distance of 100 pipe diameters or 50 ft away from first hanger at in-line pump, whichever is greater.									

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install and adjust vibration isolation devices as specified, as shown on drawings and according to manufacturer's recommendations.
   1. Adjust isolators after the fan system is at operating weight.

2. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
3. Adjust active height of spring isolators.
4. Adjust restraints to permit free movement of equipment within normal mode of operation.
5. Adjust air-spring leveling mechanism.

B. In no case shall installation short circuit isolation devices.

3.02 INERTIA BASES (TYPE I BASES)

A. Provide required concrete for inertia bases. Refer to Section 20 0000 - General Mechanical Requirements for concrete work.

B. Raise inertia bases to final elevation with temporary blocking prior to making piping connections to pumps or ductwork connections to fans. After connections are complete, install vibration isolators in accordance with manufacturer's installation instructions.

3.03 FLEXIBLE PIPING CONNECTIONS

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

B. Piping connected to coil which is in assembly where fan is separately isolated by vibration isolators and duct flexible connections does not require flexible piping connectors or piping vibration hangers.

C. Piping connected to HHW boilers shall have flexible piping connections and piping vibration hangers to prevent thermal stress in piping system.

3.04 AIR HANDLING UNITS

A. Roof mounted air handling units with internal supply and general exhaust fans are to be provided with internal fan vibration isolation.

3.05 FLEXIBLE DUCT CONNECTIONS

A. Provide flexible connections for duct connected to air handlers and exhaust fans; refer to Section 23 3314 - Ductwork Specialties (Duct Flexible Connections).

END OF SECTION

SECTION 230594
WATER SYSTEMS TEST ADJUST BALANCE

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 23 2118 - Valves
B. Section 23 2120 - Piping Specialties
C. Section 23 2123 – Pumps
D. Section 23 5214 – Primary Heating Equipment

1.02 REFERENCE

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

1.03 DESCRIPTION

A. TAB Contractor shall be responsible for providing complete testing, adjusting and balancing (TAB) work for HVAC hydronic systems, such as pumps, boilers, coils and other processes included in this project.
B. Work required shall consist of setting volume flow rates and adjusting speed controls, recording data, making tests, and preparing reports, as specified herein.
C. Scope of work includes TAB of new work specified herein and includes all equipment, distribution systems, and terminal units connected.
D. Work is limited to new areas within the construction boundaries and does not include central pumping equipment or other areas. Make attempts to balance flows to values indicated. If flow is low, attempt to proportional balance flows to the same percentage below design.
E. TAB work shall be performed by persons trained in TAB work and certified by Associated Air Balance Council (AABC) or National Environmental Balancing Bureau (NEBB). Procedures shall be in accordance with the latest edition of AABC, NEBB or TABB Standards, ASHRAE - 2011 HVAC Applications Chapter 38, and as detailed herein.
F. Mechanical Contractors who are members of AABC or NEBB and who have qualified personnel available to perform work may submit Quality Assurance Submittal for approval. Mechanical Contractors who cannot meet these requirements shall subcontract with independent TAB Contractor who meets these requirements. TAB subcontractor shall prepare Quality Assurance Submittal for Contractor who will submit it for approval.
G. Upon direction of Architect/Engineer or TAB subcontractor, Mechanical Contractor shall provide at no additional cost to Owner, any additional work and/or devices necessary to properly balance system, including calibrated balancing valves, gauge tappings, flow sensors, and thermometer wells. Mechanical Contractor shall be responsible for trimming and balancing pump impellers as necessary to obtain design pump flow rates at the minimum pressure differential.
H. TAB work shall not proceed until all assigned personnel have been approved by Architect/Engineer via Quality Assurance Submittal. Coordinate each phase of TAB work with overall project schedule. Each phase of TAB work shall be done in timely manner as detailed herein. Fieldwork must be completed before occupancy. Certificate of Substantial Completion shall not be issued until after Final Report is accepted by Architect/Engineer.

1.04 SUBMITTALS

A. General:
    1. Make submittals in accordance with project submittal procedure. Submit minimum of 5 copies of submittals unless otherwise directed (3 for O&M Manuals, 1 for A/E, 1 for Contractor).
    2. Reports shall be assembled using 3-ring hard cover binder with project name and location on cover and side panel. Information sheets shall be 8-1/2" x 11" white bond paper. Use pre-printed forms of NEBB or AABC wherever possible. Provide sortable electronic version

as well as hard copy. Provide numbered tabs for each system. Assemble report in the following order:
a. Transmittal letter
b. Cover sheet with project title, location, submittal date, and name and addresses of Owner, Mechanical Contractor, TAB subcontractor, Architect, and Engineer
c. Index of numbered tabs listing major systems
d. Data organized by system in the following order:
1) Equipment data and measurement summary
2) Equipment measurement data
3) Branch main measurement data
4) Terminal device measurement data arranged by room or zone
e. Reduced-size copies of “As-Built” Mechanical Piping drawings on 11” x 17” white bond paper

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

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

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

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

1.05 REFERENCE STANDARDS

A. Refer to the latest publications of NEBB, AABC and ASHRAE publications for establishing required procedures.

PART 2 - PRODUCTS

2.01 INSTRUMENTATION

A. Provide required instrumentation to obtain proper measurements. Application of instruments and accuracy of instruments and measurements shall be in accordance with requirements of NEBB or AABC Standards and instrument manufacturer's specifications.

B. Instruments used for measurements shall be accurate, and calibration histories for each instrument shall be available for examination by Architect/Engineer upon request. Calibration and maintenance of all instruments to be in accordance with requirements of NEBB or AABC Standards.

PART 3 - EXECUTION

3.01 GENERAL

A. TAB work shall be done in separate phases as outlined herein. TAB schedule shall allow ample time to complete TAB work before occupancy. Follow procedures outlined herein and as described in Planning Phase narratives.

B. Unless otherwise specified, maximum acceptable offset tolerance shall be ± 10% of design flow rates indicated on drawings and schedules.

3.02 PLANNING PHASE

A. Procedure:

1. Obtain the latest Contract Documents including addenda, construction bulletins and change orders. Obtain shop drawings and performance curves from Mechanical Contractor for pumps, flow measuring devices, and terminal devices. Prepare Planning Report as detailed herein. Make adjustments in Planning Report and/or measuring instrument calibration.

B. Planning Report:

1. Planning Report shall contain the following minimum requirements.
2. Narratives: Furnish written narratives of procedures to be used. Include separate narratives for each pump and liquid fluid handling system. Identify flow-measuring devices to be used at each pump and terminal device. Include different narratives for constant and variable flow systems. For non-standard water systems, include narratives on how to measure and adjust for different viscosities. Narratives shall include references to published standards of NEBB or AABC. Narratives shall include measuring instruments to be used and ranges required for each procedure. Narratives shall include specified adjustment tolerances.
3. Prebalance Checklist shall include, but not be limited to:
    a. Check for completeness of work
    b. System cleaning
    c. System fill and air venting
    d. Place system into operation
    e. Check expansion tanks and fill pressures
    f. Pump bearings, alignment, starters, vibration isolators, rotation
    g. Setting valves to proper position including shut-off and bypass valves
    h. Set up of controls and control devices
4. Measuring Instrument List: List of measuring instruments will be used for each procedure. Indicate ranges required for each procedure. Provide data on each measuring instrument to be used. This data shall include:
    a. Manufacturer name and model number
    b. Measurement range
    c. Pressure/temperature limits
    d. Date put into service
    e. Date of last calibration
    f. Certificate from calibration firm
5. Architect/Engineer reserves the right to request adjustments in any procedure and/or ask for recalibration of any measuring instrument that has not been recalibrated within past year.
6. Samples: Submit copies of TAB forms to be used.
7. Branch circuit and terminal measurements and adjustments: Indicate on pre-printed forms all measurements to be taken and adjustments to be made in field. Include branch circuit or terminal identification, system, space served, location, design flow rates (including zone and system summaries), and flow measuring device size, type, Cv, and manufacturer. Indicate the initial set points on forms.

3.03 SET-UP PHASE

A. Procedure:
   1. Perform prebalance checkout as per Planning Phase narrative.
B. Initial Test:
   1. Measure pump data and flow rates in "as found" condition after initial valve settings are made.
C. Initial Test Report:
   1. Submit report to Architect/Engineer and Mechanical Contractor indicating measurements made and including notes of items that are not complete or are not within design tolerance.

3.04 FINAL BALANCE PHASE

A. Procedure:
   1. Perform procedures as per Planning Phase narrative. Correct deficiencies and redo procedures as required prior to submitting Final Report.
   2. Tag full load amps/voltage on each pump motor over 1 hp after final balance is completed.
B. Final Report:
   1. Submit report to Architect/Engineer and to Mechanical Contractor indicating all data, measurements and adjustments as per requirements herein and per Planning Phase narrative. Do not submit partial or incomplete reports.
C. Final Report Adjustments:
   1. Architect/Engineer reserves the right to check any measurement or adjustment made and to reject any portion of work not within specified tolerance. Contractor shall resubmit all or portions of Final Report as directed by Architect/Engineer.

END OF SECTION

SECTION 230595
AIR SYSTEMS TEST ADJUST BALANCE

PART 1 - GENERAL

1.01 REFERENCE

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

1.02 DESCRIPTION

A. This Contractor shall be responsible for providing complete testing, adjusting and balancing (TAB) work of all air systems, such as air handling units, return fans, exhaust fans, air terminal devices, diffusers, grilles and other air moving processes included in this project.

B. Work required shall consist of setting volume (flow) and speed adjusting facilities provided or specified for the systems, recording data, making tests and preparing reports, all as hereinafter specified.

C. TAB work may be performed by Mechanical Contractors who are members of Associated Air Balance Council (AABC) or National Environmental Balancing Bureau (NEBB) and who have qualified personnel available to perform work. Mechanical Contractors who cannot meet these requirements shall subcontract with independent TAB Contractor who meets these requirements.

D. Upon direction of Engineer, Contractor shall provide at no additional cost to Owner, any additional work and/or devices necessary to properly balance system, including fan sheave, motor sheave and/or drive belts.

1.03 SUBMITTALS

A. General:
   1. Make submittals in accordance with project submittal procedure.
   2. Use NEBB or AABC standard forms wherever possible.

B. Planning Report:
   1. Submit Planning Report as detailed in Part 3 of this Section to demonstrate to Architect/Engineer and Owner that proper procedures are being followed. Planning Report shall be submitted at least 60 days before any fieldwork starts.

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

D. Final Report:
   1. A preliminary Final Report shall be submitted within 30 days after completion of field work and no less than two weeks prior to Substantial Completion for review by Project Engineer of Record, and Commissioning Agent. All deficiencies noted by the TAB firm shall be listed in the preliminary report. The deficiencies deemed “minor” in nature, by the Engineer of Record, consensus shall not prevent the project from being deemed “Substantially Complete”.
   2. All deficiencies identified in the preliminary Final Report prior to Substantial Completion shall be corrected prior to Final Completion. A Final Report, with no deficiencies, shall be submitted by the TAB firm prior to Final Completion for review and verification by the University and the Project Engineer of Record.
   3. Submit Final Reports as detailed in Part 3 of this Section to assure design objectives are met and to assist Owner in future maintenance.
   4. Submit Final Reports in Adobe Acrobat PDF format, consisting entirely of standard text characters compatible with the keyword search function in Adobe Acrobat. Organize Final Reports by system number and furnish table of contents and tabs for each piece of equipment or system. Each piece of equipment or system shall be represented by a

unique, specific Bookmark using the Adobe Acrobat navigation pane. Final Reports consisting of PDF pages that contain images of scanned documents are not acceptable and will be returned without review.

5. Incomplete report forms will not be approved.
6. Submit revisions to the Final Report as required to document results of Seasonal Testing.

1.04 PROCEDURES

A. Unless otherwise specified, test, adjust and balance air systems including all equipment, apparatus and distribution systems in accordance with the latest edition of NEBB or AABC Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems.

B. Seasonal Testing:
   1. Perform TAB work for each air handling unit to measure and record the performance of each system under full heating and cooling load conditions.
   2. Schedule each phase of seasonal testing based on outside air conditions:
      a. Perform heating season TAB work when the outside air is no more than 10°F greater than the scheduled peak heating dry-bulb temperature condition.
      b. Perform cooling season TAB work when the outside air is no lower than 5°F less than the than the scheduled peak cooling dry-bulb temperature condition.
      c. When variations in outside air conditions do not allow for scheduled seasonal testing to be performed during the construction phase, return to the site to provide additional phases of TAB work after construction is complete to allow for seasonal testing during conditions noted herein.
   3. Seasonal Testing is only required for air handling units; air terminal, branch ducts, and outlets are not required to be included in Seasonal Testing.

C. Additional Air Handling Unit Coil Capacity Testing:
   1. After temperature controls installation is complete, test each air handling unit coil at four different air flow settings: 25%, 50%, 75%, and 100% of full design air flow rate. Cooling coil control valve and pump system shall modulate automatically to maintain setpoints as described in control sequences.
   2. Measure and record entering/leaving water temperatures corresponding to each air flow setting to document as-installed capacity and part-load performance.

1.05 GUARANTEE

A. Guarantee that all test-adjust and balance work, be performed in accordance with NEBB Standards and that all air systems operate within plus or minus 10% of design flow rates as shown on plans and/or as scheduled.

B. Where supply airflow rates and exhaust airflow rates are used to maintain lab offset air directional control or room pressure relationships, maximum acceptable supply air offset shall be 0 to +10% of design flow rate. Associated exhaust air (or return air) flow rate shall be balanced to provide indicated differential between supply air and exhaust air (or return air) after supply air system has been balanced.

PART 2 - PRODUCTS

2.01 INSTRUMENTATION

A. Provide all required instrumentation to obtain proper measurements. Application of instruments and accuracy of instruments and measurements shall be in accordance with requirements of NEBB or AABC Standards and instrument manufacturer's specifications.

B. Instruments used for measurements shall be accurate, and calibration histories for each instrument to be available for examination by A/E upon request. Calibration and maintenance of instruments to be in accordance with requirements of NEBB or AABC Standards.

2.02 INSTRUMENT TEST HOLE PLUGS

A. Center-pull plugs similar to Alliance Plastics CP Series. Plug material shall be Grade 1 virgin polyethylene.

PART 3 - EXECUTION

3.01 GENERAL

A. Test, adjust and balance all air systems and the associated components in accordance with procedures outlined in the Standards.
B. Upon completion of TAB work, mark equipment settings, including damper control positions, fan speed control levers, and similar devices to indicate final setting in approved manner.
C. Plug holes in insulation, ductwork and housings with acceptable test plugs.

3.02 PLANNING PHASE

A. Procedure:
   1. Obtain the latest Contract Documents including addenda, applicable construction bulletins and change orders. Obtain shop drawings and performance curves from Mechanical Contractor for fans, flow measuring devices, and all terminal devices. Prepare Planning Report as detailed herein. Make adjustments in Planning Report and/or measuring instrument calibration.

B. Planning Report:
   1. Planning Report shall contain the following minimum information:
      a. Samples: Provide copies of all forms to be used.
      b. System narratives: Provide narratives for each air system which shall include procedures for measuring static pressures at each component of air handling system to generate a static pressure profile. Measurements shall be made to measure performance of system in all operating modes.
      c. Air terminal narratives: Narratives shall describe procedures for measuring flows and adjusting controls to meet specified minimum and maximum flow rates based on actual field installed conditions.
      d. Branch duct and air outlet measurements: Indicate on preprinted forms all measurements to be taken in field. Include branch duct or air outlet identification, system, space served, location, and design flow rates (include zone and system summaries). Indicate duct or air outlet neck size, make, model number, Ak factor, and design velocities.
   2. Prebalance Checklist - to include, but not limited to:
      a. Check for completeness of work.
      b. System cleaning if required.
      c. Check fire, smoke and balancing damper positions.
      d. Place system into normal operation without economizers.
      e. Install test openings where required.
      f. Indicate type of test holes to be used and installation procedure.
      g. Note condition of filters.
      h. Provide temporary blankoffs to simulate design pressure drops of filters.
      i. Chisel holes and duct tape are not allowed.
      j. Wet cooling coils.
      k. Fan wheels, blades, bearings, alignment, starters, vibration isolators, and rotation.
      l. Drive belt tension and alignment.
      m. Setting of automatic dampers to proper position.
      n. Set up of controls and control devices.
   3. Measuring Instrument List: List measuring instruments that will be used for each procedure. Indicate ranges required for each procedure. Provide data on each measuring instrument to be used. This data shall include:
      a. Manufacturer name and model number
      b. Measurement range
      c. Pressure/temperature limits
      d. Date put into service

e. Date of last calibration
f. Certificate from calibration firm

4. Architect/Engineer reserves the right to request adjustments in any procedure and/or ask for recalibration of any measuring instrument, which has not been recalibrated within past year.

3.03 SET-UP PHASE

A. Procedure:
1. Perform prebalance checkout as per Planning Phase narrative.

B. Initial Test:
1. Measure fan and terminal data and flows in "as found" condition after initial damper settings are made.

C. Initial Test Report:
1. Submit report to Architect/Engineer and Mechanical Contractor indicating all measurements made and make notes of all items, which are not complete or are not within design tolerance.

3.04 FINAL BALANCE PHASE

A. Procedure:
1. Perform all procedures as per Planning Phase narrative. Correct all deficiencies and repeat procedures as required before submitting Final Report.

B. Final Report:
1. Submit reports indicating all data and measurements as per requirements herein and per Planning Phase narrative. Do not submit partial or incomplete reports.
2. Assemble report in the following order:
a. Transmittal letter
b. Cover sheet with Project title, location, submittal date, and name and addresses of Owner, Mechanical Contractor, TAB subcontractor, Architect, and Engineer.
c. Index of numbered tabs listing all systems.
d. Data organized by system in the following order:
1) Equipment data and measurement summary
2) Equipment measurement data
3) Branch main measurement data
4) Terminal device measurement data arranged by room or zone
3. Each individual Final Report Form submitted shall bear name of person who recorded data and seal of supervisor of TAB Contractor.
4. Include identification of all types of instruments used and their last dates of calibration with Final Reports.
5. Note any and all discrepancies in design flows on report forms.

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

END OF SECTION

SECTION 230901A
CONTROL SYSTEMS

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 20 0513 - Motors
B. Section 23 0550 - Vibration Isolation
C. Section 23 2118 - Valves
D. Section 26 0519 - Low-Voltage Electrical Power Conductors and Cables
E. Section 26 0533 - Raceway and Boxes for Electrical Systems
F. Control Sequences: Refer to Drawings

1.02 REFERENCE

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

1.03 DEFINITIONS

A. The following abbreviations, acronyms, and definitions are used in addition to those details found elsewhere in contract documents.

1.	Actuator:	Control device to provide motion of valve or damper in response to control signal
2.	AI:	Analog Input
3.	AO:	Analog Output
4.	Analog:	Continuously variable state over stated range of values
5.	Auto-Tune:	Software routine used to adjust tuning parameters based on historical data
6.	BAS:	Building Automation System
7.	BMS	Building Management System
8.	DDC:	Direct Digital Control
9.	DDCP:	Direct Digital Control Panel
10.	Discrete:	Binary or digital state
11.	DI:	Discrete Input (Sometimes referred to as Binary Input BI)
12.	DO:	Discrete Output (Sometimes referred to as Binary Output BO)
13.	EMCS:	Energy Management and Control System (Typically interchangeable with BAS or BMS)
14.	E/P:	Voltage to pneumatic transducer (Often a solenoid valve is referred to as an E/P transducer)
15.	FA	Field Adjustable
16.	FC:	Fail Closed position of control device or actuator. Device moves to closed position on loss of control signal or energy source
17.	FMS:	Facility Management System linking two or more BAS
18.	FO:	Fail Open position of control device or actuator. Device moves to open position on loss of control signal or energy source
19.	I/P:	Current to pneumatic transducer
20.	Instrument:	Device used for sensing input parameters or used for actuation
21.	Modulating:	Movement of a control device through an entire range of values proportional to an infinitely variable input value
22.	Motorized:	Control device with actuator
23.	NC:	Normally Closed position of switch after control signal is removed
24.	NO:	Normally Open position of switch after control signal is removed
25.	Node:	DDCP, operator workstation, or other control device connected to communication's network

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

1.04 ACCEPTABLE CONTROL CONTRACTORS

A. Control Contractor shall have full service office within 100 miles of Project site. Full service office is defined as having complete parts inventory, having all required test and diagnostic equipment, and to be home office of Applications Engineers, Supervisors, and Field Technicians. Control Contractors shall be factory authorized agent or dealer of controllers and control hardware as manufactured by:
   1. Siemens Building Technologies
   2. Johnson Controls, Inc
   3. Honeywell, Inc
   4. Alerton Technologies
   5. Automated Logic Corporation
   6. KMC Controls

1.05 SYSTEMS DESCRIPTION

A. System shall be electric and/or electronic.
B. Control system shall be Direct Digital Control (DDC).
C. Damper and valve actuators shall be electric type, unless otherwise noted.
D. Damper and valve actuators for major equipment in mechanical rooms shall be electric type, unless otherwise noted. Actuators for all remote devices located in spaces outside of mechanical rooms shall be electronic type.
E. Provide modular designed stand-alone DDCP capable of future BAS architecture with low/medium speed communication networks. Upgrade to full BAS architecture shall not require removal of existing DDCP, sensors, actuators, etc.
F. Provide BAS architecture consisting of communication network, operator workstations, modular designed DDCP with all points addressable and modifiable from operator workstations or from master DDCP using laptop computer. BAS shall be fully expandable with addition of hardware and/or software. Expansion shall not require removal of existing DDCP, sensors, actuators, or communication networks.
G. System shall support operator workstations as specified and shall be capable of additional workstations, limited only by systems maximum node capacity.

H. System intelligence shall be such that operator workstation(s) can be used for programming controls, performing analysis on filed data, generating maintenance and operation reports and providing permanent storage for programs and data.
I. Operator Workstations (OWS) and printers will be furnished by Owner.
J. Provide hardware interface card to communicate with BAS network and all required software for each workstation, as defined in this Section, to make each PC full function workstation.
K. All safety devices shall function in both auto and hand modes on starter.
L. All safety devices shall function in both VFD and bypass starter modes.
   1. Dampers interlocked with fans shall operate in both VFD and bypass starter modes to prevent dead-head of fans.
   2. Valves interlocked with pumps shall operate in both VFD and bypass modes of operation to prevent dead-head of pump.

1.06 SCOPE OF WORK

A. Provide all labor and materials for complete and fully functioning control systems in accordance with Contract Documents including this Section.
B. Engineering services shall be performed by factory-trained engineers. System shall be installed either by trained mechanics directly employed by Control Contractor or by subcontractors who are under direct supervision of Control Contractor's field representative.
C. Control Contractor shall be responsible for complete installation of all control devices, (except as noted), wiring, and pneumatic terminations at DDCP locations to accomplish control sequences specified in this project manual or on drawings. Power for field mounted devices that require 24 VAC, 60 Hz shall be powered from 120 to 24 VAC transformer panels provided by the Control Contractor. Control Contractor shall also be responsible for any additional instrumentation described in point schedules found in Contract Documents, which may not be directly related to any specified control sequences.
D. Mechanical Contractor shall furnish and install all wells, taps, and other mechanical interfaces required for control equipment mounting into piping systems. Mechanical Contractor shall install all in-line mounted devices, such as valves, dampers, flow meters, static pressure probes, etc., furnished by Control Contractor. Control Contractor is responsible for installation of all other control devices, such as actuators, linkages, sensors, air terminal controllers, flow transducers, remote mounted control devices, control panels, control transformers, etc.
E. Coordinate requirements above with Mechanical Engineer and Section 23 3600 – Air Terminal Devices, for required control devices. Define what is to be provided to the Air Terminal manufacturer for mounting at the factory, what the Mechanical Contractor is to install in the field and what the Control Contractor is to install in the field.
F. All electrical work required, as integral part of work is responsibility of Control Contractor. Provide final control power connections including conduit, wire, and/or disconnect switches to all control devices from appropriate electrical distribution panels.
   1. Electrical Contractor will provide circuit breakers, junction boxes, and wiring required to provide electrical power to DDCP’s panels.
   2. 120 to 24 VAC transformer panels shall be mounted adjacent to DDCP panels and powered from dedicated electrical circuit.
   3. Should any change in number of DDCPs or addition of other electrical equipment after contracts are awarded, Control Contractor shall immediately notify Electrical Contractor of change. Additional costs due to these changes shall be responsibility of this Contractor.
G. Materials shall be as specified unless approved through procedures for product substitution specified in Division 01. Control Contractor shall provide components not specifically indicated or specified, but necessary to make system function within the intent of specification.
H. All electrical products to be listed and labeled by UL and comply with NEMA Standards.
I. Provide weather protection cover or weatherproof control devices where required for control devices located outdoors.

1.07 SUBMITTALS

A. Shop Drawings:

1. Refer to Division 01 General Requirements.
2. Submit manufacturer's printed product data sheets for all control devices and all materials listed in bill of material in Control Contractor's control drawings. Organize sheets in order of model number, alphabetically, then numerically.
3. Submit data concerning type of signal wiring and installation methods including raceway types and grounding methods.
    a. Submit voltage drop calculations for all low voltage DDC circuits. Voltage drop to include number of devices and wiring run lengths, calculated voltage available at each device.
4. Submit control drawings including, but not limited to, the following:
    a. Front sheet index for projects with more than 10 control drawing sheets.
    b. Overall system/network architecture drawings: Provide block diagram showing relationship of each controller, control panel, or other network devices relative to each other, label room location of each device, number and indicate model number of each device, indicate network types, and general cabling routing.
    c. Control Drawings: Provide graphic representation of systems with all major inline components to properly locate all control devices. Identify controlled devices with their software designation on drawings, including unique valve and damper tag numbers.
    d. Detailed wiring and piping diagrams show point-to-point hookup details of all transducers, relays, outputs, inputs and subsystem components. Label all pneumatic lines and control wires with field ID numbers/colors.
    e. Bill of Materials: Identify actual product model number used for each control device for each schematic control drawing.
        1) Bill of material shall be included on flow diagrams for each system and on panel layouts showing panel components.
    f. Sequence of operation: Provide written narrative describing each control sequence indicating method of control. Identify sensors, controllers, and actuators used with references to tag number of the controlled device. Include setpoints and offsets of each control loop.
5. Instrumentation submittals can be submitted as a separate submittal from control shop drawings but must be submitted at the same time as control shop drawings.
6. Submit valve schedules with shop drawings that indicate unique tag numbers for each device, equipment or system served, device model numbers, sizes, shutoff head required, actuator air pressure or force required to meet shutoff head, torque requirements for rotary valves, flow coefficients (Cv) for 10% and 100% valve stem travel, actual flow requirements based on equipment shop drawings, calculation of actual pressure drops, actuator model number, actuator torque capacities and pilot positioner locations.
7. Valve and damper shop drawing submittals will not be processed unless all supporting data and sizing calculations are included.
8. Submit damper schedules with shop drawings that indicate unique tag numbers for each device, equipment or system served, device model numbers, duct sizes, damper sizes, flow rates, pressure differentials, calculation of actual damper pressure drops, approach velocities, leakage rates, torque requirements, actuator model number, actuator torque capacities and pilot positioner locations.
9. Select dampers to meet their intended service with respect to maximum approach velocities and maximum pressure differential. Damper materials shall match duct construction materials in which they are installed (galvanized steel, aluminum, 304 or 316 stainless steel, etc.).
10. Aluminum dampers may be used in galvanized ductwork.

B. Thermostat/Room Sensor Schedules:
   1. Submit thermostat/room sensor schedule with shop drawings. Thermostat/room sensor schedule shall have detailed listing of which type is used for each room including data concerning service and model numbers, sizes, cover types, and engineering data sheets for each control device.
C. Operation and Maintenance Manuals:
   1. Refer to Division 01 - General Requirements.
   2. Operation and maintenance manuals shall provide descriptions of maintenance on all system components, including sensors and controlled devices. These shall include inspection requirements, periodic preventative maintenance, fault diagnosis, and repair or replacement of defective components, calibration instructions, parts lists, and name, address, and phone number of manufacturers' representative.
D. Software Manual:
   1. As part of operation and maintenance manuals, submit one software manual per workstation plus one extra copy for archive use. Software manuals shall be divided into separate parts with tabs for each part.
   2. Software Manual parts shall include:
      a. Complete description of operating system including all commands, configuration programs, printouts, logs, database functions and passwords. Describe general operating procedures, starting with system overview and proceeding to detailed description of each software command feature with sample printed displays and system function description for each option. Include instructions on verifying errors, status, changing passwords and initiating or disabling control programs.
      b. Complete description of programming language including all commands, configuration programs, control loop functions and testing. Describe general programming procedures, starting with system overview and proceeding to detailed description of each software command feature. Include instructions on creating or modifying any control algorithm or parameter, debugging, etc. This shall include all control functions, algorithms, mathematic equations, variables, setpoints, time periods, messages, and other information necessary to load, alter, test and execute custom or pre-written programs.
      c. Software Backup: Upon successful completion of acceptance testing, submit to Owner 2 archive copies of all accepted versions of source code and compiled code for all application programs and data files, on CD ROM backup disks. All control software must be readily accessible by Owner using BAS workstation hardware and software.
E. Record Drawings:
   1. Refer to Division 01 - General Requirements.
   2. Submit revised Shop Drawings indicating all changes made during project.

1.08 VALVE SELECTION AND SIZING

A. General:
   1. Select control valves to meet their intended service without cavitation. Provide cavitation calculations for modulating globe control valves over 250°F and all modulating butterfly valves over 60°F.
   2. Select control valves and actuators for 100% shut-off against system maximum differential pressure.
   3. Valve body ratings indicated in Part 2 are minimum required. Valve body, trim and packing selected shall be designed to withstand maximum pressure and temperature encountered in the systems.
   4. Submit engineering calculations for sizing modulating control valves unless valves are scheduled. Control valves serving terminal devices may be sized based on flow ranges for each pump system.

5. Shut-off and two-position valves shall be full pipe size.
6. Calculations for sizing modulating valves shall be based on actual characteristics of equipment and system being installed. Valve calculations shall include information such as pump head or available pressure; branch piping circuit losses including all pipe, fittings, valves, and coils; flow rates; and pressure losses of other in-line devices.
7. Control Contractor is responsible for obtaining adequate system information necessary for sizing.

B. Instrumentation Shut-off Valves:
1. Unless otherwise noted, instrumentation shut-off valves for isolation of gauges, switches, transmitters, etc., shall be as follows:
   a. Compressed air/instrumentation air systems: ball or plug-type valves
   b. Water systems: globe-type valves
   c. Steam and condensate systems: gate-type valves
   d. Ductwork, air handling unit or air terminal device penetrations: ball or plug-type valves
   e. Liquid line sampling valves: multiple turn, metering-type valves

C. Water Valves:
1. Design criteria for sizing modulating valves shall be based on two port, normally open, equal percentage valves unless otherwise specified. Heating control valves shall be globe type and shall be selected for a minimum of 25% of equipment subcircuit pressure drop, but not more than maximum available pump head allowing minimum 2 psi drop for balance valve.
2. Select control valves based on pressure drop calculations based on Cv values at 100% stroke.
3. Subcircuit is defined as all of branch supply and return piping to terminal device, including all valve, coil, control valves, and balance valve.

1.09 DAMPER SELECTION AND SIZING

A. Submit Engineering calculations for sizing modulating control dampers including outside, return, and relief air dampers of air handling units unless dampers are scheduled.
B. Calculations for sizing dampers shall be based on actual characteristics of ductwork system being installed. Opposed blade dampers shall be sized for minimum of 10% of duct system pressure drop. Parallel blade dampers shall be sized for minimum of 30% of duct system pressure drop. Duct section is defined as ductwork containing flow control damper starting with inlet or branch tee and ending with outlet or branch tee. Calculate actual duct pressure drops for each duct section containing modulating damper using latest version of ASHRAE Handbook of Fundamentals. If control systems fixes pressure drop, use those pressure setpoints. Use balance damper to provide additional pressure drop as required to obtain linear damper response.
C. Control Contractor is responsible for obtaining adequate system information necessary for sizing.
D. Provide dampers as shown on drawings or as scheduled.
E. Two position dampers shall be sized as close as possible to duct size, but in no case is damper size to be less than duct area.
F. Submit leakage and flow characteristics data for all control dampers along with shop drawings. Leakage ratings to be based on AMCA Standard 500 and dampers to bear AMCA Air Leakage Seals.

1.010 FCC COMPLIANCE

A. All digital equipment furnished under this contract shall have been tested and made to comply with limits for Class A computing device pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against interference when operated in commercial environment. All literature shall so note and all equipment shall be so labeled to show this compliance.

PART 2 - PRODUCTS

2.01 GENERAL

A. Pressure and temperature ratings of devices indicated in Part 2 are minimum required. All devices shall be designed to withstand maximum pressure and temperature encountered in the system.

2.02 CONTROL WIRING

A. Control wiring shall be in accordance with National Electric Code and local electrical codes. Final connection points at devices and panels shall be made at terminal blocks either integral to device or separate terminal blocks mounted inside of control panel enclosures. Use of wire nuts and crimped connections are not allowed for terminating control wiring unless approved by Engineer.

B. Refer to Division 26 for specification requirements for conduits and conductors, except as noted.

C. Signal and Power Conductors (24 V and Under):

1. No wire smaller than #18 AWG shall be used, except for manufacturer supplied instrument specific wire, or unless otherwise specified. Use 2 wire stranded twisted/shielded pair 24 VDC for analog and/or discrete input and 24 VAC/VDC output devices. For RTD signal wiring, use #18 AWG stranded, tinned copper twisted/shielded three lead conductors.
2. Conductors not concealed in raceway shall have UL listed plenum rated teflon insulation.
3. Communication Cable: Use control system manufacturer's standard communications cable or #22 to #24 AWG twisted, shielded pairs, coaxial cable, or fiber optics for communications between remote control panels/devices. Provide 250 ohm, 5 watt, 0.1% tolerance dropping resistors in 4 – 20 mA circuits as required to generate 1 to 5 V signals in 24 VDC powered instrument loops. Provide isolated instrument grounding system per manufacturer's recommendations.
4. 24 VAC Power Conductors shall be #18 AWG, 2-wire twisted pair or larger. Provide Metal Oxide Varistors (MOVs) on 24 VAC/VDC discrete outputs connected to inductive loads to reduce noise levels (i.e., solenoid valves, motor contactors, relays, damper/valve electric actuators, etc.).
5. Stranded twisted/shielded control conductors are required with the shields to be terminated within variable frequency Drive enclosures to reduce the effects of noise from VFD. Follow VFD manufacturer's installation instructions for wiring control conductors to VFD.

2.03 LOCAL CONTROL PANELS

A. Local control panels shall be constructed of steel or extruded aluminum with hinged door and keyed lock, with baked enamel finish of manufacturer's standard color. Construction shall comply with NEMA 1 Standards for interior panels, NEMA 4 for exterior panels.

B. Controlling instruments, temperature indicators, relays, switches and gauges shall be factory installed and permanently labeled. Devices shall be located inside or mounted on face of panel.

C. Unless otherwise indicated, mount control and adjusting switches, temperature indicators and other indicating or manually operated devices on front face of panel with black phenolic engraved nameplates.

2.04 DIRECT DIGITAL CONTROL PANEL (DDCP)

A. General:

1. Direct Digital Control Panels (DDCP) shall be microprocessor based, field programmable controllers, capable of performing control and energy management functions, and shall be UL Listed as Signaling Systems. Each DDCP shall include its own microprocessor, power supply, input/output modules, and termination modules as required to perform its intended function.

2. DDCP shall receive discrete electrical or analog electronic field input signals, convert signals for use by controller, perform control sequences, convert controller information into output signals, and provide control output signals to actuators and field control device. All inputs and outputs, including communication connections, shall be electrically or optically isolated from controller.
3. DDCP with analog input modules shall be capable of accepting any form of linear or non-linear voltage (0-5 VDC or 0-10 VDC), current (4-20 mA) or resistive input (0-1000 ohm).
4. DDCP with discrete input modules shall be capable of accepting discrete inputs from any device with isolated, dry-type contacts (no grounds or no voltage) of either normally open (NO) or normally closed (NC) configuration. Provide visible status lights (LEDs) to indicate input point status.
5. Provide input modules capable of interfacing with pulsed output type sensors as required.
6. DDCP with discrete output modules shall have isolated, dry-type contacts (no grounds or no voltage) of either normally open (NO) or normally closed (N.C.) configuration.
7. Provide manual H-O-A override switch for each discrete output point. Provide feedback point to BAS to indicate when output point has been overridden. Provide visible status lights (LEDs) to indicate output point status.
8. DDCP shall have capability to scale, offset, and display proper analog value without field hardware modification. DDCP shall convert analog input signals to digital values (A/D conversion) and convert digital values to analog outputs (D/A conversion) for modulating control purposes.
9. Failsafe hardware shall be provided such that BAS failures result in immediate return to local control. If DDCP uses database values from other DDCP and communication network fails or malfunctions, control loop outputs shall continue to function using last value received from BAS.
10. DDCP shall have ability to interface and communicate with central BAS through a dedicated network. DDCP shall be fully operable from and have all points and functions available to centrally alarm at any master DDCP or PC workstation connected to BAS network.

B. DDCP Operator's Interface:
1. Provide communications port to connect display device for operator access to all information and all operating system functions except database reports and graphics functions in each mechanical room.
2. Display keyboards to be alphanumeric with special dedicated keys for functions such as manual-auto, test, function, value, and enter.
3. Keyboard/display units shall be able to display analog variables, binary conditions, point values and condition, and other information required for analysis and adjustment.
4. Provide minimum of one permanent panel mounted keyboard and display for each mechanical equipment room. If manufacturer does not offer dedicated panel mounted keyboard and display unit, provide portable hand held keyboard and display unit. If manufacturer does not offer dedicated hand held keyboard and display unit, provide battery powered portable PC unit with proper software and hardware to interface with local DDCP.

2.05 DIRECT DIGITAL CONTROL SOFTWARE

A. DDCP control strategies shall be Owner definable from operator terminals or workstations.
B. Software functions and algorithms shall be sufficient to enable implementation of control sequences as specified and able to maintain continuous control as intended.
C. Control functions shall include both mathematical and logical operators. Control algorithms shall include proportional, integral and derivative control (PID). Adaptive (self-tuning) PID loop parameters, if offered by DDCP manufacturer, shall not be used unless adaptive limits are used to adjust limit values based on system status; or written request is submitted and approved by Engineer.

D. Allow operator to assign unique identifiers of their choice to each connected point. Identifiers must have at least 8 alpha/numeric characters. All reference to these points in programs, reports and command messages shall be by these identifiers.
E. Provide access control (user defined passwords) for system operation. There shall be minimum of 3 access levels. First level shall allow system monitoring only. Second level shall allow monitoring and setpoint, and scheduling revision. Third level shall allow modification of control algorithms. System shall return to secured (monitoring only) mode after 5 minutes of inactive operation.
F. Each DDCP shall contain self-diagnostics that continuously monitor proper operation of panel.
G. If microprocessor malfunctions, control loop outputs shall continue to function using last value received from microprocessor.

2.06 NETWORK HARDWARE

A. Provide network interface hardware for each device connected to network. Each device shall have sufficient performance as not to degrade processing speed specified.
B. Provide network cabling with sufficient performance as not to degrade communication speed specified. Cabling shall be compatible with proposed system.
C. Provide other network support devices that are required for proper operation of network, such as file servers, signal repeaters, network hubs, etc.

2.07 CONTROL VALVES

A. General:
   1. If control valves are not scheduled, refer to Part 1 of this Section for sizing criteria.
   2. Use 2 or 3 port normally open globe type control valves with equal percentage contoured throttling plugs for water applications and linear contoured throttling plugs for steam applications, unless otherwise noted.
   3. Butterfly valves may be used for water system control valves 130 mm(5”) and larger provided that valves meet pressure and temperature requirements. High performance butterfly valves shall be used for modulating applications. General-purpose butterfly valves may be used for two-position control.
B. Globe Valves:
   1. Valves shall be bronze or brass body, threaded, 1035 kPa(150 psi) rating for 50 mm(2”) and smaller, iron body bronze mounted, flanged, 860 kPa(125 psig) rating for 65 mm(2-1/2”) and larger.
   2. Valves shall have stainless steel stems, spring-loaded Teflon packing, replaceable seats and discs.
C. General Purpose Butterfly Valves:
   1. Refer to Section 23 2118 – Valves. Refer to Damper and Valve Actuators in this Section for valve actuators.
D. Solenoid Valves:
   1. Brass or bronze body. Valves shall be selected to match required temperatures and pressure, and shall have materials, that are compatible with, intended working fluid.
   2. All line voltage actuators shall be Class "H" (high temperature) and listed by UL or CSA.

2.08 CONTROL DAMPERS

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

1. Damper frames shall be minimum of 16 ga galvanized steel or 14 ga extruded aluminum. Blades shall be minimum of 16 ga galvanized steel or 14 ga aluminum. Blades shall have maximum blade width of 8" with steel trunnions mounted in bronze sleeve, nylon or ball bearings.
2. Furnish dampers with blade seal and stainless steel side seals. Dampers and seals shall be suitable for maximum system temperature, pressure differential and approach velocity, but not less than temperature range of -40 to 200°F, pressure differential of 6" WG, and approach velocity of 4000 fpm.
3. Dampers when closed shall be guaranteed by control manufacturer not to leak air in excess of 100 cfm at 4" WG static pressure for 48" x 48" damper size (6.25 cfm per ft^2).

C. Standard Modulating and Two Position Dampers:
1. Damper frames shall be minimum of 16 ga galvanized steel or 14 ga extruded aluminum. Blades shall be minimum of 16 ga galvanized steel or 14 ga aluminum. Blades shall have maximum blade width of 8" with steel trunnions mounted in bronze sleeve, nylon or ball bearings.
2. Furnish dampers with blade seal and side seals. Dampers and seals shall be suitable for maximum temperature, pressure differential and approach velocity to be encountered in the system, but not less than temperature range of -40 to 200°F, pressure differential of 4" WG, and approach velocity of 2500 fpm.
3. Dampers when closed shall be guaranteed by control manufacturer not to leak air in excess of 176 cfm at 4" WG static pressure for 48" x 48" damper size (11 cfm per ft^2).

D. Smoke Dampers:
1. Dampers to be leakage rated at no higher than Leakage Class I (4 cfm/ft^2 at 1" WG and 8 cfm/ft^2 at 4" WG) under UL 555S at temperature category 250°F. Furnish dampers with factory-mounted, caulked sleeve and pneumatic operator. Damper shall have 16ga frame with air foil-shaped blades, rated to minimum 4" WG in closed position and to 2000 fpm in open position.
2. Pneumatic actuator to be installed outside airstream, linked to damper for fail (normally) closed operation, suitable for use on 20-psig air system, and be UL Listed and labeled for application. Actuator to be capable of closing damper at pressures encountered in system.
3. Size smoke dampers as close as possible to duct size, but in no case is damper size to be less than duct size.

2.09 DAMPER AND VALVE ACTUATORS

A. Analog Electronic:
1. Actuators shall be hydraulic or electric motor/gear drives that respond proportionally to analog voltage or current input. Stroke time for major equipment shall be 90 seconds or less for 90□ rotation. Stroke time for terminal equipment shall be compatible with its associated local controller, but no more than 6 minutes.
2. Provide spring return feature for fail open or closed positions as required by control sequence for critical applications such as outside, return, or exhaust dampers, heating and cooling coils on major air handling units, humidifiers, heat exchangers, and flow control for major equipment items such as chillers, cooling towers, boilers, etc.
3. Provide position feedback potentiometers connected to controller for closed loop control on major equipment analog control loops.
4. Actuators for terminal heating/cooling equipment do not require spring return feature.

B. Discrete Two-Position Electric:
1. Actuators shall be hydraulic or electric motor/gear drives for two-position control. Stroke time shall be 90 seconds or less for 90° rotation.
2. Provide spring return feature for fail open or closed positions as required by control sequence.

2.010 GENERAL INSTRUMENTATION

A. General:
   1. No devices containing mercury will be allowed under this specification.
B. Pressure Gauges:
   1. Refer to Section 23 2120 - Piping Specialties.
C. Thermometers (Dial-Type):
   1. Refer to Section 23 2120 – Piping Specialties.
D. Analog Electronic Instrument Indicators:
   1. Electronic indicators, used for displaying sensor and/or output values as measured by current or voltage, shall be panel mount type and at least 2" square. Output may be analog needle type or digital with 1/2" high LED or backlit LCD displays.
   2. Electronic indicators shall be marked in appropriate units (Degrees, psi, %RH, gpm, cfm, etc.) and with appropriate range of values. Panel mounted indicators shall have minimum accuracy of 1% of scale range. Digital units shall be scaled to show 3 digits plus 1 decimal point.

2.011 DISCRETE ELECTRIC INSTRUMENTATION

A. General:
   1. Electrical devices, switches, and relays shall be UL listed and of type meeting current and voltage characteristics of the project. Terminal connections shall be made at terminal blocks inside of NEMA 1 enclosures unless otherwise specified. Outdoor units shall be NEMA 4 with concealed adjustment.
   2. Ratings of normally open and closed contacts shall be adequate for applied load (Minimum 5 amps at 240 V).
   3. Accuracy of devices shall be ± 1% of scale with adjustable offset unless otherwise specified.
B. Temperature Switches (Electric Thermostats):
   1. Line voltage or low voltage type suitable for application with adjustable setpoint and setpoint indication.
   2. Low voltage type to have heat anticipation.
   3. Thermostats with remote sensing bulb shall have liquid filled sensing element and exposed setpoint adjustment.
   4. Wall mounted space thermostat enclosure shall have concealed sensing element and exposed setpoint adjustment.
   5. Unless otherwise stated, space thermostat covers shall be brushed aluminum or brushed nickel.
   6. Manufacturer's standard plastic covers may be used in lieu of metal covers.
C. Temperature Low Limit Switches (Freezestats):
   1. Electric 2-position type with temperature sensing element and manual reset. Controls shall be capable of opening circuit if any one-foot length of sensing element is subject to temperature below setting.
   2. Sensing element shall not be less than one lineal foot per square foot of coil surface areas. Unless otherwise indicated, calibrate temperature switch setpoint to 38°F.
D. Relays:
   1. Equal to IDEC type RH2B-U, miniature 8 blade pilot relay with DPDT silver cadmium oxide contacts rated at 15A, 30 VDC, or 120 VAC. Coil shall match control circuit characteristics. DDC outputs shall be 24 VDC with maximum current burden of 50 milliamps. Rectangular base socket mount with blade type plug-in terminals and polycarbonate dust cover.
   2. Provide DIN rail mountable (Snap type) mounting sockets equal to IDEC SH2B-05.
E. Pressure Differential Switches:
   1. Adjustable set point, differential pressure type. Select switches for accuracy, ranges (20 to 80% of operating range) and dead-band to match process conditions, electrical requirements and to implement intended functions.

2. Pressure differential switches for air systems shall have pressure rating of at least 10" WG.
3. Pressure indicating differential switches for air systems shall be equal to Dwyer Series 3000 photohelic gauge.
4. Pressure differential switches for water systems shall be rated for 1035 kPa(150 psig) unless otherwise noted. Chilled water pressure differential switches shall be provided with totally sealed vapor tight switch enclosure on 300 psi body. Differential pressure switches to have 3-valve manifold for servicing.
   a. Max Temperature Rating: 300°F
   b. Repeatability: ± 1%

F. Position Switches (End Switches):
1. Provide damper position switches, as required to meet specified sequence. Rotary switches shall be cam action, lever, or proximity type. Provide damper brackets and connecting rods for connecting position switch actuation levers to damper blades or jackshafts.
2. “Tip Switches” or other position switches that contain mercury shall not be used for damper and valve end switch applications.

G. Current Switches - Constant Load, Constant Speed:
1. Manufacturers: Veris Industries, N-K Technologies, Absolute Process Instruments, Kele & Associates, R-K Electronics or approved equal
2. These shall be induction type sensors clamped over single-phase conductor of AC electrical power and shall be solid-state sensors with adjustable threshold and normally open contacts. Each current switch shall be selected for proper operating range of current.
   a. Output: Solid state relay or relay contacts
   b. Trip Setpoint: Adjustable by multi-turn potentiometer
   c. Operating Temperature: 0 to 55°C (32 to 131°F)
   d. Response Time: < 0.5 second

H. Current Switches - Variable Load, Variable Speed
1. Manufacturers: Veris Industries, N-K Technologies or approved equal
2. These shall be induction type sensors clamped over single-phase conductor of AC electrical power and shall consist of solid-state sensors with self-calibrating threshold and normally open contacts. Each current switch shall be selected for proper operating range of current.
   a. Output: Solid state relay or relay contacts
   b. Trip Setpoint: Self-calibrating through microprocessor
   c. Operating Temperature: 0 to 55°C (32 to 131°F)
   d. Response Time: < 0.5 seconds

I. Mechanical Room and Local Control Panel Alarm Horns:
1. 24V alarm horn suitable for panel mounting.

J. Indicator Lights:
1. 1/4" minimum size. Use green for normal, yellow for warning (low/high values), and red for alarm or fail (low-low or high-high conditions). AC or DC type with voltage matched to control circuit without transformers.

2.012 PNEUMATIC INSTRUMENTATION

A. Fan Inlet Airflow Traverse Probe:
1. Air Monitor Corporation, Tek-Air, Ultratech or approved equal.
2. These shall be averaging differential pressure type flow elements mounted in inlet cone of fan capable of continuously measuring air volume of fan.
3. Inlet flow element shall consist of:
   a. Sensing tube with two internal chambers. One shall sense upstream pressure (velocity pressure) and one shall sense downstream pressure (static pressure).

b. These chambers shall have ports of quantity and size to accurately sense flow rate in fan inlet size into which these are specified to be installed.
c. Sensing tube shall have form so shaped as to minimize measurement inaccuracies.

4. Sensing assemblies shall be provided with suitable supports to prevent damage to these assemblies at maximum flow-rate.
   a. Accuracy: Error < ± 3.0% of actual flow
   b. Materials: Standard extruded aluminum with anodized finish. Optional 316 stainless steel, PVC, Kynar and other materials.
   c. Mounting Hardware: Galvanized Steel
   d. Approved Fan Inlet Installations: Centrifugal Fan
      Plug Fan
      Ducted Vane Axial Fan
      Vane Axial Fan with Bellmouth

B. Single-Probe Air System Static Sensing Elements:
   1. Sensors to be similar to Dwyer Model A-301 or Tek-Air Model T-SPP7620, with angled tips and 1/4" metal tubing connections.

C. Differential Air Pressure Indicator:
   1. Dwyer model 2000 Series magnehelic gauge for surface or panel mounting. Four inch dial readout, die cast aluminum housing. Case and aluminum parts Iridite-dipped. Exterior finish to be baked dark grey hammerloid. Hi/lo 1/8” pressure taps. Provide adapters to match tubing type.
      a. Accuracy: ± 2% of full scale.
      b. Ambient Temperature Range: 20 to 140°F.
      c. Rated Total Pressure: -20" Hg to 15 psig.
      d. Range: 0-2 times normal setpoint. (Use 0-0.25" WG for building and space pressure indication.)

2.013 ANALOG ELECTRONIC INSTRUMENTATION

A. Space Temperature Sensors:
   1. Sensors shall be nickel or platinum RTD type, with the following minimum performance:
      a. Temperature Coefficient of Resistivity (TCR): .00385 ohm/ohm/°C
      b. Accuracy: ± (0.30°C(.54°F) + (0.005 X T) (Class B)
      c. Accuracy: ± (0.15°C(.27°F) + (0.005 X T) (Class A)
         T = Temperature of interest
      d. Conformance: DIN-IEC 751
      e. Operating Range: -50 to 500°F
         0 to 99% rh
   2. Thermistors or nickel RTD's will be acceptable in lieu of platinum RTD provided thermistor carries 5 year guarantee that device will maintain its accuracy within tolerance of ± 0.36°F between 32°F and 150°F, and 0.5°F between -20°F and 212°F.
   3. Unless otherwise stated, space sensor cover shall be brushed aluminum or brushed nickel.
   4. Manufacturer's standard plastic covers may be used in lieu of metal covers.
   5. Provide visible setpoint, setpoint adjustment, and space temperature indication.

B. Duct Mounted or Insertion Temperature Sensors:
   1. Nickel or platinum RTD type, with the following minimum performance:
      a. Temperature Coefficient: .00385 ohm/ohm/°C
      b. Accuracy: ± (0.30°C(.54°F) + (0.005 X T) (Class B)
      c. Accuracy: ± (0.15°C(.27°F) + (0.005 X T) (Class A)
         T = Temperature of interest
      d. Conformance: DIN-IEC 751

e. Operating Range: -50 to 170°F
0 to 99% rh

2. Install insertion sensors in stainless steel probes or wells.
3. Outside air sensors shall be weatherproof of noncorrosive construction and protected with solar shield. Mount outside air sensors on north side of building or in area intake wells for air handling systems to avoid thermal effects from direct sunlight.
4. Sensors mounted in air streams, such as air handling units, supply ducts, exhaust ducts or return ducts, shall be averaging type. Mount averaging sensor across duct area in a "Z" pattern using mounting clips specific for averaging temperature sensor probes.
5. Thermistors or nickel RTD will be acceptable in lieu of platinum RTD provided thermistor carries 5 year guarantee that the device will maintain its accuracy within a tolerance of ± 0.36°F between 32°F and 150°F, and 0.5°F between -20°F and 212°F.

C. Space Humidity Sensors/Transmitters:
1. General Eastern, Automation Components Inc., Veris Industries, Minco (Kele & Associates, Rotronic or Vaisala.
2. Space humidity sensors shall be wall mount type with brushed aluminum or brushed nickel cover to match room thermostats and/or temperature sensors.
3. Sensing element shall be resistive bulk polymer, or thin film capacitive type. Sensor/transmitter shall have the following minimum performance.
a. Accuracy: ± 2% rh at 25°C over 20-95% rh including hysteresis, linearity and repeatability
b. Temperature Effect: Less than 0.06% per °F
c. Sensitivity: 0.1% rh
d. Repeatability: 0.5% rh
e. Hysteresis: Less than 1%
f. Long Term Stability: Less than 1% rh drift per year
g. Adjustment: ± 20% rh zero, non-interactive
± 10% rh span, non-interactive
h. Operating Range: 0-99% rh, non-condensing, sensor
0-95% rh, non-condensing, electronics
i. Output: 4-20 mA, 0-100% linear, proportional
j. Power: 12-36 VDC

D. Duct Mounted Humidity Sensors/Transmitters:
1. Manufacturers: General Eastern, Automation Components Inc., Veris Industries, Minco (Kele & Associates), Rotronic or Vaisala
2. Probe type, temperature compensated, resistive bulk polymer or thin film capacitive type. Sensor/transmitter shall have the following minimum performance.
a. Accuracy: ± 2% rh at 25°C over 20-95% rh including hysteresis, linearity and repeatability
b. Temperature Effect: Less than 0.06% per °F
c. Sensitivity: 0.1% rh
d. Repeatability: 0.5% rh
e. Hysteresis: Less than 1%
f. Long Term Stability: Less than 1% drift per year
g. Adjustment: □ 20% rh zero, non-interactive
□ 10% rh span, non-interactive
h. Operating Range: 0-99% rh, non-condensing, sensor
0-95% rh, non-condensing, electronics
i. Output: 4-20 mA, 0-100% linear, proportional
j. Power: 12-36 VDC

E. Ducted Air System Static Pressure and Differential Pressure (Velocity) Transmitters:

1. Manufacturers: GE Modus, Setra, Ashcroft XLDP or approved equal
2. Provide transducers/transmitters to convert velocity pressure differential or static duct pressure relative to sensor location into electronic signal.
3. Unit shall be capable of transmitting linear 4 to 20 mA DC output signal proportional to the differential (total minus static or static minus ambient) pressure input signals with the following minimum performance and application criteria:
   a. Span: Not greater than twice duct static or velocity pressure at maximum flow rate, nor more than 16 times velocity pressure at minimum flow rate.
   b. Accuracy: ± 1.0% of span or □ 1.0% of full scale
   c. Dead Band: Less than 0.5% of output
   d. Hysteresis: Within 0.5% of span or within 0.5% of full scale
   e. Linearity: Within 1.0% of span or within 0.5% of full scale
   f. Repeatability: Within 0.5% of output
   g. Response: Less than 1 second for full span input
4. Return and exhaust air system static pressure transducers/transmitters shall be furnished with protective integral air filters on pressure sensing lines from the static pressure sensing stations, and static air probes to prevent migration of moisture or particulate matter into transducers. If inputs to pressure transducers/transmitters are dead-ended, integral air filters are not required. Supply air system sensors do not require integral air filters.

F. Insertion Type Turbine Flowmeter/Transmitter:
1. Manufacturers: Onicon, EMCO, FTI Flow Technology, or approved equal
2. Provide turbine type flowmeter with hot tap type insertion assembly and microprocessor based transmitter. Selected span shall be not greater than twice design flow range. Select units for 10:1 turndown.
3. Hot tap assembly shall be insertion/extraction type with depth gauge and shutoff valve. Select turbine and body for intended service and pressure/temperature range. Transmitter shall have linear output of 4- 20 mA with nominal 24 VDC power requirement. Enclosure shall be NEMA 4.
   a. Accuracy: ± 0.5% in linear range
   b. Repeatability: 0.25% in linear range
   c. Construction Materials:
      1) Non-wetted Parts: Aluminum
      2) Wetted Parts: 316 Stainless Steel
      3) Turbine: 17-4 pH Stainless Steel with tungsten carbide bearings
4. Transmitter shall be integral mounted on flow meter.
5. Provide remote mounted indicator/transmitter. Indicator shall be ½" LCD or back lit LED type.
6. Refer to Section 25 3003 - Process Instrumentation Device Specifications.

G. Electronic Controllers:
1. Provide dedicated function type controllers with electronic analog and/or discrete electric type inputs and electronic analog and/or discrete electric type inputs, capable of performing sequences specified. Analog loop controllers shall have PID programs. Units shall have face-plate with adjustable setpoints, calibration, offset, gain factors, and visual display of all parameters.

PART 3 - EXECUTION

3.01 GENERAL

A. Install control equipment, wiring and air piping in neat and workmanlike manner to satisfaction of Architect and/or Engineer, and in accordance with manufacturer's recommendations. Maintain clearances, straight length distances, etc. required for proper operation of each

device. Mark and detail exact location of inline devices, wells, and taps to be installed by Mechanical Contractor on Coordination Drawings.

B. Coordinate timely delivery of materials and supervise activities of other trade contractors to install inline devices such as immersion wells, pressure tappings, any associated shut-off valves, flow switches, level switches, flow meters, air flow stations, and other such items furnished by Control Contractor that are to be installed by Mechanical Contractor.
C. Install control devices in accessible location.
D. Mount motor control devices within 5 ft of disconnect switch, or starting device furnished by Electrical Contractor unless noted otherwise. Maintain required NEC clearances.

3.02 CONTROL WIRING

A. Provide all electrical wiring required for complete functional control systems, including power circuit to control panels, both line and low voltage, in accordance with all applicable local codes, and the latest version of National Electric Code and NFPA when applicable.
   1. Voltage drops for all low voltage circuits shall be calculated prior to installing low voltage circuits. Voltage drop calculations shall be made available to Engineer on demand.
B. Control panels serving equipment fed by emergency power shall also be served by emergency power. Equipment fed by emergency power is so indicated on mechanical equipment schedules and electrical motor schedules.
C. Control panels shall be powered by local UPS (Uninterruptible Power Supply) to ensure continued control of equipment powered by site standby power sources when primary power source is lost. Devices such as Operator Workstations, Floor Level and Building Level Controllers and other critical devices shall be provided with UPS power.
D. Power wiring to control compressors and dryers will be provided by Electrical Contractor. Provide field mounted starters to Electrical Contractor for installation and supervise installation.
E. Install control wiring in raceway system per Division 26 - Electrical, unless otherwise noted.
F. BAS Network Communication Cable:
   1. Run communication cable in separate raceways or in cable trays with proper clearances.
   2. Install special cable connectors in accordance with manufacturer's recommendations.
   3. BAS network communication cable shall not be spliced.
      a. .

3.03 LOCAL CONTROL PANELS

A. Provide local control panel for each system where more than one control device requires field mounting (air handling units, exhaust fans, miscellaneous control systems including pump controls, heat exchanger controls, etc.). Single devices may be exposed mounted on piping, wall or ductwork. Install local control panel where indicated on drawings or suitable location adjacent to system served.
B. Mount panel on wall with suitable brackets or on self-supporting stand. Mount top of panel no higher than 6 ft above floor. Install panels so front cover door can swing full open without interference.
C. Label all local control panels with its respective unique ID number per Section 20 0553 - Mechanical Systems Identification.

3.04 ADJUSTMENT AND COMPLETION CHECK LIST

A. After completion of installation, follow check standard list procedures defined by instrument vendors to adjust and calibrate all thermostats, control valves, control actuators, controllers, sensors, and other equipment provided in this Contract.

3.05 OWNER TRAINING

A. Provide minimum of 8 hrs of on-site training to Owner's representatives. Conduct training sessions during normal business hours after system start-up and acceptance by Owner. Scheduling of training session(s) will be established by Owner.

3.06 OVERALL BAS ARCHITECTURE

A. Provide hardware/software to update database in less than 1 second for fast-acting control loops such as pressure control, air or water volume control, and air handling unit temperature control, or 10 seconds or less for all other control loops.
B. Control loop software algorithm for each analog control loop shall reside on the same controller as all inputs and outputs required for that specific control loop.
C. Networks that operate via polled response or other types of protocols that rely on central processors, file servers, or other such devices to maintain or manage peer-to-peer communications shall have redundant components to maintain network in the event of failure at central device. Provide automatic changeover to redundant device upon failure of any central type processor without operator intervention.
D. Network shall be multi-drop digital transmission network. Network shall provide communication link between operator's workstation and all remote DDCP and field panels.
E. Each multi-drop trunk shall be within manufacturer's allowable line lengths without signal degradation. All multi-drop trunks shall be interfaced to system via standard EIA or other industry recognized interfaces so that single failure does not disrupt or halt network.
F. Communications between DDCP's and operator's workstations shall allow multiple users to access and use system simultaneously with no loss of system performance.
G. Provide levels of connected networks to connect all DDCP, including terminal DDCP. Communications to terminal devices shall be similar to capabilities and functions of other DDCP and shall be transparent to operator.
H. Number of nodes (devices connected) on any one network shall not exceed 50 % of maximum node capacity published by equipment manufacturer. Provide additional hardware, DDCP, network controllers, etc.) to meet this requirement.
I. Alarm reports from DDCP shall not be impeded by use of either remote or local monitor, nor control stations on network either in access mode or programming mode.
J. Provide telephone modem for remote access to system from remote operator's workstation. Coordinate telephone communications with Owner for modem connection point.

3.07 DIRECT DIGITAL CONTROL PANELS

A. DDC Panel Usage:
   1. Select DDCP to provide speed of response required for each control loop type.
   2. Each DDCP shall have sufficient I/O capacity to perform specified control sequences and/or included points listed in any point schedules. If DDCP does not have sufficient capacity, provide additional panels to achieve required point count.
   3. Analog and critical safety discrete control loops shall have inputs and outputs into/from the same DDCP. Analog control loops for major equipment (chilled water, hot water, convertors, air handling units, etc.) shall have PID control.
   4. For valves and dampers within 100 ft of its DDCP, mount current to pneumatic (I/P's) convertors within DDCP or in adjacent panel. Otherwise mount I/P convertors at valve or damper. Provide pressure gauges on main air, and all control output signals.
B. Cabinets:
   1. Provide local control cabinets for all DDCP. DDCP cabinets may be used directly if enclosures are rated for NEMA 1. All cabinets shall utilize one masterkey. Provide 2 spare key sets to Owner.

3.08 SOFTWARE

A. Software from panels shall be permanently stored on CD ROM.
B. Provide the latest version of all standard software, including, operating system and control software. Include any software updates for period of 1 yr coinciding with warranty period. No beta released software shall be used.

3.09 INITIAL PROGRAMMING

A. Control Contractor shall provide initial programming of all controllers to accomplish sequences specified.
B. Provide back-up documentation per software manual submittals for all programs in both written and magnetic media formats.
C. Provide programming of menus to assist new users in accessing screen displays of each point group. Point groups (user definable) shall be initially arranged by DDCP for major equipment and by floor and area for terminal devices. Terminal devices shall also be grouped by air handling system where applicable.
D. Program historical file for run-times and number of start/stops of all motor driven equipment and filters.
E. Program maintenance alarms based on run-times and number of start/stops for all motor driven equipment.
F. Program alarms using the following levels:
    1. Level 1 - Maintenance alarm, requiring attention within one to 2 days. (Examples; 2-3°F temperature variance from setpoint, 15-25% relative humidity variance, etc.)
    2. Level 2 - Low Level Alarm, requiring attention within 8 hours, preferably during the same shift. (Examples; 4°F or more variance from setpoint, 30% relative humidity or more variance from setpoints, etc., excess start/stops per day, etc.)
    3. Level 3 - Critical Alarm, requiring immediate attention. (Examples; non-operation of primary equipment, H-O-A overrides.)
    4. Level 1 and 2 alarms shall not interrupt current user operation, but shall be logged into alarm summary file indicating status, acknowledgment, and by whom. Level 3 alarms shall interrupt user via audible and/or flashing warning until acknowledged without losing any work in progress. When alarms are acknowledged, the program shall display point group or appropriate graphic display. Level 3 alarms shall also be logged into alarm summary file similar to Level 1 and 2 alarms.

3.010 POINT LIST

A. Provide all points required to implement control sequences specified, whether or not they are listed in schedules. In addition to control points, provide additional monitoring points listed in point schedules or defined in Control Sequences.
B. All outputs, whether sequenced or not, shall have separate programmable hardware outputs. For air handling units, minimum outside air, maximum (economizer) outside air, return, relief air, smoke dampers, heating coil valves, cooling coil valves, humidifier valves, etc., shall each have separate output.

3.011 CONTROL VALVES

A. Furnish control valves as shown on drawings and/or as required to perform control sequence specified.
B. Control valves furnished by Control Contractor will be installed by Mechanical Contractor under coordinating control and supervision of Control Contractor.
C. Increaser and decreaser fittings required to facilitate valves will be provided by, Mechanical Contractor.

3.012 CONTROL DAMPERS

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

3.013 ACTUATORS AND PILOT POSITIONERS

A. Provide actuator for each automatic damper or valve with sufficient capacity to operate damper or valve under all conditions. Select actuators to provide tight shut off against maximum system temperatures and pressure encountered. Each actuator shall be full-proportioning or two-position type as required or specified, and shall be provided with spring-return for fail open or fail closed position for fire, freeze, occupant safety, equipment protection, moisture, heating or cooling protection on power interruption as indicated and/or as required. Smoke dampers and steam valves serving pressure rated heat exchangers or convertors shall fail closed.
B. Where sequencing of valves or dampers is required for pneumatic systems, such sequencing shall be accomplished by spring ranges adequate for applications to avoid overlap of operation and simultaneous use of heating and cooling.
C. Provide pilot positioners for pneumatic modulating valves and dampers for major equipment such as air handling unit coils, humidifiers, heat exchangers, convertors, major water system temperature controls, etc. Pilot positioners are not required for terminal heating/cooling equipment or booster humidifiers.
D. Provide pilot positioners for all sequenced devices, and devices that require adjustable operating speeds.
E. Provide pilot positioners for pneumatic modulating outside and return air dampers and fan volume control devices such as fan inlet dampers where used.
F. Provide pilot positioners for pneumatic modulating valve and damper operators when torque required by controlled devices exceeds 50% of torque capacity of operator.
G. Valve and damper operating speeds shall be selected or adjusted so operators will remain in step with controller without hunting regardless of load variations. Operators acting in sequence with other operators shall have adjustment of control sequence as required by operating characteristics of system.
H. Provide speed control valves for On/Off actuators for adjustment of actuator speed to prevent water hammer or excessive stress on large valves and dampers.
I. Provide proper linkage and brackets for mounting and attaching actuators to devices. Design mounting and/or support to provide no more than 5% hysteresis in either direction (actual movement of valve steam/damper shaft/ideal movement) due to deflection of actuator mounting.
J. Calibrate position feedback potentiometers where specified, with range and gain factors as required for proper operation per manufacturer's recommendations.
K. Integral actuator end switches or feedback potentiometers shall not be used. Provide separate end switches/feedback potentiometers that provide actual damper/valve position.
    1. Integral actuator end switches or feedback potentiometers can be used if damper or valve shaft is keyed or directly affixed to the actuator such that the shaft cannot slip and provide false position. U-clamp type actuator mounting always requires separate end switches/feedback potentiometers.

3.014 GENERAL INSTRUMENTATION

A. Pressure Gauges (Pressure Indicators):
    1. Install pressure gauge for indication of supply and control pressure in pneumatic systems at output of controllers, I/P transducers, electric air solenoid valves and pressure switches, and other points where visible indication of air pressure is required for operation and maintenance purposes.
    2. Provide test port for quick connection of test gauges at valve, damper motor and other actuator branch lines.
    3. Pressure gauge tappings in piping will be installed by Mechanical Contractor.
B. Thermometers (Temperature Indicators):
    1. Install thermometers at each point of temperature transmission and control except those indicated at local control panels. Install thermometers to permit easy reading from floor or operating platform (within 3 ft of line of sight). Provide remote bulb thermometers with

readout indicators mounted within 3 ft of line of sight whenever sensing point is more than 3 ft from line of sight.

2. Thermometer wells in piping will be installed by Mechanical Contractor.

3.015 LOCAL CONTROL PANELS

A. Install remote mounted devices, controllers, I/O terminal blocks, power supplies, etc. inside of local control panels.

B. Locate panels as shown on drawings.

C. Locate panels adjacent to equipment served with a minimum of 3 ft clearance in front of the door. Provide sufficient clearances to allow full door swing and full access to all internal components. Submit proposed panel locations with shop drawings.

D. Mount top of panel between 5 and 6 ft above floor so gauges and indicators are at eye level.

E. General Instrumentation at Local Control Panels:

1. Provide record control drawings of systems served by each local panel, in location adjacent to or inside of panel cover. Provide protective cover for drawing.
2. Provide indications and adjustments at each panel as follows:

Point	Item
1	Hot water in degrees F
2	Hot water out degrees F
3	Discharge temperature degrees F
4	Mixed air temperature, degrees F
5	Return air temperature, degrees F
6	Return air relative humidity %
7	Outdoor temperature, degrees F
8	Filter pressure drop, inches WC (Provide static pressure sensor across filter banks.)
9	Supply duct static pressure, inches WC for system air volume control.

Station Description

Key: a = Adjustment
i = Indication
b = Adjustment and indication

3. Adjustment and indication shall be on front panels.
4. Adjustment shall be concealed inside panels.
5. Indication shall be on front panels.

	Point										
	1	2	3	4	5	6	7	8	9	10	11
AHU-1	i	i	-	-	b	i	i	b	i	i	i
[XXX]											
[XXX]											

3.016 DISCRETE AND ANALOG INSTRUMENTATION

A. Wall Mounted Space Sensors:

1. Install space thermostats/sensors where indicated, as required to perform specified controls, or directed to meet job site conditions.
2. Mount thermostats/sensors 5 ft above floor unless otherwise indicated.
3. Mount space thermostats/sensors with accessible setpoint adjustment or temperature reading (thermometer or digital temperature readout) at 4 ft above floor meeting ADA requirements.

4. Any room thermostats/sensors mounted on exterior walls shall be mounted on thermally insulated sub-base.
5. Relocate room thermostats/sensors if required due to draft, interferences with cabinets, chalkboards, etc., or improper sensing.
6. Mount room thermostats/sensors in corridors, stairways and public toilets 7 ft above floor.
7. Room thermostats/sensors in gymnasium, locker rooms, corridor, stairways, vestibules and toilets shall be aspirating type.
8. Room thermostats/sensors in gymnasium, locker rooms and [XXX] shall be protected by heavy-duty cast and die formed guard.

B. Low Limit Temperature Switches (Freeze Stats):
1. Install low limit controls where indicated on drawings or as specified. Unless otherwise indicated, install sensing element at downstream side of heating coils.
2. Distribute sensing element across entire area of medium being sensed. Install controls at accessible location with suitable mounting brackets and element duct collars where required.

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

D. Water Flow Meters and Flow Switches:
1. Install flow measuring devices with recommended straight pipe diameters upstream and downstream of elbows, tees, valves, or other fittings, that cause uneven turbulent flow conditions.
2. If no recommendations are given, provide straight pipe equal to 10 pipe diameters upstream and 5 pipe diameters downstream of flow measuring device.

E. Sensor Wells:
1. Mount sensor wells as shown on drawings as required by other contract documents. Wells mounted in pipe 3" and larger may be installed in horizontal or vertical lines provided element is always in flow (for condensate and other gravity return lines, install in bottom of pipe). Wells mounted in pipe 2-1/2" and smaller shall be installed at elbow tee fittings with well pointed upstream. Minimum of 2" pipe size for elbow tee installation.

F. Transmitters and Indicators:
1. Locate transmitters at sensing device or within 100 ft for remote mounted transmitters. For hot systems (150°F and higher) mount electronics on side of pipe or remotely mount. For indicating type instruments, locate indicating element with 6 ft of floor with readout easily visible from floor level. Provide remote readouts if necessary.

END OF SECTION

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SECTION 232116
PIPE AND PIPE FITTINGS

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 20 0529 - Mechanical Supporting Devices
B. Section 23 0594 - Water Systems Test Adjust Balance
C. Section 23 2118 - Valves
D. Section 23 2120 - Piping Specialties
E. Section 23 2514 - Chemical Treatment Systems (Pipe Cleaning)

1.02 REFERENCE

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

1.03 DESCRIPTION

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

1.04 SUBMITTALS

A. Shop Drawings for each piping system for all pipe sizes including, but not limited to, the following:
    1. Name of system
    2. Pipe; ASTM number, grade if known, type, wall thickness, material
    3. Fittings; ASME number, grade if known, class, type, wall thickness, material
    4. Joint type
    5. Flanges; ASTM number, grade, class, type, material
    6. Bolts and nuts; material
    7. Thread joint sealants; material
    8. Flange gaskets; material, rating
    9. Unions; ASTM number, type, material, rating
    10. Type of welding

11. Welding Quality Control Program
12. Test pressure and media
13. Pipe flushing procedures
14. Pipe cleaning method
15. All other appropriate data

B. Submit pipe certification as specified under Pipe Certification in this Section.
C. Submit required documents as specified under Pipe Welding in this Section.

1.05 PRODUCT DELIVERY, STORAGE AND HANDLING

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

1.06 PIPE WELDING

A. Procedure and Welding Qualification Records:
   1. Submit Welding Procedure Specifications (WPSs) and their supporting Procedure Qualification Records (PQRs) to be used on the work to Engineer for review and approval prior to performing any welding. These documents shall meet requirements of ASME B31.9.
   2. Unless otherwise indicated, welding shall be done using only the following processes:
      a. Shielded Metal Arc Welding (SMAW), also known as "stick" welding
      b. Gas Tungsten Arc Welding (GTAW), also known as TIG and Heliarc welding
      c. Gas Metal Arc Welding (GMAW), also known as MIG welding
      d. Flux-Cored Arc Welding (FCAW), a variation of GMAW
      e. Submerged Arc Welding (SAW)
   3. Root pass must be applied by GTAW process with argon gas purge for high-pressure steam and condensate (400 psig (2758 kPa) and over) and high temperature hot water (450°F (232°C) and over) services.
   4. Root pass must be applied by only GTAW process with argon gas purge for stainless steel pipe.
   5. Unless otherwise stated, fabrication, installation, inspection, examination and testing shall be in accordance with ASME B31.9.
   6. Backing rings (chill rings) or consumable inserts are not allowed, unless specifically requested by Owner or Engineer.
B. Quality Control Program:
   1. Submit written quality control program for review and approval prior to implementing any welding on this project. Quality control program shall include the following as minimum:
      a. Explanation of how Contractor will assure proper fitup for each weld.
      b. Explanation of how Contractor will assure that proper welding procedure is being followed.
      c. Credentials of personnel responsible for required weld examinations.
C. Weld Inspection and Examination:
   1. Provide examination services for all welding for this Project. Examination shall be in accordance with requirements of ASME B31.9.
   2. Periodically, as welding progresses, submit report, signed by weld examiner, indicating status of project welding quality.

3. Arrange with Owner's Inspector for observation of fitup and welding methods prior to implementing any welds, including shop welds, on this Project.
4. In addition, Owner's Inspector will perform any additional observations deemed necessary before, during, or after fabrication to assure, to Owner's satisfaction, that proper welding is provided. Owner reserves the right to perform independent examination of welds. If Owner has any concern as a result of such examination Owner reserves the right to stop in progress welding work, without any cost to Owner, until resolution satisfactory to Owner is reached.

D. Welder Qualifications:
1. Each welder and welding operator must qualify by passing required procedure test before performing any project welds. Submit copy of Manufacturer's Record of Welder or Welding Operator Qualification Tests (WPQS) as required by Section IX of ASME Boiler and Pressure Vessel Code for all welding procedures to be performed by welding operator.
2. Welder qualifications must be current. If qualification test is more than 6 months old, provide record of welding continuity for each welder.
3. Record of welding continuity is intended to show that welder has performed welding at least every 6 months since the date that welder qualification test was passed for the submitted welding procedure specification.
4. Record of welding continuity shall include, at minimum, the following:
   a. Welder's employer name and address
   b. Date Welder Qualification Test was passed
   c. Dates indicating welding continuity
5. Welders shall be qualified as required by ASME B31.9. In addition, there shall be an independent witness of welder tests. That witness shall be representative of independent testing laboratory, Authorized (Code) Inspector, Owner's or Engineer's Inspector or consultant approved by National Certified Pipe Welding Bureau.
6. Welder qualifications must cover all pipe sizes and wall thickness used on this project. Test segments or coupons shall be appropriately selected for qualification. Test position shall be arranged in "6G position."

1.07 PIPE CERTIFICATION

A. Type E or S Pipe:
1. Furnish manufacturer's mill certificates (material test report) including dimensions, heat numbers, chemical analysis and tensile test results for pipe shipped to project site.

PART 2 - PRODUCTS

2.01 HEATING HOT WATER

A. 2" and Smaller:
1. Pipe: ASTM A53, Type F, standard weight, carbon steel.
2. Fittings: ASME B16.4, Class 125, cast iron, threaded or ASME B16.3, Class 150, malleable iron, threaded.
3. Unions: ASME B16.39, malleable iron, Class 250. Refer to Unions and Flanges in this Section.
4. (Alternate Pipe Type if Approved by the Owner): ASTM B88 seamless, Type L, hard temper copper tube
5. Fittings: ASME B16.22, wrought copper solder joint
6. Joint: ASTM B32, lead free solder, similar to Bridgit, Silvabrite, Silverflow or Canfield
7. Unions: ASME B16.18 cast copper alloy or ASME B16.22 wrought copper solder joint, Class 125. No unions to be used for line sizes 3/4" and smaller. Unions shall be used for line sizes over1".
8. Flanges: ASME B16.24, Class 150, cast copper alloy

9. Use solder joints for valves and piping specialties in copper piping

B. 2-1/2” and Larger:
1. Pipe: ASTM A53, Grade B, Type E or ASTM A106, Grade B, standard weight, carbon steel
2. Fittings: ASTM A234 Grade WPB/ASME B16.9, standard weight, seamless, carbon steel weld
3. Flanges: Class 150. Refer to Unions and Flanges in this Section

2.02 REFRIGERANT PIPING

A. ASTM B88 Type L hard drawn copper tube, cleaned and capped in accordance with ASTM B280, and marked "ACR" with ANSI B16.22 wrought copper or forged brass solder-type fittings.

2.03 COOLING COIL CONDENSATE DRAIN

A. Piping shall be:
1. Pipe: ASTM B88, Type M, hard temper copper tubing
2. Fittings: ASTM B16.22 wrought copper fittings
3. Joint: ASTM B32, 95-5 tin-antimony solder, Bridgit or Silvabrite

2.04 BREECHING AND VENTING OF CONDENSING BOILERS

A. Refer to section 23 5100 Smokestack, Breeching and Vent Piping

2.05 DIELECTRIC UNIONS, FLANGES AND FITTINGS

A. Copper to Steel Pipe:
1. Dielectric Unions: Dielectric unions are not acceptable for copper to steel pipe joints; use dielectric nipples.
2. Dielectric Nipples:
a. ASTM A120/A53 electro zinc-plated steel pipe with high temperature polyolefin polymer liner, suitable for continuous use at temperatures up to 225°F (107°C) and pressures up to 300 psig (2068 kPa).
b. Equal to Perfection Corporation, Clearflow Dielectric Waterway Fittings.

2.06 UNIONS AND FLANGES

A. Unions:
1. 2" (50 mm) and Smaller: Malleable iron, ASME B16.39 with ground joint, bronze or brass to iron. Provide black malleable iron for carbon steel piping and galvanized malleable iron for galvanized steel piping. Unless otherwise specified, pressure class and joint type of union shall be equal to that specified for fittings of respective piping service. Minimum pressure class of unions shall be Class 250.

B. Flanges:
1. 2-1/2” and Larger: ASTM A105, ASME B16.5, hot forged steel, welding neck pattern. Slip-on pattern is not allowed. Bore dimension of welding neck flange shall match inside diameter of connected pipe.
2. Use raised face flanges for mating with other raised face flanges with self-centering flat ring gaskets. Use flat face flanges for mating with other flat face flanges with full face gaskets.
3. Flange pressure class indicated in respective piping service is minimum required. Mating flange pressure class shall match pressure class of connected device, such as valves and piping specialties.

C. Flange Gaskets:
1. Gasket material shall be asbestos free and suitable for pressures, temperatures and fluid of respective piping system. Non-metallic gaskets shall be in accordance with ASME B16.21 and ASTM F104.
2. Service Temperature (through 249°F) – Garlock, Klingersil or J.M. Clipper, similar to Garlock 5500. Gaskets similar to Garlock Style 3000 may be used for hydronic piping. Unless otherwise indicated or recommended by manufacturer, gaskets shall be compressed inorganic

fiber with nitrile binder 1/16" thick for flanges 12" and smaller and 1/8” thick for flanges 14” and larger.

3. Service Temperature (250°F thru 800°F) - Flexitallic, Garlock, Lamos equal to Flexitallic Style CG, flexible graphite filler, 304 SS winding, carbon steel centering ring, 0.175" thickness.

D. Bolting:
   1. Bolts, bolt studs, nuts and washers shall have zinc plated finish.
   2. Thread shall be in accordance with ASME B1.1, Class 2A tolerance for external threads and Class 2B tolerance for internal threads. Threads shall be coarse-thread series except that alloy steel bolting 1/8” and larger in diameter shall be 8 pitch thread series.
   3. Threaded rods are not allowed as fastening elements.
   4. For Class 150 and Class 300 flanges not exceeding 400°F temperature, use carbon steel bolts or stud bolts conforming to ASTM A307, Grade B with nuts conforming to ASTM A194.
   5. Bolts conforming to ASTM A307, Grade A may be used for piping governed by ASME B31.9

2.07 THREADED JOINT SEALANTS

A. Paste type for brush application or cord type. Products shall be non-toxic, chemically inert, non-hardening, rated for -50°F (-46°C) to 400°F (204°C) and up to 10000 psi (68,948 kPa) (liquids) and 2600 psi (17,926 kPa) (gases), certified by UL, CSA, and NSF.

B. Use sealant similar to Loctite Model 54531 for piping handling oil or petroleum products.

2.08 WELD BRANCH OUTLET FITTINGS (WELDOLETS, THREADOLETS AND SOCKOLETS)

A. Weld branch outlet fittings shall conform to MSS-SP-97, ASME B16.9 for weldolets, ASME B1.20.1 for threadolets and ASME B16.11 for sockolets.

B. Materials shall match material of header piping and wall thickness of outlet or branch end shall match wall thickness of branch pipe.

PART 3 - EXECUTION

3.01 GENERAL

A. Remove foreign materials before erection. Ream ends of piping to remove burrs.

B. Install piping parallel to building walls and ceilings and at such heights so as not to obstruct any portion of window, doorway, stairway, or passageway. Install piping to allow adequate service space for equipment. Refer to drawings and/or manufacturer's recommendations. Install vertical piping plumb. Where interferences develop in field, offset or reroute piping as required to clear such interferences. In all cases, consult drawings for exact location of pipe spaces, ceiling heights, door and window openings or other Architectural details before installing piping.

C. Provide anchors, expansion joints, swing joints and expansion loops so that piping may expand and contract without damage to itself, equipment or building.

D. Mitered elbows, welded branch connections, notched tees and "orange peel" reducers are not allowed. Unless specifically indicated, reducing flanges and reducing bushings are not allowed. Reducing bushings may be used for air vents and instrumentation connections.

E. Unless otherwise indicated, use fittings as specified in Part 2 of this Section for elbows, tees, reducers, etc.

F. Install drains throughout systems to permit complete drainage of entire system.

G. Do not install piping over electrical panelboards, switchgear, switchboards or motor control centers.

H. Install valves, control valves and piping specialties, including items furnished by others, as specified and/or detailed. Provide reducing fittings for valves smaller than pipe size.

I. Make connections to all equipment installed by others where that equipment requires piping services indicated in this Section.

J. "Weldolets" with outlet size 2-1/2” and larger and "Threadolets" or "Sockolets" with outlet size 2" and smaller may be used for branch takeoff up to one pipe size smaller than main. Use

"Threadolets" where threaded fittings are specified and use "Sockolets" where socket weld fittings are specified. Install in accordance with PFI (Pipe Fabrication Institute) Standard ES49.

K. Provide temporary bypasses and valves at all equipment locations to facilitate the flushing of the pipe system during construction. Flushing must occur before connecting to AHUs, coils or boilers.

3.02 THREADED PIPE JOINTS

A. Threads of pipe and fittings shall conform to ASME B1.20.1.
B. Ream pipe ends after cutting and clean before erection. Apply thread sealants to cleaned male threads. Assemble joint to appropriate depth and remove any excess pipe joint compound from tightened joint.

3.03 FLANGED JOINTS

A. Clean flange surfaces and align them parallel. Bolt holes of gaskets shall be cut slightly larger than bolt diameter. Gasket ID shall be slightly larger than flange ID.
B. Position gasket concentrically so compression is equally distributed over entire gasket surface.
C. Lubricate bolts and run nuts down by hand.
D. By using torque wrench, tighten nuts in the proper sequence so gasket is compressed evenly, and to the appropriate torque specified by bolt manufacturer.
E. Re-torque bolts 12 to 24 h after start up.

3.04 WELDED PIPE JOINTS

A. Inspect pipe and pipe fittings for roundness before they are fit-up or set in place.
B. Properly clean and prepare pipe base material before fit-up. Verify joint land and bevel.
C. Preheat pipe base material as required by welding procedure specification. Temperature of pipe material must be minimum of 32°F before welding.
D. Properly align and adjust joint as required by welding procedure and thickness of material. Verify tolerances after tacking sequence.
E. Use weld material diameter as procedurally required for type and thickness of work being done.
F. Use sufficient argon pre-purge and argon post-purge for GTAW processes. Post purge should be until weld is no longer glowing plus 5 seconds. Maintain purge for at least 2 layers of weld material.
G. Properly store welding materials.
H. Clean tacks before welding out. Remove slag after each pass by grinding to avoid slag inclusion.
I. Weld reinforcement shall not exceed limits established in Chapter V of ASME B31.1.
J. Brush each weld free of rust and paint with rust resistant product that matches piping surface color.
K. For piping within scope of ASME B31.1, each weld shall be permanently marked by welder performing weld. Each welder shall sign and date field welding log record for all welds performed by welder as indicated in Part 1.

3.05 COPPER PIPE JOINTS

A. Cutting of tubing shall not make tubing out of round. Ream cut tube ends to full inside diameter.
B. Remove slivers and burrs remaining from tube cut by reaming and filing both pipe surfaces. Clean fitting and tube with emery or sand cloth. Remove residue from cleaning operation, apply flux and assemble joint. Use solder or brazing to secure joint as specified for specific piping service.

3.06 WATER SYSTEMS

A. Pitch horizontal mains up at 1” per 40 ft in direction of flow. Install manual air vents at all high points where air may collect. If vent is not in accessible location, extend air vent piping to nearest code acceptable drain location with vent valve located at nearest accessible location to pipe.
B. Main branches and runouts to terminal equipment may be made at top, side or bottom of main provided that there are drain valves suitably located for complete system drainage and manual air vents are located as described above.

C. Unless otherwise indicated, for upfeed risers, use top or top 45° connection to main and for downfeed risers use side or bottom 45° connection to main. If side or bottom 45° connection is not practical and bottom connection to main must be used, provide line size Y strainer with shut-off valve at each side at branch connection.
D. Use minimum of 3 elbows in each pipeline to terminal equipment to provide flexibility for expansion and contraction of piping systems. Offset pipe connections at equipment to allow for service, such as removal of terminal device.
E. Use concentric fittings for changes in pipe sizes and for valves smaller than pipe sizes.

3.07 COOLING COIL CONDENSATE DRAIN

A. Trap each cooling coil drain pan connection with trap seal of sufficient depth to prevent conditioned air from moving through piping. Extend drain piping to nearest code approved drain location. Construct trap with plugged tee for cleanout purposes.
B. Pitch pipe down at 1/4" (6.5 mm) per one foot for proper drainage.
C. Traps and plugged tee cleanouts shall not be located directly under or in front of air handling unit access doors. If drain pan connections are located under access doors, offset drain piping and route as required to provide clear, unobstructed access under and in front of the access door. Pitch offsets as required for drainage.

3.08 RAW WATER MAKE-UP

A. Refer to Section 22 1118 - Water Distribution System
B. Install piping where indicated, including valves, piping specialties and dielectric unions required for functional system.
C. Raw water make-up piping for this Section is defined as fill line containing pressure reducing valve for water systems.

3.09 CHEMICAL TREATMENT

A. Install piping as indicated on drawings, as detailed, and as recommended by supplier of chemical treatment equipment.

3.010 VENTS AND RELIEF VALVES

A. Install vent and relief valve discharge lines as indicated on drawings, as detailed, and as specified for each specific valve or piping specialty item.

3.011 DIELECTRIC FITTINGS

A. Install dielectric, flanges or fittings in main and branch piping of water systems at each point where copper to steel pipe connection occurs. Dielectric fittings shall not be used at terminal device connections.
B. Concealed dielectric fittings are not allowed.
C. Install steel to steel pipe dielectric flanges in chilled water piping at each point where interior steel piping is connected to exterior underground steel piping.

3.012 UNIONS AND FLANGES

A. Install union or flange at each automatic control valve and at each piping specialty or piece of equipment that requires tube pull or removal for maintenance, repair or replacement. If required, provide additional unions or flanges in order to facilitate removal of piping sections that interfere with tube pulls or equipment removal. Where valve is located at piece of equipment, provide flange or union connection on equipment side of valve.
B. Concealed unions or flanges are not allowed.

3.013 SYSTEMS STARTUP

A. All piping systems shall be cleaned, tested, and accepted by the Engineer prior to being placed in service.

3.014 SITE QUALITY CONTROL

A. Inspection
   1. Engineer will witness piping systems' pressure test.
   2. Notify Engineer at least 24 hours in advance of each inspection.

3.015 REFRIGERANT PIPING

A. Solder joints shall be ASTM Grade 4 or 5 and have melting point of approximately 1,250°F. Solder impurities shall not exceed 0.15%. Tubing shall be new and delivered to job site with original mill end caps in place. Clean and polish joints before soldering. Avoid prolonged heating and burning during soldering. Purge pipes with nitrogen during soldering. Provide manual shut-off and check valves as required.
B. Leak test by charging system to pressure of 10 psig with the same type of refrigerant that will be used in the system.
C. Charge refrigerant into system through Sporlan catchall filter-drier. Finally increase pressure to 300 psig with oil pumped dry nitrogen. Rap joints with rubber or rawhide mallet and check for leaks with electric leak detector having certified sensitivity of at least one ounce per year. Seal any leaks that may be found and retest.
D. After completion of leak test, evacuate system with vacuum pump to 2.5 mm Hg absolute as measured on accurate gauge.
E. System ambient temperature shall be above 60°F during evacuation, charge refrigerant into system to 0 psig, then repeat evacuation to 2.5 mm Hg absolute. Allow system to stand evacuated for at least 12 h. If no noticeable rise in pressure occurs, system may be charged.
F. Charge system with new refrigerant through charging valve and filter-drier. Continue charging until bubbles disappear from liquid line sight glass while compressor is in operation.
G. Refrigeration piping must be installed by firms who are experienced in installation of such piping.

3.016 PIPING SYSTEM PRESSURE TESTS

A. Owner and/or Owner's representative may elect to witness pressure test. Notify Owner and/or Owner's representative at least 3 days in advance.
B. Conduct pressure test prior to flushing and cleaning of piping systems.
C. Conduct hydrostatic (HYDRO) test in accordance with ASME B31.1 137.4. Test pressure shall be in accordance with ASME B31.1, but shall not be lower than the minimum test pressure listed below.
D. If leaks are found, repair with new materials and repeat test until leaks are eliminated. Caulking will not be acceptable.
E. Pressure tests may be made of isolated portions of piping systems to facilitate general progress of installation. Any revisions made in piping systems require retesting of affected portions of piping systems.
F. No systems shall be insulated until it has been successfully tested. If required for additional pressure load under test, provide temporary restraints at expansion joints or isolate them during test. Unless otherwise noted, minimum test time shall be 4 h plus such additional time as may be necessary to conduct examination for leakage.
G. No pressure drop shall occur during test period. Any pressure drop during test period indicates leakage.
H. Provide pumps, gauges, instruments, test equipment, temporary piping and personnel required for tests and provide removal of test equipment and draining of pipes after tests have been made.
I. For hydrostatic tests, remove air from piping being tested by means of air vents. Measure and record test pressure at high point in system. Where test pressure at high point in system causes excessive pressure at low point in system due to static head, portions of piping system may be isolated and tested separately to avoid undue pressure. However, every portion of piping system must be tested at the specified minimum test pressure.
J. Conduct pressure tests with parameters indicated below:

System	Minimum Test Pressure	Remarks
Heating hot water	100 psig	HYDRO

3.017 FLUSHING AND CLEANING PIPING SYSTEMS

A. Notify Owner and/or Owner's representative at least 7 days in advance.
B. Flush new water, fluid, steam and condensate systems thoroughly for 15 minutes or longer, as required to ensure removal of dirt and foreign matter from piping system. Bypass pumps and equipment and remove strainers from strainer bodies. Provide circulation by Contractor-supplied portable pumping apparatus.
C. Provide temporary piping or hose to bypass coils, control valves, heat exchangers, other factory-cleaned equipment, and any component that may be damaged.
D. Sectionalize system to obtain minimum velocity of 6 fps. Provide temporary piping to connect dead-end supply and return headers as necessary. Flush bottoms of risers.
E. After initial flushing of system, use portable pumping apparatus to circulate cold water detergent for water systems. Refer to Section 23 2514 - Chemical Treatment Systems for pipe cleaning.
F. After initial flushing of system, use portable pumping apparatus for continuous 24 h minimum circulation of cold water detergent similar to Nalco 2567 cleaner. Flush detergent clear with continuous draining and raw water fill for additional 12 h or until all cleaner is removed from system. Replace strainers and reconnect permanent pumping apparatus and all apparatus bypassed.
G. Refer to Section 23 2514 - Chemical Treatment Systems for water analysis.

3.018 INITIAL SYSTEM FILL AND VENT

A. Fill and vent systems with proper working fluids.
B. Use fluids chemically treated as specified in Section 23 2514 - Chemical Treatment Systems.

3.019 PIPE PAINTING

A. Exposed exterior and exposed interior (mechanical rooms) carbon steel, black iron or other ferrous pipe, fittings, and pipe supports shall be prepared and painted by qualified painters using corrosion inhibitive paints. Pipe shall be prepared in accordance with paint manufacturer's instructions and primed (2 coats) and finish painted (2 coats). Paint type shall be approved by Architect/Engineer.
B. Protect piping from weather and paint promptly to prevent corrosion.

END OF SECTION

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SECTION 232118
VALVES

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 20 0700 - Mechanical Systems Insulation
B. Section 23 2120 - Piping Specialties

1.02 REFERENCE

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

1.03 SUBMITTALS

A. Shop Drawings for each system for all sizes including, but not limited to, the following:
   1. Name of system
   2. Manufacturer's name
   3. Type
   4. Model number
   5. Materials of construction
   6. Temperature/pressure ratings
   7. Manufacturer's data sheets clearly cross-referenced
   8. All other appropriate data

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Gate valves, globe valves, check valves, and drain valves: Crane, Nibco, Stockham, Powell, Milwaukee, Hammond, or Grinnell equal to manufacturer's Figure number listed. Provide valves of same make for these services.
B. Other valves: acceptable manufacturers and Figure Number listed under each item.

2.02 WATER SYSTEM VALVES

A. General:
   1. Valves 2" and smaller in steel piping shall have threaded ends.
   2. Valves 2" and smaller in copper piping shall have solder ends.
   3. Provide valve stem extensions with sufficient length to allow for insulation where insulation is specified.
B. Ball Valves:
   1. 2" and Smaller: ASTM B584 bronze body, chrome plated brass/bronze or stainless steel ball, full port for 3/4" and smaller and conventional port for 1” and larger, Teflon seat rings, blowout-proof stem, 2-piece construction, 600 psi WOG, 150 psi SWP, Nibco Fig. T(S)-580-70, Apollo No. 70, Watts, Milwaukee BA-150, Hammond, FNW or Anvil
C. Spring Loaded Check Valves:
   1. 2" and Smaller: bronze or iron body, Class 125 (200 psi WOG), Nibco Figure T(S)-480, Mueller Figure 303-AP or Metraflex No. 700
   2. 2-1/2" and Larger: cast iron or ductile iron body, flanged or wafer type, 302/304 or 316 stainless steel spring, aluminum bronze, carbon steel or ductile iron totally encapsulated in EPDM disc, Buna-N or electroless nickel plated seat, Class 125 (200 psi WOG), Nibco Figure F-910 or W-910, Milwaukee 1800 or 1400, Metraflex No. 700, Stockham Figure WG-970, Mueller Sure Check Model No. 71, or Crane Duo-check II
D. Shut-Off Valves:
   1. 2" and Smaller: ball valves as specified in this Section
   2. 2-1/2" and Larger: butterfly valves as specified in this Section
E. Balancing Valves:
   1. 2" and Smaller: calibrated balancing valves:

a. Variable orifice with multiple turn valve type as manufactured by Armstrong Series CBV or ABV, Tour & Andersson (Victaulic) Series 786 or 787, NIBCO 1709 or 1710, or fixed orifice with ball valve type as manufactured by IMI Flow Design, Hays, Nexus, HCi or Taco. (Taco Accu-Flo is Basis of Design). Bronze or brass body, 250 psi maximum working pressure, 250°F maximum operating temperature. Furnish valve with adjustable memory stop and quick disconnect taps with built-in check valve for pressure differential measurement, integral valve setting index and memory locking device.
b. Valves shall measure down to 0.3 gpm with accuracy of ±5%.
c. Valves shall be leak-tight at full rated working pressure.
d. Unless otherwise indicated, size balancing valves so that at design flow rate, pressure drop across balancing valve with valve approximately 50% open will be at minimum 25% of reading range of meter used for balancing.

2. 2-1/2" and Larger: Armstrong Series CBV or Tour and Anderson (Victaulic) Series 788/789, ductile iron body, ASME/ANSI B16.42 Class 150 flange, 250 psi maximum working pressure, 250°F maximum operating temperature. Fixed orifice with ball valve or butterfly valve as manufactured by FDI, Presco or Gerand, Class 150 flange, 225 psi maximum working pressure, 250°F maximum operating temperature will be acceptable up to 4" size.
3. Furnish portable meter kit within durable case similar to Gerand Model "R". Furnish meter with minimum 4-1/2" diameter aluminum or brass body/brass internals with reading range of either 0" to 50" or 0" to 100" water column differential as appropriate, 200°F maximum temperature, 300 psi working pressure. Meter accuracy shall be ± 2% full scale. Provide in kit: equalizing valves, 10 ft purge hose and size devices specified. Meter shall become property of Owner.
4. Contractor shall furnish meter for calibration and shall retain meter after final calibration.

F. Butterfly Valves:
1. 2-1/2" and Larger 20”:
a. Manufacturers: DeZurik, Keystone, Nibco, Milwaukee, or Bray
b. Ductile iron body, stainless steel shaft, aluminum-bronze disc, or Nylon 11 coated ductile iron disc, upper thrust bearing, EPDM resilient seat, rated at 200 psi bidirectional shut-off pressure, suitable for continuous operation at temperature up to 225°F, compatible to ANSI B16.1 Class 125/150 flange standards, conforming to MSS-SP-67.
c. Dead end pressure rating shall be 150 psi with no downstream flange/piping attached.
d. For valves 6" and smaller, provide 10-position lever actuators with locking devices. For valves 8" and larger, provide rotary hand wheel operators with adjustable position stop and position indicators. Size hand wheel operators with no higher than 80 lb rim pull at full valve pressure rating.
e. External disc-to-stem connections using screws or pins are not allowed.
f. Valve necks shall be of sufficient length to allow for insulation where insulation is specified. Wheel shaft shall be sufficient length so wheel does not touch insulation.
g. Provide full lug type valves permitting removal of downstream piping while using valve for system shut-off.
h. Furnish valves used for balancing with adjustable memory stops.

G. Water Pressure Regulating Valves:
1. Manufacturers: Thrush, Watts, Cash-Acme, Taco, or B & G
2. Brass or bronze body, spring and diaphragm operated, pressure adjustable with check valve and inlet strainer and designed for maximum working pressure of 125 psig and maximum operating temperature of 160°F.

H. Lockshield Valves:

1. Ball valves as specified above with locking handles for padlocking in open or closed position.

I. Drain Valves:

1. Ball valve as specified above with threaded hose adapter and cap. Provide 3/4" minimum drain valve for piping larger than 1/2", except strainer blowdown valves shall be blowdown connection size. Provide 1/2" drain valve for 1/2" piping. If 3-piece ball valves are specified, use 2-piece ball valves with same construction.

2.03 RELIEF VALVES

A. Manufacturers: Kunkle, Consolidated, Thrush, Watts, Cash-Acme, Lonergan, Keckley, or B & G. Iron or bronze body, direct pressure actuated, Teflon seat, stainless steel stem and spring, and suitable for maximum working pressure of 125 psig at 240°F.

B. Valves to conform to State Requirements and have ASME Stamps.

2.04 GAUGE VALVES

A. Unless otherwise indicated, gauge valves for steam, steam condensate and feedwater services shall be gate valves. Gauge valves for all other services shall be needle ball valves. Gauge valve size shall match gauge pipe size as specified in Section 23 2116 - Pipe and Pipe Fittings.

PART 3 - EXECUTION

3.01 GENERAL

A. Install valves as shown on plans, details and according to manufacturer's installation recommendations.

B. After piping systems have been pressure tested and put into service, but before final adjusting and balancing, inspect valves for leaks. Adjust, replace packing or replace valves to stop leaks.

C. Install control valves furnished under Control Systems. Provide reducer and increaser fittings as required.

D. Refer to Section 23 2116, Part 3 for reducing fittings requirement for valves smaller than pipe size.

E. Provide chain operators for manually operated valves 4" and larger, located more than 8 ft above equipment room floor.

3.02 SHUT-OFF VALVES

A. Provide shut-off valves at all equipment, at riser take-offs at each floor, and at each automatic valve for servicing.

B. Install steam system shut-off valves in horizontal piping. Shut-off valves are not allowed in vertical piping.

3.03 BALANCING VALVES

A. Provide balancing valves where indicated on drawings and as required for complete balancing of water systems.

B. Provide straight inlet and outlet pipe length in accordance with manufacturer's recommendation.

3.04 GAUGE VALVES

A. Provide gauge valves at each pressure gauge as shown and at each pressure tapping where pressure sensing tubing is connected.

3.05 DRAIN VALVES

A. Provide drain valves at all low points of piping systems for complete drainage of systems.

B. Unless otherwise indicated, provide 1/2" drain valve for 1/2" piping and minimum 3/4" drain valve for 3/4" and larger piping, except strainer blowdown valves shall be blowdown connection size.

3.06 WATER PRESSURE REGULATING VALVES

A. Set valves for pressure required or as scheduled.

3.07 RELIEF VALVES

A. Unless otherwise indicated, provide one relief valve in each closed water system in the pump inlet piping.

3.08 SPRING LOADED CHECK VALVES

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

END OF SECTION

SECTION 232120
PIPING SPECIALTIES

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 23 0594 - Water Systems Test Adjust Balance
B. Section 23 2118 - Valves

1.02 REFERENCE

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

1.03 REFERENCE STANDARDS

A. Metal bellows expansion joints shall be constructed and applied in accordance with "Standards of the Expansion Joint Manufacturer's Association", 8th Edition, 2003.

1.04 SUBMITTALS

A. Shop Drawings for all items in this Section including, but not limited to, the following:
   1. Manufacturer's name and model number
   2. Identification as referenced in the Documents
   3. Materials of construction
   4. Dimensional data
   5. Capacities/ranges
   6. Temperature/pressure ratings
   7. Pressure drop
   8. All other appropriate data.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Unless otherwise specified, select devices for highest pressures and temperatures existing in respective systems in accordance with ANSI Specifications.
B. Piping specialties in copper piping shall have bronze or brass body with solder ends.

2.02 THERMOMETERS

A. Manufacturers: Taylor, Trerice, Weksler, Miljoco, Winters, or Weiss
B. Pipeline mounted thermometers: 9" scale cast aluminum case and frame, clear acrylic plastic window front, permanently stabilized glass tube with mercury free indicating fluid, adjustable angle stem, extended neck suitable for insulated piping as required, and compatible with sockets as specified herein.
C. Thermometers used in duct reheat coil piping: Bi-metal adjustable type, 3” dial, equal to Trerice B836 or Weiss 3VBM.
D. Range of thermometers shall be:

Service	Scale Range	Increment
Heating Hot Water	30°F to 240°F	2°F
Air (indoor)	0°F to 160°F	2°F
Air (outdoor)	(-40°F to 100°F)	2°F

E. Thermometers by temperature control manufacturer meeting above Specification will be acceptable.

2.03 THERMOWELLS AND TEST WELLS

A. Trerice 5550 Series or approved equal.
B. Brass construction with threaded connections suitable for thermometer stems or bulbs and temperature control sensing elements, well length suitable for pipe diameter with extended neck as required to suit pipe insulation. For test well, furnish with brass cap and short chain to secure cap to body.

C. Stainless steel construction for stainless steel piping.

2.04 PRESSURE GAUGES

A. Manufacturers: Ashcroft, U.S. Gauge, Marsh, Trerice, Miljoco, Marshalltown, Weksler, Winters or Weiss equal to Trerice 600 Series

B. Minimum 4-1/2" diameter die cast aluminum case, glass or acrylic plastic window, phosphor bronze bourdon tube with bronze bushed movement, recalibration from front of gauge dial and 1/4" NPT forged brass socket.

C. Gauge accuracy shall meet ANSI B40.100 Grade 1A (±1% full scale).

D. Reading range of gauges shall be:

Service	Scale Range
Heating Hot Water	0 to 100 psig

E. Pressure Snubbers:

1. 1/4" or 1/2" size, matching gauge pipe size as specified in Section 23 2116 - Pipe and Pipe Fittings, 1000 psig WP. Brass for carbon steel pipe or copper pipe. Stainless steel for stainless steel pipe.

F. Coil Syphons:

1. 1/4" or 1/2" size, matching gauge pipe size as specified in Section 23 2116, 500 psig WP. Material shall match gauge pipe material.

2.05 PRESSURE/TEMPERATURE TEST STATIONS

A. Pete's plugs made by Peterson Equipment Company, Sisco, Super Seal by Flow Design Inc. (FDI), or approved equal.

B. Test plugs shall be 1/4" or 1/2" NPT, brass body and cap, 1-1/2" length for non-insulated pipe and 3" length for insulated pipe, with Nordel self-closing valve cores, rated at 500 psig at 275°F, and shall receive either temperature or pressure probe with 1/8" OD.

C. Furnish portable test kit within durable case containing the following:

1. A compound pressure gauge,3-1/2" dial, 30" Hg – 100 psi, field calibration screw, surge protector and stainless steel gauge adapter with 1/8" diameter probe (2% accuracy of mid range).
2. Two pocket testing thermometers, 1-3/4" dial, 5" long stainless steel stem, 0 - 220°F and 25 - 125°F ranges with external calibration (1% accuracy of entire scale).

2.06 PIPE EXPANSION DEVICES

A. Expansion Loops:

1. Size expansion loops including L-bends and Z-bends as indicated on drawings or as scheduled.
2. Size expansion loops including L-bends and Z-bends to allow adequate expansion of main straight runs of system within stress limits specified in ANSI B31.1.

2.07 PIPELINE STRAINERS

A. Manufacturers: Metraflex, Mueller Steam Specialty, Nibco, Hoffman, Eaton (formally Hayward), Sarco, Keckley, Armstrong, Wheatley, Conbraco, Titan, or Streamflo

B. Liquid System:

1. 2" and Smaller: full pipeline size, Y-type, with removable screen caps, cast iron, Class 250 (400 psi/150°F WOG), threaded ends for carbon steel piping and cast bronze, Class 150 (200 psi/150°F WOG), solder ends for copper piping. Screen caps shall have threaded blowdown connection.
2. 2-1/2" and Larger: full pipeline size, Y-type, Class 125(200 psi/150°F WOG), cast iron, flanged ends. Furnish strainer with bolted screen retainer and off-center blowdown connection.
3. Liquid Service Screens: stainless steel with screen perforation as indicated below. For strainers serving equipment where manufacturer requires specific screen perforation,

provide per manufacturer requirements. Maximum pressure drop shall be 4 ft WG through clean strainer.

Pipe Size	Closed System	Open System
2" and smaller	1/32" (20 mesh)	1/8"
2-1/2" to 4”	1/16”	1/8"
5" and over	1/8"	1/8"

2.08 EXPANSION TANKS

A. Manufacturers: Amtrol, Taco, Bell and Gossett, Armstrong, Wheatley, or Wessels
B. Tanks shall be replaceable bladder type air pre-charged to initial fill pressure as scheduled. Furnish tank suitable for 125 psig WP, constructed, tested and stamped in accordance with ASME Code, and sealed-in elastomer bladder suitable for operating temperature of 240°F. Bladder shall be compatible with water and with ethylene and propylene glycol. Furnish mounting saddles for horizontal tanks and mounting base for vertical tanks. Furnish tanks with system connections; drain connections for floor-mounted tanks, and air charging valves.

2.09 AIR SEPARATORS

A. Manufacturers: Bell and Gossett, Amtrol, Armstrong or Taco
B. 1-1/2” and Smaller: Cast iron construction with steel diffuser tube, bottom and side threaded inlet connections, bottom and top threaded outlet connections, threaded top connection for air elimination, designed for maximum 125 psig WP.
C. 2” and Larger:
    1. Centrifugal type, cast iron or carbon steel construction, flanged connection, threaded connections acceptable for 3” and smaller, perforated stainless steel air collector tube to direct air toward air elimination connection at top of unit, inlet and outlet connections tangential to vessel shell, bottom blow down connections, constructed and stamped in accordance with ASME Boiler and Pressure Vessel Code for 125 psig design pressure at 350°F.
    2. Vessel shell diameter shall be at least 3 times nominal inlet/outlet pipe diameter.
    3. Manufacturer’s data sheet shall include air collection efficiency and pressure drop at design flow scheduled.

2.010 AIR AND DIRT SEPARATORS

A. Manufacturers: Taco, Spirovent or approved equal. Eliminators by Caleffi and Wessels will be acceptable, provided units meet the specified requirements.
B. Coalescing type combination air and dirt separator, designed for maximum 150 psig WP, stamped and registered in accordance with ASME Section VIII, Division 1 for unfired pressure vessels. Connections 2” and larger shall be flanged. Smaller connections may be flanged or threaded. Inlet size shall be no smaller than scheduled size. Inlet velocity shall be 4.0 feet per second or less, except where model VHN or VHR is indicated, velocity may be in the range of 4.0 to 10.0 feet per second.
C. Coalescing medium shall consist of copper core tube with continuous wound copper wire permanently attached and followed by a separate continuous wound copper wire permanently affixed or stainless steel. Submittal shall show that medium fills the entire vessel above and below relatively smaller chambers for dirt collection and venting, respectively. Partial fill is not acceptable.
D. Air elimination efficiency shall be 100% of free air, 100% of entrained air, and 99.6% of dissolved air.
E. Dirt separation efficiency shall be 80% of particles 30 microns and larger within 100 passes.
F. Venting chamber shall be provided with integral full port float actuated brass venting mechanism.
G. Unit shall include valved side tap to flush floating dirt or liquids and for quick bleeding of large amounts of air during system fill or refill.

H. Drain valve at bottom of unit for flushing/dirt removal, 1” for units size 12” and smaller, 2” for units size 14” and above.

2.011 PUMP SUCTION DIFFUSERS

A. Manufacturers: Bell & Gossett, Armstrong, Mueller Steam Specialty, Wheatley or Taco
B. Cast iron or ductile iron body with angle pattern flow straightening vanes and combination diffuser-strainer-orifice cylinder with 3/16” diameter openings, 175 psig WP, at 250°F. Threaded ends for 2” and smaller and flanged ends for 2-1/2” and larger. Orifice cylinder shall have free area of at least 5 times cross section area of pump suction opening. Furnish each unit with disposable fine mesh start-up strainers, gauge tappings, blow down connection, and adjustable support foot to carry weight of suction piping.

2.012 AIR VENTS

A. Manual Air Vents:
   1. Manufacturers: Bell & Gossett Model 4V, 125 psig at 210°F or approved equal. Use 1/2” ball valve for main pipes.
B. Automatic Air Vents:
   1. Manufacturers: Amtrol, Watson McDaniel, B&G, or Hoffman
   2. Metal construction, non-corrosive working parts, 150 psig WP at 240°F
   3. Normal capacity vent shall be similar to B&G Model 87
   4. High capacity vent shall be float actuated and shall have minimum air elimination rate of 10 cfm at 100 psig, similar to B&G Model 107A.

2.013 FLOW ELEMENTS (MEASURING STATIONS)

A. Venturi Flow Elements:
   1. Manufacturers: Hyspan, Gerand, or Preso
   2. Elements shall be flanged ends for 2-1/2” and larger and threaded ends 2” and smaller. Furnish tubes with quick disconnect taps and shut off valves, suitable for 125 psig WP. Select tubes for size and pressure drop as scheduled and tag for mark number, flow and pressure drop as specified.
   3. Provide portable meter kit within durable case. Furnish with 6” diameter forged brass meter having dial range from 0” to 50” WG. Provide in kit equalizing valves, vent hose and size devices specified. Meter shall become property of Owner.
   4. Contractor shall furnish meter for calibration and shall retain meter after final calibration.

PART 3 - EXECUTION

3.01 GENERAL

A. Install piping specialties as indicated on plans, details and according to manufacturer's recommendations.

3.02 THERMOMETERS

A. Install thermometers in thermowells in locations indicated.

3.03 THERMOMETER TEST WELLS

A. Install test wells in locations as shown and at each point where temperature-sensing device is required under Control Systems.

3.04 PRESSURE GAUGES

A. Install gauges for services other than steam with pressure snubbers and gauge valves.
B. Install gauges for steam service with coil syphons and gauge valves.

3.05 PRESSURE GAUGE TAPPING

A. Install tappings with gauge valves at each point where sensing device is required under Control Systems and at gauge locations as shown.
B. Use threadolets or tee fittings to mount gauge tappings or test stations. Install fittings for side mounting to avoid collection of air or dirt.

3.06 PRESSURE/TEMPERATURE TEST STATIONS

A. Pete's plug may be used in lieu of thermometer test well and pressure gauge tappings.
B. Use threadolets or tee fittings to mount gauge tappings or test stations. Install fittings for side mounting to avoid collection of air or dirt.
C. Provide a Pete's plug adjacent to each BAS pressure sensor or temperature sensor even if they are not specifically shown in the plans. The Pete's plugs are to be used for the calibration of the BAS sensors.

3.07 PIPE EXPANSION DEVICES

A. Stretching of expansion joints or connectors to correct for piping misalignment is not allowed.
B. Install expansion loops, L-bends, Z-bends, and compensators where shown on drawings and as necessary to allow expansion and contraction in piping systems.

3.08 PIPELINE STRAINERS

A. Provide drain valve at each strainer blowdown connection with hose threaded adapter and cap. Valve size shall be same as blowdown connection size.
B. Install strainers in steam system on entering side of all automatic control valves and as indicated elsewhere. Install Y-type strainers in horizontal lines so that basket is in horizontal plane to prevent condensate build-up in basket.
C. Install strainers in water systems on suction side of all pumps, entering side of automatic control valves of heating and cooling coils of air handling units, and as indicated elsewhere.

3.09 AIR SEPARATORS

A. Provide valved blow down connections and extend drain piping to nearest floor drain.

3.010 PUMP SUCTION DIFFUSERS

A. Pipe blow down to the nearest floor drain with drain valve at unit.
B. Remove disposable fine mesh start-up strainers after start-up. Clean permanent strainer and replace after pipe cleaning process.

3.011 AIR VENTS

A. Install manual air vents at all high points in water systems where air may collect and where shown on drawings. Manual air vent valve outlets are to be provided with a threaded brass plug.
B. Install automatic air vent at top of air separator and where shown on drawings. Provide shut-off valve to isolate air vent from system. Pipe automatic air vent to the nearest floor drain.

3.012 FLOW ELEMENTS/FLOWMETERS

A. Flow elements/flowmeters located in common piping after multiple pump discharge lines shall be furnished with hot tap feature.
B. If flow elements/flowmeters are furnished by Control Contractor, this Contractor shall install them in accordance with manufacturer's installation instructions. Wiring of flowmeters will be provided by Control Contractor.

END OF SECTION

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SECTION 232123
PUMPS

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 20 0513 - Motors
B. Section 20 0514 - Variable Frequency Drive (VFD) System
C. Section 23 0550 - Vibration Isolation
D. Section 23 2120 - Piping Specialties

1.02 REFERENCE

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

1.03 SUBMITTALS

A. Shop Drawings including, but not limited to, the following:
   1. Manufacturer's name and model number
   2. Identification as referenced in the documents
   3. Capacities/ratings
   4. Pump curves with operating point clearly indicated. For parallel pump applications, indicate operating point of combined case as well as operating point of only one pump.
   5. Motor data (refer to Section 20 0513 - Motors)
   6. Seals
   7. Materials of construction
   8. Dimensions and weights
   9. Manufacturer's installation instructions
   10. All other appropriate data
B. Complete equipment data sheet attached at end of this Section for each piece of equipment and submit with Shop Drawings. Shop Drawings will be returned without review if data sheets are not provided for each piece of equipment and if data sheet is not filled out completely.

1.04 DESIGN CRITERIA

A. Pump sizes, capacities, pressures and operating characteristics shall be as scheduled.
B. Pumps shall meet or exceed operating efficiencies scheduled.
C. Furnish pumps complete with motors, impellers, drive assemblies, bearings and accessories as hereinafter specified. Furnish pump couplings with OSHA compliant coupling guards.
D. Where pump is indicated for parallel operation, scheduled conditions are for that pump with two pumps operating; i.e., total system flow rate is twice that scheduled for single pump. When only one of two pumps is operating, operating point of that pump must fall within manufacturer's recommended operating range.
E. Select motor with sufficient hp rating for non-overloading operation over entire pump curve.
F. Furnish each pump and motor with nameplate giving manufacturer's name, serial number of pump, capacity in gpm and head in ft at design condition, hp, voltage, frequency, speed and full load current.
G. Test pumps hydraulically at 150% of rated pressure per Hydraulic Institute Standards, clean and paint before shipment. Manufacturer shall certify all pump ratings.
H. Pumps shall operate without objectionable noise or vibration.
I. After completion of balancing, if water balancing results in pump discharge balancing valve being closed 50% or more, replace or trim impeller so that balancing valve is opened at least 75% to maintain design flow rate. Where pumps are driven by VFDs, balancing should be performed with pumps at design speed.
J. Furnish one spare seal for each pump to Owner.

K. Where pumps are located remotely from their controlling VFDs, provide disconnect switches at the pump location. The disconnect shall be designed to shut off the VFD so as to prevent damage to the VFD when turning off a pump at the pump location by opening the disconnect switch.

1.05 FACTORY TESTING

A. Pump manufacturer shall conduct factory performance testing of completely assembled pump, drive line, motor, and frame base plate unit before shipment for all water system pumps above 25 hp.
B. Factory performance testing shall be in accordance with Hydraulic Institute, ANSI/HI 1.6-2000, American National Standard for Centrifugal Pump Tests for Acceptance Level A.
C. For pumps provided with variable speed drives, test shall include operating the assembled unit over the entire variable speed range, variable head, and variable flow performance range contained on submitted pump Shop Drawing performance curves performance window formed between minimum flow and maximum flow limitations established by submitted NPSHR curve. Test each pump at 50 rpm intervals between 100 rpm and maximum design performance rpm specified.
D. After testing is complete and before pump is shipped, manufacturer shall submit to Engineer for final acceptance, 6 original test reports which present all measured test data. Each original report shall be signed by authorized factory pump Design/Pump Test Engineer.
E. Signed test reports shall include the following statement:

"Provided that the pump being furnished is operated within the entire window of operating points between the tested speeds, heads, and flows, manufacturer shall warranty the pump against any performance loss, rotating part damage, stationary part damage, or structural damage caused by mechanically induced or fluid induced vibration occurring within the pump or within the foot print of the pump frame base plate." This warranty includes all materials and labor to repair the pump for a period extending 12 months after final acceptance of the system.

PART 2 - PRODUCTS

2.01 END SUCTION CENTRIFUGAL PUMPS (FLEXIBLE COUPLED)

A. Manufacturers: Taco, Armstrong, Peerless, Aurora, PACO or Goulds
B. Pumps shall be base mounted, end suction, flexible coupled, cast iron casings with ANSI Class 125 flange, bronze fitted with working pressure of 175 psi and continuous operating temperature of 225°F. Pumps shall be back pull out design allowing for servicing of impeller and bearing assembly without disturbing piping, motor or requiring shaft realignment.
    1. Pumps scheduled to have higher working pressure than175 psi shall have ductile iron casing with ANSI Class 250 flanges, rated for 300 psi working pressure and continuous temperature of 225°F.
C. Casings shall have tapped and plugged openings for vent, drain, and suction and discharge gauge connections.
D. Impellers shall be single suction enclosed type made of bronze, hydraulically and dynamically balanced to ANSI/HI 1.1-1.5-1994, Section 1.4.6.1.3.1, Figure 1.106 Balance Grade G6.3, keyed and locked to pump shafts and protected by replaceable bronze shaft sleeves.
E. Pump shafts shall be 416 stainless steel, sealed and gasketed from pumped fluid.
F. Hot water pumps shall be furnished with mechanical seals with carbon rotating faces, ceramic stationary seats, Buna-N elastomer and 316 SS spring, rated up to 225°F continuous operation.
G. Bearing assemblies shall be cast iron with regreasable ball bearings
H. Spacer type couplings or couplings with extended hubs shall be used to allow for pump servicing. Couplings shall be Woods Dura-Flex or Sure-Flex in accordance with manufacturer's recommendation for their application.
I. Pumps shall be furnished with groutable steel base plates

J. Pump bases shall be furnished with drip pans and drain connections for pumps with packed stuffing box shaft seals.
K. Provide cast iron suction diffusers at the inlet of each pump.
L. Pumps and bases that are installed in an exterior application shall be provided with a factory applied corrosion inhibiting epoxy paint.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install pumps in strict accordance with manufacturer's instructions to avoid any stress and misalignment.
B. Set base mounted pumps on concrete bases, or concrete inertia base, level and bolt down prior to grouting. Fill entire base with non-shrinking grout. Use end caps during grouting to prevent overflow when end caps are not integral with base plates.
C. Align flexible coupled pumps after base grouting is complete. Align pump and motor in all four planes: vertical angular, horizontal angular, vertical parallel and horizontal parallel. Alignment shall be within the recommended value by manufacturer, but not over 1/64” for parallel alignment and 1/64 per inch of coupler radius for angular alignment. Record and submit all results of alignment procedure to Engineer. After alignment is complete, pin pump and motor to base.
D. Install full line size spring loaded check valve and balancing valve in pump discharge piping.
E. Where pump connection size and indicated line sizes are not identical, provide necessary concentric reducers/increasers for vertical piping at pump connection and eccentric reducers/increasers for horizontal piping at pump connection. Install eccentric reducers/increasers with top of pipe level. Valves and piping specialties shall be full line size as indicated on drawings.

3.02 STARTUP

A. Verify that piping system has been flushed, cleaned and filled.
B. Prime pump, vent air from casing and verify that rotation is correct. To avoid damage to mechanical seals, never start or run pump in dry condition.
C. Verify lubrication of motor and pump bearings and lubricate properly in accordance with manufacturer’s recommendation and Section 23 0000, Part 3, under LUBRICATION.
D. After several days' operation, verify removal of disposable startup strainer in suction diffuser and turn them over to Owner.
E. Perform field mechanical balancing, if necessary, to meet vibration tolerance specified in Section 23 0550 - Vibration Isolation.

END OF SECTION

Pump Data Sheet

General
- Project _____
- Identification _____
- Service _____
- Location _____
- Type _____
- Manufacturer _____
- Model Number _____

Performance
- Capacity (Flow) _____
- Head (Ft) _____
- Max. Net Positive Suction Head Req. (Ft) _____
- Efficiency (%) _____
- Horsepower required for non-overloading operation over entire pump curve _____

Physical Characteristics
- Suction Size _____
- Discharge Size _____
- Casing Material _____
- Impeller Material _____
- Shaft Sleeve Material _____
- Shaft Material _____
- Seal Type _____
- Seal Face Material _____
- Seal Seat Material _____
- Bearing Assembly Material _____
- Working Pressure & Continuous Operating Temp. _____
- Maximum Intermittent Temperature _____

Motor
- Manufacturer _____
- Horsepower _____
- Voltage _____
- Phase _____
- Hertz _____
- RPM _____
- Motor Type _____
- Enclosure Type _____
- Frame Type _____
- Insulation Class _____
- NEMA Design Designation _____
- Service Factor _____
- Nominal Efficiency _____
- Nominal Power Factor _____
- Full Load Amps _____
- Variable Frequency Drive Driven (Yes or No) _____

Miscellaneous

SECTION 232514
CHEMICAL TREATMENT SYSTEMS

PART 1 - GENERAL

1.01 RELATED WORK

A. Control Sequences
B. Section 23 2116 - Pipe and Pipe Fittings

1.02 REFERENCE

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

1.03 SUBMITTALS

A. Shop Drawings for each system including, but not limited to, the following:
   1. Manufacturer's name and model number
   2. Capacities/ratings
   3. Chemicals; description of chemicals, its composition and function
   4. Operating sequence
   5. Composite wiring diagrams
   6. Materials of construction
   7. Dimensions and weights
   8. Manufacturer's installation instructions
   9. All other appropriate data
B. Submit overall installation diagram for each system locating chemical injecting points, bleed-off assemblies, water meters, number of tanks and pumps, and field piping.
C. Submit complete make-up water analysis.
D. Submit directly to Owner, Material Safety Data Sheets (MSDS) for all chemicals used in chemical treatment systems. Include with MSDS written notice of Owner's responsibility to notify its employees of the use of those chemicals.

1.04 OPERATION AND MAINTENANCE DATA

A. Provide for services of manufacturer's trained, representative to approve installation, and instruct Owner's representative in operation, testing and maintenance of each system.
B. Include data on chemical feed pumps, meters, and other equipment including spare parts lists, procedures, and treatment programs. Include step-by-step instructions on test and adjust procedures including target concentrations.

1.05 MAINTENANCE SERVICE

A. Provide service and maintenance of treatment systems for 1 yr from date of substantial completion.
B. Provide monthly technical service visits to perform field inspections and make water analysis on site. Detail findings in writing on proper practices, chemical treating requirements, and corrective actions needed. Submit 2 copies of field service report after each visit.
C. Provide laboratory and technical assistance services for warranty period.
D. Provide site inspection of equipment during scheduled shutdown to evaluate success of treatment program. Make recommendations in writing based on these inspections.

1.06 WATER ANALYSIS

A. Submit complete water analysis and results of performance test of each system signed by manufacturer's service representative.
B. Water analysis shall include the following:
   1. Heating Hot Water:
      a. Hardness
      b. pH
      c. M" alkalinity

d. Inhibitor level
e. Total dissolved solids
f. Temperature

1.07 DESIGN CRITERIA

A. Periodic test procedure and chemical shall be recommended for each system.
B. Chemicals shall be suitable for pipe material, fluid medium and intended treatment.
C. Materials of construction for equipment used shall be compatible with water treatment chemicals provided.
D. Treat the following systems:
   1. Heating Hot water
E. Provide initial chemical treatment and equipment for all systems based on complete system fluid analysis, including make-up water, prior to equipment installation.
F. Initial supply of chemicals for chemical treatment of each system shall be adequate for start up and testing period, for the time systems are being operated by Contractor for temporary heating and cooling, and for 1 yr after start-up of system.
G. Inhibitor for closed water systems shall use nitrites or phosphonate as primary inhibitor.
H. Chemicals used in condenser water treatment system shall be liquid only and contain no chromates.
I. Provide electrical devices, wiring and conduit in accordance with the applicable sections of Division 26.

1.08 WATER QUALITY REQUIREMENTS

A. Minimum water quality requirements for closed loop, heating hot water system shall be as follows:

1.	pH	8.0 – 9.0
2.	TDS	< 500 ppm
3.	Hardness as CaCO3 and Alkalinity	< 120 ppm
4.	Chlorides	< 200 ppm
5.	Sulphates	< 200 ppm
6.	Iron	< 1.0 ppm
7.	Dissolved Oxygen	<0.1 ppm
8.	Ryznar Index	>6.0
9.	Suspended Solids	≤10 micron
10.	Bacteria Counts	
	a. Total Aerobic Bacteria Counts	≤100 cfu per mL
	b. Total Anaerobic Bacteria Counts	≤10 cfu per mL

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers:
   1. GE Water & Process Technologies (formerly Betz-Dearborn)
   2. Ecolab (formerly Nalco)
   3. HOH Chemical
   4. Earthwise Environmental, Inc.

2.02 PIPING SYSTEM CLEANER

A. Use cleaning compound to remove organic soil, hydrocarbons, flux, pipe mill varnish, pipe compounds, iron oxide, and like deleterious substances, with or without inhibitor, suitable for system metals without deleterious effects. Cleaner shall not contain phosphate.

2.03 HOT WATER CHEMICAL TREATMENT

A. Provide by-pass type batch feeder to receive chemicals in liquid or pellet form. Each independent hot water heating system shall have separate feeder. Chemical treatment shall control corrosion and scale.
B. Feeder shall have capacity of 5 gal and shall be constructed of steel with minimum working pressure of 150 psig. Feeder shall be complete with air vent, drain valve, and inlet/outlet pipe connections.
C. Furnish feeders with screw type cover with replacement gaskets, or valved funnel opening and with exterior prime coat finish.

2.04 TEST CABINET AND EQUIPMENT

A. Provide complete chemical treatment test equipment and cabinet with appropriate reagent, burettes, and glassware to conduct all tests necessary for determination of proper treatment and blowdown.
B. Provide detailed, written test procedures for each system in manual with plastic protection cover for each page.
C. Test equipment shall include but not be limited to, the following:
    1. Closed Loop Water System:
        a. Inhibitor test kits

PART 3 - EXECUTION

3.01 ELECTRICAL WIRING

A. Provide all field electrical wiring for system, in metal conduit and in accordance with Division 26 and all applicable Electric Codes.

3.02 APPLICATION OF CHEMICALS

A. Apply initial chemical treatment for each system after systems have been cleaned and flushed.
B. Add, adjust or modify treatment based on results of period tests until turned over to Owner.

3.03 PERFORMANCE TEST

A. Conduct performance test for each system to determine required capacity and performance of chemical treatment system. Refer to Part 1 for water analysis and water quality requirements.
B. Conduct water quality test in all systems weekly and submit test result reports to Mechanical Contractor and Owner until project is turned over to Owner.
C. Conduct water quality tests before and after new work tie-in to existing systems.

3.04 BATCH FEEDERS

A. Install in bypass arrangement at pump discharge as indicated.
B. Install ball valve in inlet line, balancing valve in outlet line and unions.

3.05 PIPE CLEANING

A. General:
    1. Piping systems shall be cleaned before they are used for any purpose except pressure tests, which shall be conducted before cleaning. Add cleaner to closed systems at concentrations as recommended by cleaner manufacturer. Remove water filter elements from system before starting circulation.
    2. Use neutralizer agents on recommendation of system cleaner supplier and approval of Architect/Engineer.
    3. Remove, clean, and replace strainer screens or filters.
    4. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed.
    5. New piping system shall not be connected to existing system for operation until flushing and cleaning have been completed. Obtain permission from Owner prior to opening up new work to existing system.
B. Water Systems:

1. Piping systems shall be filled, vented and circulated employing chemical cleaner solution for period of at least 24 hours or more in accordance with manufacturer's recommendations and job site chemical tests. Bring concentration to level, which raises M Alkalinity to manufacturer's recommended value above that for existing water used for fill. Conduct chemical tests to verify levels and submit results to Architect/Engineer. Flush detergent clear with continuous draining and make-up water fill for period of at least 12 hours or more until original M Alkalinity level is achieved (or until pH of system water is within 0.5 pH of make-up water). Conduct chemical tests to verify levels and submit results to Architect/Engineer. When cleaning process is complete, replace strainers or filters and reconnect permanent pumping apparatus.

END OF SECTION

SECTION 233114
DUCTWORK

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 20 0529 - Mechanical Supporting Devices
B. Section 20 0700 - Mechanical Systems Insulation
C. Section 23 0550 - Vibration Isolation
D. Section 23 0595 - Air Systems Test Adjust Balance
E. Section 23 3314 - Ductwork Specialties

1.02 REFERENCE

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

1.03 SUBMITTALS

A. For each duct system, submit schedule utilizing reinforcement tables from SMACNA HVAC Duct Construction Standards where applicable. Each duct system schedule shall include, but not be limited to, the following:
   1. Name of Contractor/manufacturer fabricating each duct system
   2. Material and gauge
   3. Pressure class
   4. Transverse joint type and length and reinforcement rigidity class with designated joint T number or proprietary duct connection if utilized for each system
   5. Certified test results of proprietary joint products, if used, tested in accordance with SMACNA procedures
   6. Intermediate reinforcement spacing and rigidity class with metal angle dimensions and gauge
   7. Type of longitudinal seam
   8. Fitting construction details
   9. Support methods including spacing, upper attachments, and lower attachments
   10. Sealant and gasket
   11. Sealing class
B. Duct leakage testing methods, apparatus and apparatus certification signifying meter is in conformance with ASME Requirements for testing meters.
C. Submit the following information for welded sheet metal ductwork:
   1. Welding Procedure Specification (WPS) for welded joints. Form to be similar to ANSI/AWS D9.1-90 Code, Appendix "D".
   2. Procedure Qualification Record (PQR) for each WPS. Form to be similar to ANSI/AWS D9.1-90 Code, Appendix "E".
   3. Welder Qualification Test Record (satisfactory performance) for each field or shop welder. Form similar to ANSI/AWS D9.1-90 Code, Appendix "F".

1.04 DESCRIPTION

A. Furnish and erect ductwork free of objectionable vibration, chatter, and pulsations. Verify dimensions at site, making field measurements and drawings necessary for fabrication and erection.
B. Duct sizes indicated are net inside dimensions.
C. Where size for a duct segment is not indicated, the duct segment size shall be equal to the largest duct segment to which it is connected. Transition to smaller size shall occur on side of fitting where smaller size is indicated.

1.05 DESIGN CRITERIA

A. All products shall conform to NFPA 90A, and shall possess flame spread rating of not over 25 and smoke developed rating no higher than 50.
B. Unless otherwise indicated, construct all ductwork of galvanized sheet metal for pressure class not less than +2" WG (500 Pa) for positive pressure ductwork and not less than -2" WG (-500 Pa) for negative pressure ductwork.
C. Ductwork shall comply with Local, State and Federal requirements.
D. Unless otherwise indicated, pressure class for VAV system supply ductwork between supply fan discharge and air terminal device inlet shall be equal to static pressure at fan discharge but not less than 4" WG (1000 Pa); pressure class for ductwork on suction side of air handling unit and suction side of return fan shall be equal to static pressure at inlet of return fan but not less than -2" WG (-500 Pa).
E. Unless otherwise indicated, pressure class for fume hood exhaust ductwork between exhaust fan inlet and exhaust valve outlet shall be equal to static pressure at exhaust fan inlet but not less than --4" WG (-1000 Pa).
F. Unless otherwise indicated, pressure class for constant air volume system ductwork shall be equal to external static pressure (fan entrance or discharge pressure minus associated unit internal component pressure drop), but not less than + or - 2" WG (+ or – 1000 Pa).
G. Duct transverse joints and reinforcement material, including angle ring flanges and stiffeners, shall be of same material as duct.
H. Except as modified in this Section of specifications, use material, weight, thickness, gauge, construction and installation methods as outlined in the following SMACNA publications:
    1. HVAC Duct Construction Standards, Metal and Flexible, 2nd Edition, 1995, for rectangular and round ductwork up to positive 10" WG (2500 Pa) and negative 10" WG (2500 Pa) and flat oval ductwork up to positive 10" WG (2500 Pa).
        a. Internal tie rods or bracing are not allowed for ductwork 40” (1016 mm) and smaller. Tie rods shall be 1/2" (13 mm) or 3/4" (19mm), galvanized steel EMT/conduits with bolt assembly consisting of rubber washer and friction anchored threaded insert similar to Ductmate Easyrod or PPI Condu-Lock.
        b. Internal tie rods are not allowed for welded ductwork and special exhaust systems, such as fume hood exhaust.
    2. Round Industrial Duct Construction Standards, 2nd Printing 1999.

1.06 WELDING REQUIREMENTS

A. The following requirements cover arc and braze welding of nonstructural sheet metal ductwork for HVAC, architectural metal and other FDA process applications where pressures do not exceed 120" WG (30 kPa) (positive or negative). These requirements also apply to welding of structural members whose sole purpose is stiffening, supporting, or reinforcing of sheet metal material, as well as attachment of brackets or other accessories/components required to provide complete systems.
B. Procedure and Qualification:
    1. Welding Procedure Specification (WPS) and Procedure Qualification Record (PQR) shall be prepared by installing contractor and/or fabricator prior to execution of related work. Qualification of welding procedure shall meet or exceed requirements of the latest revision of American Welding Society, Sheet Metal Welding Code ANSI/AWS D9.1.
    2. Provide certification of satisfactory performance testing for all welders and welding operators, which provide welding services on Project.
    3. Establish and provide written quality control (QC) procedures to ensure compliance with specification requirements. Clearly identify appropriate steps for safe welding procedures (review Appendix J of D9.1) including additional safety material, screens, eye, personnel and clothing protection, fire suppression equipment, and fume extraction equipment needed adjacent to welding work area.

PART 2 - PRODUCTS

2.01 GALVANIZED STEEL SHEET

A. First quality, Lock Former Quality (LFQ), cold rolled, open hearth soft steel sheet capable of double seaming without fracture, ASTM A924 or ASTM A653. Galvanized coating shall be G90.
B. Use G90 Galvaneal or Zincgrip where painting is specified.

2.02 STAINLESS STEEL SHEET

A. First quality, cold rolled annealed, pickled, ASTM A240 and A480, Finish No. 2B for concealed work and Finish No. 4 for exposed work. Unless otherwise indicated, use Type 304L where welded duct construction is specified and Type 304 where non-welded duct construction is allowed.

2.03 NON-METALLIC FLEXIBLE DUCT

A. Manufacturers: Thermaflex, Casco, or Flexmaster, similar to Thermaflex Model M-KE or Flexmaster Type 6
B. Factory fabricated, UL listed under UL-181 as Class 1 duct, meeting requirements of NFPA 90A with flame spread of 25 or less and smoke developed rating of 50 or under.
C. Flexible duct shall be suitable for:
   1. Operating Temperature: -20° (-29°C) to 250°F (121°C)
   2. Operating Pressure: +10" WG (2500 Pa) (4-12" (100-300 mm) ID)
      +6" WG (1500 Pa) (14-16" (350-400 mm) ID)
      +4" WG (1000 Pa) (18-20" (460-500 mm) ID)
      -1" WG (-250 Pa) (4-12" (100-300 mm) ID)
      -0.5" WG (-125 Pa) (14-20" (350-500 mm) ID)
   3. Velocity: 5000 fpm (1524 mpm)
D. Unless otherwise indicated, duct shall be nonmetallic insulated type composed of polyester film, polyethylene film, nylon film or coated woven fiberglass liner bonded permanently to corrosion resistant coated steel wire helix.
E. Insulation shall be minimum R6.0 fiberglass insulation blanket with maximum thermal conductance of 0.23 K at 75°F (24°C). Vapor barrier jacket shall be aluminum foil reinforced, polyethylene, or metalized polyester film with minimum perm rating of 0.05 perm.
F. Insulation material shall not be exposed to air stream.
G. Lined flexible duct shall have the following minimum acoustical performance in accordance with ARI Standard 885. Dynamic Insertion Loss in each octave band of 5 ft or 10 ft straight duct shall not be less than the following:

Dynamic Insertion Loss (dB)
Octave Band Center Frequency (Hz)
(Based on 5 ft (1.5 m) length)

Duct Diameter (in./mm)	125	250	500	1000	2000	4000
6 / 150	6	9	18	22	24	15
8 / 200	6	10	18	20	21	12
10 / 250	5	11	18	18	18	9

(Based on 10 ft (3 m) length)

Duct Diameter (in./mm)	125	250	500	1000	2000	4000
6 / 150	10	15	28	33	35	22
8 / 200	10	18	29	32	32	20
10 / 250	9	19	28	31	29	18

2.04 METALLIC FLEXIBLE DUCT

A. Manufacturers: Flexmaster Triple Lock Aluminum or approved equal.
B. Construction:
C. All aluminum construction with a thermal conductance (C-factor) of not more than 0.23.
D. Factory fabricated, UL listed under UL-181 as Class 1 duct, meeting requirements of NFPA 90A with flame spread of 25 or less and smoke developed rating of 50 or under.
E. Flexible duct shall be suitable for pressures and temperatures involved, but not less than 250°F service temperature, 12” WG positive, min. 8” WG negative pressure rating, and velocity rating of 5500 fpm. All tests shall be performed according to Air Diffusion Council Flexible Air Duct Test Code FD72 R1.
F. Insulation shall be fiberglass with R value of at least 4.2 at a mean temperature of 75°F.
G. Insulation material shall not be exposed to air stream.

2.05 MANUFACTURED ROUND OR FLAT OVAL DUCTWORK (POSITIVE PRESSURE)

A. Single Wall:
   1. Manufacturers: Ajax, Lindab, Semco or United McGill, equal to United McGill Uni-Seal duct and fittings suitable to positive 10" WG (2500 Pa).
   2. Ducts shall be machine formed round and/or flat oval as shown on drawings, constructed of G90 galvanized steel. Use spiral lockseam construction. Longitudinal seam construction may be used for ductwork over 80" (2032 mm) diameter with minimum 16 ga (1.6 mm). Use fittings as indicated on drawings, as specified, and as required in accordance with manufacturer's published data.
   3. Unless otherwise indicated, connection shall be slip type with minimum 2" (50 mm) insertion length or flanged joint in accordance with manufacturer's recommendations. When flange joints are required, use Van Stone angle rings welded to duct.
   4. Internal bracing is not allowed.
B. Double Wall (insulated):
   1. Manufacturers: Lindab, Semco or McGill AirFlow duct and fittings suitable to positive 10” WG.
   2. Ducts shall be machine formed round and flat oval as shown on drawings, constructed of G90 galvanized steel. Use spiral lockseam construction. Inner liner shall be perforated or solid as indicated, and annular space shall be filled with 1” thick fiberglass insulation. Use fittings with solid liner as indicated on drawings, as specified, and as required in accordance with manufacturer's published data.
   3. Unless otherwise indicated, connection shall be slip type connection with minimum 2” insertion length or flanged joint in accordance with manufacturer's recommendations. When flange joints are required, use Van Stone angle rings welded to duct.
   4. Internal bracing is not allowed.

2.06 MANUFACTURED ROUND DUCTWORK (NEGATIVE PRESSURE)

A. Manufacturers: United McGill Industrial duct and fittings. Semco and Lindab are acceptable manufacturers, provided meeting requirements in this Section.
B. Ducts shall be machine formed round duct constructed of G90 galvanized steel. Use spiral lockseam construction unless otherwise indicated. Use fittings as indicated on drawings, as specified, and as required in accordance with manufacturer's published data.
C. Connection shall use slip coupling, angle ring or Van Stone connectors in accordance with manufacturer's recommendations.
D. Fitting gauge shall be one even gauge heavier than the lightest allowable gauge of connecting downstream section of duct.

2.07 DUCT SEALANT AND GASKET

A. Sealant:

1. UL Classified sealant as compounded specifically for sealing joints and seams in ductwork. Hardcast, United McGill, Ductmate, Mon-Eco Industries or H.B. Fuller/Foster. Duct tapes are not allowed.
2. Select sealants as recommended by manufacturer for specific application.
3. Submit sealant manufacturer's data sheets including performance data, pressure ratings, surface burning characteristics data, detailed installation instructions.

B. Gaskets:
1. Butyl, copolymer or neoprene based tape similar to Ductmate 440 Gasket Tape or Neoprene Gasket Tape for flanged joints.

C. Duct Sealant and Gaskets for Fume Hood Exhaust Ductwork:
1. Sealant shall be similar to Hardcast Sure-Grip 404 Ductmate Proseal.
2. Gasket material shall be Teflon based similar to Gore-Tex Series 300.
3. Gasket thickness and width shall be as required for flange and surface irregularities to seal joint air tight.

2.08 CABLE SUSPENSION SYSTEM

A. Cable Suspension systems are not allowed.

PART 3 - PRODUCTS

3.01 GENERAL

A. Install ductwork parallel to building walls and ceilings and at such heights not to obstruct any portion of ceiling, window, doorway, stairway, or passageway. Install ductwork to allow adequate access and service space for equipment. Refer to drawings and/or manufacturer's recommendations. Install vertical ductwork plumb. Where interferences develop in field, offset or reroute ductwork as required to clear such interferences. In all cases, consult drawings for exact location of duct spaces, ceiling heights, door and window openings or other architectural details before installing ductwork.

B. Make allowances for beams, pipes or other obstructions in building construction and for work of other contractors. Check plans showing work of other trades and consult with Engineer in event of interference. Transform, divide, or offset ducts as required, in such a manner as to maintain same cross sectional area of duct as indicated on drawings. Where it is necessary to install pipes or similar obstructions through ducts, consult with Engineer and obtain written approval from Engineer and Owner. If approved, provide streamlined encasement or collar designed in accordance with SMACNA Standards and seal to prevent air leakage.

C. Ductwork shall be free of kinks and dents.

D. Fabricate and install duct, fittings, joints, seams, reinforcement, supports, sealing, liner, etc., in sizes indicated on drawings and in accordance with manufacturer's published data and SMACNA Standards except as modified in this Section of Specifications.

E. Provide transitions where different size or different shape ductwork segments are connected. Use concentric transitions unless otherwise shown. Unless otherwise indicated, make diverging transitions with maximum angle of 15° per side (30° total diverging) and converging transitions with maximum angle of 25° per side (50° total converging).

F. Provide transitions at ductwork system components and connections to equipment. Refer to Specification Section 23 3713 – Diffusers, Registers, and Grilles, for additional information regarding diffuser/register/grille connections.

G. Refer to ductwork symbols list on drawings for additional and dimensional requirements for fittings.

H. Seal duct seams and joints to meet SMACNA Class A as minimum for all ductwork including low-pressure ductwork.

I. Construct ductwork so that interior surfaces are smooth. Internal duct hangers and internal bracing are not allowed. Refer to Part 1, Design Criteria for internal tie rods.

J. Support coils, filters, air terminals, dampers or other devices installed in duct systems with angles or channels, and make all connections to such equipment including equipment furnished by others. Secure frames with gaskets, nuts, bolts and washers.
K. Air terminal devices may be supported by strap hangers if air terminal manufacturer approves. Strap hangers are not allowed for fan powered devices, double wall type and Titus Steri-Loc type devices.
L. Install outside air intake duct to pitch down at minimum 1" (25 mm) per 20 ft (6 m) toward intake louver or plenum and to drain to outside of building. Solder or seal seams to form watertight joints.
M. Install exhaust air duct to pitch down at minimum 1” (25 mm) per 20 ft (6 m) toward exhaust louver.
N. Blank off unused portion of outside air intake or exhaust louvers.
O. Where 2 different metal ducts meet, install joint in such a manner that metal ducts do not contact each other by using proper gasket seal or compound.
P. Install motor operated dampers and connect to or install equipment furnished by others. Provide necessary blank-off plates or transitions to mount control dampers as specified in Section 23 0901 - Control Systems Integration.
Q. Do not install ductwork over electrical panelboards, switchgear, switchboards or motor control centers.
R. When original galvanized finish is altered or damaged, apply field galvanizing paint as follows:
    1. Prepare surface with use of power sanders or wire brushes to remove rust, paint, etc.
    2. Apply cold galvanizing material equal to ZRC Products, Inc.

3.02 ELBOWS

A. Rectangular Duct:
    1. Unless specific type is indicated, use radius elbows with minimum centerline radius to width or diameter ratio of 1.5. Where 1.5 radius elbows do not fit, use the following elbows.
        a. Supply Air Ductwork:
            1) 1.0 radius elbows
            2) Square throat elbows with turning vanes where 1.0 radius elbows do not fit
        b. Return or Exhaust Air Ductwork:
            1) 1.0 radius elbows with full splitter vanes (SMACNA Type RE3) as follows:
                a) One vane for duct width 24” (610 mm) to 48” (1220 mm)
                b) Two vanes for duct width 49” (1245 mm) to 72” (1830 mm)
                c) Three vanes for duct width 73” (1850 mm) and larger
                d) Fabricate vanes in accordance with SMACNA HVAC Duct Construction Standard, chart 4-1(p 4.11) and Figure 4-9 (p 4.13).
            2) 45° throat with radius heel elbows with full splitter vanes as follows where 1.0 radius elbows do not fit:
                a) One vane for duct width 12” (305 mm) to 24” (610 mm)
                b) Two vanes for duct width 25” (635 mm) to 36” (914 mm)
                c) Three vanes for duct width 36” (914 mm) and larger
                d) Fabricate vanes in accordance with SMACNA HVAC Duct Construction Standards, Chart 4-1 and Figure 4-9.
            3) Square throat - radius heel elbows or square throat elbows with turning vanes are not allowed unless specifically indicated.
B. Round and Oval Duct:
    1. Unless specific type is indicated, use radius elbows with centerline radius to diameter ratio of 1.5. Where 1.5 radius elbows do not fit, use 1.0 radius elbows.

3.03 LONGITUDINAL SEAM

A. Rectangular Duct:

1. Unless otherwise indicated, use Pittsburgh lock seam for rectangular ductwork.
2. Button punch snap lock construction (SMACNA L-2) may be used for ductwork for 2” WG (500 Pa) (+ or -) and lower, and sizes 48” (1220 mm) and smaller in width. All snap lock seams are to be secured with self-drilling screws at each end of the duct segment.
3. Button punch snap lock construction is not allowed for ductwork in chases and areas above inaccessible ceiling.
4. Button punch snap lock construction is not allowed on aluminum ductwork.

B. Round and Oval Duct:
1. Unless otherwise indicated, longitudinal seams shall be in accordance with SMACNA HVAC Duct Construction Standards. Snaplock seams are not allowed.

3.04 TRANSVERSE JOINT

A. Rectangular Duct:
1. Transverse joints shall be in accordance with SMACNA HVAC Duct Construction Standards.
2. Ductmate 25/35 connection systems with corner clips or optional nuts and bolts may be used. Incorporate use of all Ductmate accessories to ensure integrity of transverse connection. Install joints in strict accordance with the latest edition of Ductmate 25/35 Assembly and Installation Instruction Manual and Duct Construction Standards. Nexus or WDCI will be acceptable.
3. Lockformers TDC or Engles TDF may be used in accordance with T-25 flanges of SMACNA HVAC Duct Construction Standards, Metal and Flexible, Second Edition, 1995, provided that corner pieces with bolts are used. If TDF/TDC flanges are damaged, replace the damaged joint(s) by straightening and reinforcing with minimum 1-1/2” x 1-1/2” x 1/4" (40 mm x 40 mm x 6.5 mm) angle at each side of transverse joint.

B. Round and Flat Oval Duct:
1. Unless otherwise indicated, use beaded sleeve joints (SMACNA RT-1) with minimum 2" (50 mm) insertion length or flange joints (SMACNA RT-2 or RT-2A).
2. Connection systems manufactured by Ductmate Industries (Spiralmate and Ovalmate) may be used for supply air ductwork.
3. AccuFlange connected systems may be used with gaskets specified in Part 2 of this Section.

3.05 DUCT SUPPORTS

A. Unless otherwise indicated, use straps or Z bar hangers with 3/8” (9.5 mm) rods to support rectangular ducts 60” (1524 mm) wide and smaller and trapeze hangers with rods or angles to support rectangular ducts over 60” (1524 mm) wide.

B. Use trapeze hangers to support externally insulated ductwork with weight bearing inserts. Refer to Section 20 0700 – Mechanical Systems Insulation and details.

C. For round ducts 24" (610 mm) diameter or smaller, use single hanger.
1. Round Duct Strap Bracket by Ductmate Industries may be used up to 24" (610 mm) diameter.

D. For round ducts 25” (635 mm) diameter or larger, use 2 minimum 3/8” (9.5 mm) rods, with trapeze in accordance with the following schedule:

Duct Size	Trapeze (Half Round)
25” (635 mm) through 36” (914 mm)	1-1/2” x 1-1/2” x 1/8” (40 mm x 40 mm x 3 mm)
37" (940 mm) through 48" (1220 mm)	1-1/2" x 1-1/2" x 1/4" (40 mm x 40 mm x 6.5 mm) or 2” x 2” x 1/8” (50 mm x 50 mm x 3 mm)

Duct Size	Trapeze (Half Round)
49" (1245 mm) through 60" (1524 mm)	2" x 2" x 1/4" (50 mm x 50 mm x 6.5 mm)
61" (1550 mm) through 84" (2133 mm)	2-1/2" x 2-1/2" x 1/4" (63 mm x 63 mm x 6.5 mm)

E. Refer to Section 20 0700 - Mechanical Systems Insulation for ductwork insulation, weight bearing inserts and insulation protection shield requirements.
F. Support vertical ducts at every floor.
G. The following upper attachments, upper attachment devices, lower hanger attachments, hanger devices, and/or hanger attachments are not allowed except where specifically indicated:
   1. Hook or loop
   2. Nailed pin fasteners
   3. Expansion nails without washers
   4. Powder charged or mechanically driven fasteners (forced entry anchors)
   5. Cable Support systems
   6. Beam or "C" clamps without retaining clips or friction clamps (provide retaining clips for "C" clamps)
   7. Friction clamps for ductwork over 12" (305 mm)
   8. Non-factory manufactured upper attachments for metal pan deck including wire coil and double circle (Items 16 and 17 of Fig 4-3 of SMACNA HVAC Duct Construction Standards 95)
   9. Wire hanger
   10. Trapeze hangers supported by wires or straps
   11. Rods, straps or welded studs directly attached to metal deck
   12. Drilled hole with attachment to structural steel
   13. Lag screw expansion anchor
   14. Rivets
H. Supporting devices shall be standard products of manufacturers having published load ratings.
I. Refer to Section 20 0529 - Mechanical Supporting Devices for additional support requirements including attachments to structures.
J. For welded ducts, soldered ducts or ducts with water tight joints, do not use supports utilizing screws or other penetrations into ductwork.
K. Unless Architectural Documents indicate the required framing, provide angle iron framing around roof opening where duct penetrates through roof decking, to maintain roof decking structural integrity in accordance with roof decking manufacturer's recommendations. This is not required for concrete decking. For concrete decking, consult with the project structural engineer for location and size of opening prior to execution of Work.

3.06 SHEET METAL WELDING

A. Welded ductwork shall be butt-welded unless otherwise indicated. Backing material and slip joints are not allowed.
B. Attach welding cable leads directly to base metal to be welded. Do not jumper welding cable leads through building structure, to avoid emission of stray voltage/current through building structure.
C. Welds on exposed ductwork in occupied spaces shall be brush polished with stainless steel brush.
D. Welds at exterior of building shall be ground smooth and brush polished with stainless steel brush to prevent atmospheric contamination and rust formation.

3.07 PROTECTION OF DUCTWORK

A. Protect ductwork during construction against entry of foreign matter and construction dirt.

B. Keep ductwork capped when work is complete for the day or when duct is not being worked on or added to. Use of polyvinyl (VISQUEEN) with duct tape wrap is an adequate measure as long as it is secure with no openings or tears in product.
C. If ductwork is not protected, remove dirt and foreign matter from the duct system and obtain inspection and approval from Engineer upon completion of cleaning before operating fans.

3.08 DUCT LEAKAGE TEST

A. Refer to Test and Balancing portion of Section 20 0000 - General Mechanical Requirements.
B. Owner and/or Owner's representative may elect to witness leakage tests. Notify Owner and/or Owner's representative at least 3 days in advance.
C. Leakage test procedures shall be in accordance with test method described in Section 3 of SMACNA HVAC Air Duct Leakage Test Manual, except as modified in this Section. Test apparatus shall be in accordance with Section 5 of SMACNA HVAC Air Duct Leakage Test Manual.
D. Test pressure shall be equal to duct pressure class. Negative pressure ductwork shall be tested with negative test pressure.
E. Air leakage shall not exceed limits specified. If leakage exceeds allowable limits, identify leaked areas, repair, seal and retest.
F. Provide filter system on duct inlet to test blower. Filter system shall be equal to final filtering efficiency of AHU supply air duct system. Filters are not required for negative pressure testing.
G. Do not insulate ductwork until it has been successfully tested.
H. Ductwork systems to be tested and maximum permitted leakage of ductwork systems are as indicated on schedules on drawings.
I. Welded ductwork shall be air and watertight and shall have no air leakage with allowance stated below.
    1. When using test apparatus and procedure described in SMACNA HVAC Air Duct Leakage Test Manual, 1st Edition, Chapter 5 (modified for negative pressure), the following losses can be expected during testing and are acceptable:
        a. 1 cfm (0.03 m^3/min) per 1” WG (250 Pa) of static pressure is allowed for the test equipment and test connections (e.g. 3 CFM when testing at 3” WG (750 Pa)).
        b. 0.10 (0.003 m^3/min) cfm per inch of diameter of temporary caps, regardless of pressure (e.g. 1 cfm (0.03 m^3/min) for a cap on 10” (250 mm) diameter duct).
    2. To the extent possible, walk and observe welded ductwork under test to check for cracked or hissing welds. All leaks in welded sections of ductwork shall be reported to the Client’s Representative and repaired by welding. No caulking or sealing is allowed.

3.09 LOW PRESSURE DUCT CONSTRUCTION (PRESSURE CLASS 2" WG AND UNDER)

A. Use welds, rivets or nuts, and bolts for fabricating ductwork. Fully threaded sheet metal screws may be used on duct hangers, transverse joints and other SMACNA approved locations if screw does not extend more than 1/2" (13 mm) into duct. Sheet metal "TEK" screws 3/4" (19 mm) in length may be used as fasteners in conjunction with factory made transverse joints.
B. Unless otherwise indicated, construct branch take-off fittings as follows:
    1. For branch take-offs including branch ducts serving more than one diffuser or grille, use 45 ° entry fittings. For supply air ducts, expanded or conical taps may be used.
    2. For take-offs serving single diffuser, register or grille, use straight spin-in collars with manual balancing dampers.
C. Do not use splitter dampers and/or extractors unless manual volume dampers alone do not accomplish the intended balancing. Obtain Engineer's written approval before installing them. Use of splitter dampers and/or extractors will not eliminate need for specified or indicated manual volume dampers.

3.010 HIGH PRESSURE DUCT CONSTRUCTION (PRESSURE CLASS 3" WG AND OVER)

A. Use manufactured ductwork or Contractor fabricated ductwork meeting specified Construction Standards.
B. Submit construction details including materials, type of service, reinforcing methods, and sealing procedures.
C. Use elbows, tees, laterals, crosses and accessory fittings as shown on drawings and as required to fabricate duct system.
D. Use expanded or conical tees for branch take-offs from mains.
E. Provide manufactured bellmouth fittings at each fan supply air plenum to provide smooth entrance of air into duct system.
F. Provide positive pressure relief doors as indicated on drawings.
G. Provide negative pressure relief doors as indicated on drawings.
H. Ductwork pressure class is indicated on drawings.

3.011 NON-METALLIC FLEXIBLE DUCT

A. Non-metallic flexible duct shall not be used in exhaust systems.
B. Install flexible ducts in accordance with manufacturer's installation instructions and SMACNA Standards, except as modified in this Section of Specifications.
C. In supply air systems without air terminal devices, used flexible ducts for final connections to diffusers, grilles, and registers. Flexible ducts shall be minimum 4 ft long and maximum 6 ft long.
D. In supply air systems with air terminal devices, use flexible ducts for duct connections to diffusers, grilles, and registers for sound attenuation purposes, except above non-accessible ceilings. Flexible ducts shall be minimum 4 ft long and maximum 6 ft long.
E. In return air systems without air terminal devices, flexible ducts may be used for final connections to return grille plenum boxes, grilles, and registers. Flexible ducts shall be minimum 4 ft long and maximum 6 ft long.
F. In return air systems with air terminal devices, flexible ducts shall be used for duct connections to return grille plenum boxes and registers for sound attenuation purposed, except above non-accessible ceilings. Flexible ducts shall be minimum 4 ft long and maximum 6 ft long.
G. Centerline radius of bends shall not be less than 1 1/2 duct diameters.
H. Support flexible ductwork at a maximum of 3 ft on center and at elbow, with no portion lying on ceiling supporting system.
I. Individual sections of flexible ductwork shall be of one-piece construction. Splicing of short sections is not allowed.
J. Connect flexible duct liner to collars with draw bands. If collars have beads, position draw-bands behind beads.
K. Pull insulation and vapor barrier jacket over liner connection and secure with draw band. For terminations at externally insulated ductwork, fittings, grilles, diffusers, etc., secure flexible duct jacket to ductwork insulation jacket with compatible vapor barrier tape.
L. Flexible ducts are not allowed above non-accessible ceilings.
M. Flexible ducts are not allowed in high pressure ductwork.
N. Flexible ducts are not allowed to pass through any partition, wall, floor or ceiling.

3.012 METALLIC FLEXIBLE DUCT (GENERAL EXHAUST).

A. Install metallic flexible duct as specified below.
B. Install metallic flexible ducts in accordance with manufacturer's installation instructions and SMACNA Standards, except as modified in this Section of specifications.
C. Metallic flexible ducts shall be used for final connections to general exhaust grille plenum boxes, grilles and registers except as noted otherwise. Flexible ducts shall be minimum 4 ft long and maximum 6 ft long.
D. Metallic flexible ducts for ducts used in exhaust systems require insulation if the remainder if the duct system is to be insulated.
E. Metallic flexible ducts are not allowed to pass through any partition, wall, floor or ceiling.

F. Centerline radius of bends shall not be less than 1 1/2 duct diameters.
G. Support metallic flexible ductwork at a maximum of 3 ft on center with no portion lying on ceiling supporting system.
H. Individual sections of flexible ductwork shall be of one piece construction. Splicing of short sections is not allowed.
I. Metallic flexible ducts are not allowed in high pressure ductwork.

3.013 FUME EXHAUST DUCT CONSTRUCTION

A. General:
   1. Construct elbows with centerline radius to width or diameter ratio of at least 1.5 and 45° lateral branch take-offs from mains.
B. Ductwork pressure class is indicated on drawings.
C. Stainless Steel Ducts:
   1. Use 18 ga or heavier stainless steel sheet with all joints and seams butt-welded airtight.
   2. Use longitudinal seam construction with seam at top on horizontal runs. Spiral seams are not allowed on round duct. Square and mitered elbows are not allowed.
   3. Grind and polish smooth all interior joints.

3.014 STERILIZER EXHAUST DUCT CONSTRUCTION

A. Use 18 ga (1.3 mm) or heavier stainless steel sheet with all joints and seams welded watertight. Butt-weld all joints.
B. Use longitudinal seam construction with seam at top on horizontal runs.
C. Spiral seams will not be acceptable on round duct.
D. Install ductwork without forming dips, sag or traps, which might collect liquid. Pitch horizontal branch ducts at minimum 1/4" per foot, starting at the connection to the main duct down toward exhaust grilles.

END OF SECTION

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SECTION 233314
DUCTWORK SPECIALTIES

PART 1 - GENERAL

1.01 SUMMARY

A. This section includes ductwork specialties for systems shown in Contract Documents, except where provide by equipment manufacturer.

1.02 RELATED WORK

A. Section 23 3114 - Ductwork

1.03 REFERENCE

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

1.04 SUBMITTALS

A. Shop Drawings including, but not limited to, the following:
   1. Manufacturer's name and model number
   2. Capacities
   3. Temperature/pressure ratings
   4. Materials of construction
   5. Dimensions
   6. Manufacturer's installation instructions and/or detailed drawings
   7. All other appropriate data

1.05 DESIGN CRITERIA

A. Products and materials shall conform to NFPA Section 90A, possessing flame spread rating of not over 25 and smoke developed rating no higher than 50.

B. Ductwork specialties exposed to air stream, such as dampers, turning vanes and access doors, shall be of same material as duct at where the specialties are mounted, unless otherwise noted.

C. Unless otherwise noted, ductwork specialties shall be designed and manufactured to conform to same pressure class as ductwork in which they are installed.

PART 2 - PRODUCTS

2.01 MANUAL BALANCING DAMPERS

A. Manufacturers: Ruskin, Vent Products or Air Balance, constructed in accordance with SMACNA HVAC Duct Construction Standards, except as modified below.

B. Rectangular Dampers:
   1. For low pressure ductwork, for damper blade height up to 12” (300 mm), use single blade type with minimum 22 ga (0.8 mm) galvanized steel blade with minimum 3/8” (9.5 mm) rod for blade width up to 18” (460 mm), and with minimum 18 ga (1.3 mm) galvanized steel blade with minimum 1/2” (13 mm) continuous rod for blade width from 19” (480 mm) to 48” (1220 mm). For damper blade height more than 12” (300 mm), use multiple blade type with minimum 16 ga (1.6 mm) galvanized steel channel frames, opposed blade linkage operation, with blades minimum 16 ga (1.6 mm) and 6” (150 mm) to 8” (200 mm) maximum blade width, minimum 1/2” (13 mm) continuous rod and 1/2” x 1/2” (13 mm x 13 mm) galvanized steel angle blade stops. Bearings shall be nylon or molded synthetic. Construct dampers over 48” (1220 mm) in width or height in multiple sections with mullions.
   2. For high pressure ductwork, dampers shall be constructed to withstand maximum pressure of 5 inches WG (1250 Pa) at closed position and maximum velocity of 2000 fpm (610 m/min) at open position. Frame and blades shall be constructed of minimum 16 ga (1.6 mm) with minimum ½” (13 mm) diameter or square rod.

C. Single Blade Round Damper

1. For low pressure ductwork, damper shall have blade 24 ga (0.6 mm), but no less than two gauges more than duct gauge. Rod shall be minimum 3/8" (9.5 mm) diameter or square continuous. Bearings shall be nylon or molded synthetic.
2. For high pressure ductwork, damper blade shall be minimum 16 ga (1.6 mm). Rod shall be minimum ½" (13 mm) square continuous and tack welded to blade. Provide sealed end bearing similar to Ventlok #609 and acorn nut type dial regulator similar to Ventlok #635 or 641.

D. Provide damper operators with locking devices and damper position indicators. Sheet metal screws are not allowed in construction or installation of dampers. Use rivets or tack welds.
E. Dampers shall be properly stiffened and fabricated to prevent vibration, flutter or other noise.
F. Extend damper shafts through duct insulation or use elevated regulators for externally insulated ducts to accommodate specified insulation thickness.

2.02 TURNING VANES

A. Construct turning vanes in accordance with SMACNA HVAC Duct Construction Standards.
B. Square Throat Elbow Turning Vanes (Vane Runner Length up to 18" (460 mm) and Vane Length up to 36" (914 mm)):
   1. Use single thickness vanes having 2" (50 mm) radius and 1-1/2" (40 mm) spacing, 24 ga (0.6 mm) minimum. Construct vanes in accordance with SMACNA HVAC Duct Construction Standards.
C. Square Throat Elbow Turning Vanes (Vane Runner Length over 18" (460 mm) or Vane Length over 36" (914 mm)):
   1. Use double thickness vanes having 4.5" (114 mm) radius and 3.25" (82.55 mm) spacing, 22 ga (0.8 mm) minimum.
D. Radius Elbow Splitter Vanes:
   1. Splitter vanes for radius elbows shall be extended entire length of fitting and constructed in accordance with SMACNA HVAC Duct Construction Standards.

2.03 BACKDRAFT DAMPERS

A. Manufacturers: Ruskin, Greenheck
B. Dampers shall be multi-blade, weighted type with counter-balanced blades and with 12 ga galvanized steel frame and extruded aluminum airfoil-shaped blades equal to Ruskin Type CBS 92. Blade edges shall have silicon rubber seals with ball bearings. Dampers shall be suitable for flange and gasket connection to ductwork or fan outlet.
C. Dampers shall be rated to maximum velocity of 4000 fpm (1220 m/min), maximum temperature of 250°F (120°C) and maximum system pressure of 5" WG (1250 Pa) for damper width of 60" (1524 mm) and 14" WG (3500 Pa) for damper width of 12" (605 mm).
D. Maximum damper leakage shall be 13.5 cfm/sf based on pressure differential of 1" WG (250 Pa).

2.04 FIRE DAMPERS

A. Manufacturers: Air Balance, Prefco, Greenheck, Nailor, Cesco, Pottorff Louvers and Dampers, or Ruskin
B. Fire damper assemblies shall be listed by UL with 165°F (74°C) fusible link and shall meet construction standards as set forth in NFPA 90A.
C. Dampers shall be dynamic type dampers rated to minimum 2000 fpm (610 m/min) and 4" WG (1000 Pa).
D. Dampers shall be curtain type with blades out of air stream when in open position. Where curtain type dampers are not available because of size, use multiple blade type dampers.
E. For round ducts, dampers equal to Ruskin Model FDR25 may be used.
F. Damper fire rating shall be compatible with rating of building surface in which damper is used.
G. Submit UL installation details to showing mounting method and duct connection method.

H. Where ceiling fire dampers are used, they are to be equal to Ruskin CFD(R) 2 or 3, UL Classified for installation in fire rated floor or roof/ceiling assemblies.

2.05 ACCESS DOORS

A. Access doors shall be rectangular, minimum 22 ga (0.8 mm) frame and minimum 24 ga (0.6 mm) door, fit air tight with gasket and shall be suitable for duct pressure class. Doors shall be double-wall, insulated when installed in insulated ductwork or unit casing and located for greatest ease of access. Access doors constructed with sheet metal screw fasteners are not acceptable.

B. Low Pressure Ducts (Pressure Class 2" (50 mm) and Under):
   1. Doors shall be hinged type with sash lock for exposed application and non-hinged type with cam latches for concealed application.
   2. Access doors constructed in accordance with SMACNA HVAC Duct Construction Standard (Figure 7-2) or similar to Ruskin Model ADC or ADH will be acceptable.
   3. Sandwich style access doors made by Ductmate, Ward Industries, or Flexmaster are acceptable, provided that they meet insulation requirements and include edge protection.

C. High Pressure Ducts (Pressure Class 3" (75 mm) and Over):
   1. Use access doors factory fabricated and rated by manufacturer's published literature for installation in systems with pressures to positive or negative 10" WG (2500 Pa).
   2. Sandwich access doors made by Ductmate, Ward Industries, or Flexmaster are acceptable, provided that they meet insulation requirements and include edge protection.

2.06 DUCT FLEXIBLE CONNECTIONS

A. Manufacturers: Unless specifically indicated, Ventfabrics, Inc. or Duro Dyne, equal to Duro Dyne model indicated. Material shall be glass fabric, fire retardant, waterproof, air tight and comply with UL Standard 214 and NFPA 90A.

B. General Supply, Return and Exhaust Ductwork:
   1. Material for indoor use to be 30 oz per square yard, double coated with neoprene, suitable for -40 to 200°F (-40 to 93°C) continuous operation similar to Duro Dyne Neoprene.
   2. Material for outdoor use shall be combination of inner layer of Duro Dyne Neoprene and outer layer of 24 oz per yard, coated with Hypalon, UV resistant, suitable for -40°F up to 250°F (-40 to 120°C), similar to Duro Dyne Durolon.

C. Special Exhaust Ductwork:
   1. Material for indoor use shall be 17 oz per yard, teflon or silicon coated, suitable for -65 to 500°F (-54 to 260°C), similar to Duro Dyne Thermafab.
   2. Material for outdoor use shall be combination of inner layer of Thermafab and outer layer of Durolon.

2.07 SOUND ATTENUATING DEVICES

A. Manufacturers: Industrial Acoustics Company, Semco, Aerosonics, United McGill, Aeroacoustic, Vibro-Acoustics, Ruskin Sound, or Dynasonics

B. Units shall be tested in accordance with ASTM E-477-99 silencer test standard in aero-acoustic test facility which is NVLAP accredited for ASTM E-477-99 Standard. Each test shall have been conducted within last 12 month period. Submit copy of laboratory's NVLAP accreditation certificate on dynamic insertion loss, self-noise power levels, and aerodynamic performance.

C. Outer casing of units shall be not less than 22 ga (0.8 mm) G90 galvanized steel in accordance with recommendations in the latest edition of ASHRAE Guide and Data Book for high pressure rectangular ductwork for 8" WG (2 kPa) or pressure class indicated for duct system, if it is higher than 8" WG (2 kPa). Seams shall be lock formed or continuously welded and mastic filled.

D. Acoustic Materials:
   1. Media shall be long fiber fiberglass protected with covering material and lined with not less than 26 ga (0.5 mm) galvanized perforated steel. Filler and facing material shall meet

requirements of NFPA 90A with flame spread rating of 25 or less, and smoke development rating of 50 or less.

E. Covering Materials:
   1. Covering material shall be Tedlar or Mylar film.
F. Ends of attenuators shall be covered at factory with plastic, heavy-duty paper, cardboard, or other appropriate material to prevent entrance of dirt, water, or any other foreign matter to inside of attenuators. Caps shall not be removed until attenuator is installed in duct system.
G. Unless otherwise indicated, sound attenuating devices shall meet acoustical performance requirements as scheduled in each octave band frequency under the flow conditions.
H. Sound Attenuating Devices for Fume Hood Exhaust Fans:
   1. Similar to IAC Model KM.
   2. Provide units at exhaust fan intakes and discharges as scheduled. Unit length shall be as scheduled.
   3. Rectangular type constructed entirely of Type 304 stainless steel, in accordance with recommendations in the latest edition of ASHRAE Guide and Data Book for high pressure rectangular ductwork. Seams shall be welded. Units shall contain no sound absorptive material. Attenuation shall be accomplished by, controlled impedance membranes and broadly tuned resonators. Units shall not fail structurally when subjected to differential air pressure of 8" WG (2 kPa) inside to outside of casing.

2.08 REMOTE OPERATED VOLUME CONTROL DAMPERS

A. Young Regulator Co. or Metropolitan Air Technology similar to Young Regulator Model 830 dampers, furnished with Bowden 270-275 remote cable controls.

2.09 INSTRUMENT TEST HOLES

A. Manufacturers: Ventlok 699 (up to 1" (25 mm) insulation thickness) or Ventlok 699-2 (over 1" (25 mm) insulation thickness).
B. Use concave gaskets for round ductwork.

2.010 CONTROL DAMPERS

A. Refer to Section 25 3523.

PART 3 - EXECUTION

3.01 MANUAL BALANCING DAMPERS

A. Install manual balancing dampers in all branch ducts of supply, return and exhaust ductwork, as indicated on drawings and as required to regulate airflow to meet air balance requirements.
B. Install manual balancing damper in branch duct to each diffuser and grille. Install dampers as close as possible to take-offs.
C. Install balancing dampers so as not to flutter or vibrate and as far as possible upstream from the air outlet.
D. Balancing dampers are not required for supply ductwork upstream of air terminal devices.
E. Balancing damper is not required where terminal air device serves a single diffuser or grille.
F. Do not install manual balancing dampers in the following exhaust ductwork:
   1. Fume hood exhaust ductwork.

3.02 TURNING VANES

A. Install turning vanes as shown on drawings and for rectangular square throat elbows unless otherwise indicated. Install turning vanes in accordance with SMACNA Standards and/or manufacturer's recommendations.
B. Turning vanes are not required in transfer air ducts.
C. Install turning vanes so that they are tangent to airflow direction.

3.03 BACKDRAFT DAMPERS

A. Install backdraft dampers where indicated on drawings.

B. Where motorized dampers are shown in exhaust fan discharge duct, or in duct connecting to relief or exhaust louver, backdraft dampers are not required unless specifically indicated. Where motorized dampers are not shown, provide backdraft dampers in these locations.

3.04 FIRE DAMPERS

A. Install dampers where shown on drawings in accordance with manufacturer's installation instructions and requirements of NFPA 90A. Install dampers complete with mounting collars, retaining angles, connections to adjoining ductwork and duct access doors. Install duct access door at each damper with door size large enough to permit replacement of fusible links and resetting of dampers.

B. Test and demonstrate proper operation of each damper after system is installed and ready for operation.
   1. Manually test each damper for proper operation by removing fusible link or actuating EFL or PFL. Repair or replace any damper that does not close completely. Replace fusible link and certify in writing that each damper was installed according to manufacturer's installation instructions and that each damper can be expected to close completely when fusible link melts.
   2. Notify Owner and/or Owner’s representative at least 48 hrs prior to testing to allow for witnessing.

C. Contractor shall provide letter from manufacturer's representative indicating that dampers are installed per manufacturer's installation instructions.

3.05 ACCESS DOORS

A. Install access doors as specified, as indicated on drawings, and anywhere that provision for maintenance, service, cleaning or examination is required, including each air flow meter, automatic damper, fire damper, smoke damper, smoke detector, fan bearing, heating and cooling coil, reheat coils, humidifier, filter, bird/insect screen, valve and control device within duct or casing, at outside air intake duct and at inlet side of turning vanes in return ductwork.

B. Size and quantity of duct access doors shall be sufficient to perform intended service, but not less than the following:

Rectangular Duct Size	Minimum Access Door Quantity and Size
15" (380 mm) and smaller	(1) 16" (400 mm) x 12" (300mm)
16” (400 mm) – 21” (530 mm)	(1) 18” (460 mm) x 14” (355 mm) (1) 18" (460 mm) x 18" (460 mm)
22" (560 mm) - 27" (690 mm)	(1) 24” (600 mm) x 24” (600 mm)
28” (710 mm) – 47” (1190 mm)	
48" (1220 mm) - 96" (1240 mm)	(2) 24" (600 mm) x 24" (600 mm)

Round Duct Size	Minimum Access Door Size
10" (250 mm) and smaller	8" (200 mm) x 12" (100 mm)
15" (380 mm) and smaller	12" (300 mm) x 12" (200 mm)
29" (730 mm) and smaller	16" (400 mm) x 12" (300 mm)
30" (760 mm) and over	24" (600 mm) x 18" (460 mm)

C. Increase duct size to accommodate access door size indicated above where required.

3.06 FLASHINGS

A. Install counterflashings where shown on drawings. Install in accordance with SMACNA recommendations.

3.07 DUCT FLEXIBLE CONNECTIONS

A. Install duct flexible connections between ductwork and fans or equipment casing containing fans not internally isolated. Installed width shall be suitable for specific application but shall not be less than 4" (100 mm). Install flexible connections in accordance with SMACNA Standards with double lock or "Grip Loc" connection.

B. Provide inlet fabric duct vibration isolation section a minimum of 12” upstream of the fan inlet. The vibration inlet section is not to be used for duct misalignment and must be installed in a straight duct section. The fabric isolator is to be mounted on the exterior of the duct and may not restrict the air flow within the duct and may not enter the duct OD by more that ¼”.

C. Duct flexible connections are not allowed for fan connection serving kitchen hood, dishwasher, or perchloric acid hood.

3.08 SOUND ATTENUATING DEVICES

A. Install sound attenuating devices as indicated on drawings and/or as scheduled.

B. For modular installation of sound attenuators, install galvanized steel holding frame, gaskets, seals, supports and fasteners in accordance with manufacturer's recommendations for multiple unit installation.

3.09 REMOTE OPERATED VOLUME CONTROL DAMPERS

A. Install remote operated volume control dampers and remote operators for all manual balancing dampers located above hard ceilings. Locate remote cable control near diffuser served by respective damper.

3.010 CONTROL DAMPERS

A. Install dampers in locations indicated on drawings, as detailed and according to manufacturer's instructions.

B. Install blank-off plates or transitions as specified in Control Sections.

C. Provide adequate operating clearance and access to operators.

3.011 SMOKE DETECTORS

A. Smoke detectors will be provided by Electrical Contractor in locations indicated on drawings. Install access door in ductwork for access to detector sampling device.

3.012 INSTRUMENT TEST HOLES

A. Provide instrument test holes at air entering and air leaving side of all internal air handling system components for static pressure differential (Delta P) or temperature differential (Delta T) measurements.

B. Provide ductwork instrument test holes as shown on drawings, or as directed by TAB personnel, or Engineer.

END OF SECTION

SECTION 233400
FANS

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 20 0513 - Motors
B. Section 20 0514 - Variable Frequency Drive (VFD) System
C. Section 23 0550 - Vibration Isolation
D. Section 26 2816 - Enclosed Switches and Circuit Breakers

1.02 REFERENCE

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

1.03 SUBMITTALS

A. Shop Drawings including, but not limited to, the following:
   1. Manufacturer's name and model number
   2. Identification as referenced in the documents
   3. Capacities/ratings
   4. Fan curves
   5. Materials of construction
   6. Sound power levels
   7. Fan type, size, class, drive arrangement, discharge/rotation, bearings, drives
   8. Wheel type, diameter, rpm, tip speed
   9. Required fan horsepower including drive losses
   10. Motor data (refer to Section 20 0513 - Motors)
   11. Vibration isolators furnished with fans
   12. Dimensions and weights
   13. Special coatings where applicable
   14. Color selection charts where applicable
   15. Manufacturer's installation instructions
   16. All other appropriate data
B. Fan curves shall include series of curves indicating relationship of flow rate (cfm) to static or total pressure for various fan speeds, brake horsepower curves, and selection range (surge curves, maximum rpm, etc).
C. Indicate performance data, based on both design air quantity and 110% of design air quantity.
D. For variable air volume application, indicate operating points at 100, 80, 60 and 40% of design capacity on fan curves including data to indicate effect of variable frequency drives on flow, pressure and horsepower.

1.04 DESIGN CRITERIA

A. Fan ratings shall be tested and certified in accordance with AMCA Standards 211 and 311 and fans shall bear AMCA Seal.
B. Fans shall be furnished complete with motors, wheels, drive assemblies, bearings and accessories as hereinafter specified. Motors for V-belt drives shall be furnished with adjustable rails or bases.
C. Each fan wheel shall be statically and dynamically balanced to grade G6.3 per ANSI S2.19. Complete fan assembly shall be factory balanced statically and dynamically in accordance with Standard AMCA 204-96 for Balance Quality and Vibration Levels for Fans and meet or exceed guidelines in Application Category BV-3.
D. For fans furnished with 5 hp or larger hp motors, each fan assembly shall have factory run test including vibration signatures taken on each bearing in horizontal, vertical and axial direction. Filter-in reading as measured at fan, scheduled rpm shall not exceed the following values when fan is rigidly mounted.

1. Belt Drive (except Vane Axial) 0.15 in/sec peak velocity
2. Direct Drive0.08 in/sec peak velocity
3. Written records of run test and vibration test shall be available upon request.

E. System air balancing shall be accomplished by either trial of different fixed-pitch sheaves or use of temporary adjustable-pitch sheaves. Variable-pitch sheaves shall be replaced with fixed pitch when balancing is complete. Sheaves shall be constructed of cast iron or steel, bored to fit properly on the shafts, and secured with keyways of proper size (no setscrews) except that for sheaves having 13 mm (1/2 in.) or smaller, bores setscrews may be used. This Contractor shall provide necessary trial and final sheaves and drive belts as required by TAB Contractor.

F. Select each fan to operate at single stable operating point as predicted by fan curve. Fans having 2 potential operating points on fan curves are not acceptable.

G. Unless otherwise indicated, V-belt drives shall be selected for a minimum 150% of motor nameplate horsepower.

H. Provide OSHA Compliant belt and shaft guards for belt driven fans. Provide speed test openings at shaft locations. Paint guards bright yellow.

I. Sound power levels shall be based on tests performed in accordance with AMCA Standards 300 and 301.

J. Each fan and motor combination shall be capable of delivering 110% of air quantity scheduled at scheduled static pressure. Motor furnished with fan shall not operate into motor service factor in any of these cases.

K. Consider drive efficiency in motor selection according to manufacturer's published recommendation, or according to AMCA Publication 203, Appendix L.

L. Where inlet and outlet ductwork at any fan is changed from that shown on drawings, submit scaled layout of change and system effect factor calculations indicating increased static pressure requirements as described in AMCA Publication 201. This Contractor shall be responsible for costs associated with any motor, drive, and/or wiring changes required as a result of duct configuration changes at fan.

M. Provide a non-fused disconnect switch for each fan in a NEMA rated enclosure that is acceptable for the fan location application.

PART 2 - PRODUCTS

2.01 HIGH PLUME INDUCED DILUTION EXHAUST FANS (LAB EXHAUST FANS)

A. Manufacturers: Greenheck, MK Plastics, or Twin City.

B. Submittals:

1. Provide dimensional drawings and product data on each high-plume dilution laboratory exhaust fan assembly.
2. Provide fan curves for each fan at the specified operation point, with the flow, static pressure and horsepower clearly plotted.
3. Provide nozzle velocity of exhaust fan, total exhaust flow, and discharge plume height at specified wind velocity.
4. Provide a wind load analysis of the equipment for the location in which the equipment is to be installed to meet all applicable required design requirements. Provide design information for wind restraints where necessary to meet local wind load code requirements. Provide all necessary wind restraints connections to equipment where needed.
5. Provide exhaust stack extensions as shown on drawings.
6. Include all internal pressure losses for the system in the submittal documents including plenum, isolation damper, bypass air plenum, energy recovery assembly, fan inlet and fan outlet, stack and nozzle induced air losses in the total loss calculation. The submitted system must be shown capable of providing the external scheduled pressure and CFM flow rate.

7. Include the opening and closing torque ratings at operating pressures for the isolation and bypass dampers in the submittal documents. The dampers and actuators must be sized to operate and seal at the design system pressures.

C. General
   1. Fans must be tested in accordance with AMCA 210, 260 and 300 in an AMCA accredited laboratory and the high plume exhaust fan shall be licensed to bear the AMCA seal for Certified Sound and Air Performance. Acceptable manufacturers whose equipment is not licensed to bear the AMCA seal for Certified Sound and Air Performance must submit air and sound performance tests conducted by an independent third party and stamped by a registered professional engineer.
   2. Base fan performance at standard conditions (density 0.075 Lb/ft3).
   3. Fans selected shall be capable of accommodating static pressure and flow variations of +/- 15% of scheduled values.
   4. Each fan shall be belt driven, AMCA arrangement 1, 9 or 10, or direct drive, AMCA arrangement 2, 4 or 8.
   5. Fans to be equipped with lifting lugs.
   6. Fan stand to be coated steel with a minimum of 4 mils of Hi-Pro polyester resin or Plastifer epoxy #ES90-AS81.
   7. All fasteners to be 316 stainless steel.
   8. All exhaust fan and equipment (plenum, flow, and stack) shall be painted a color to be selected and approved by the architect.
   9. Height of the fume exhaust stacks and centerline distance of the system stacks shall be equal between systems and be coordinated with the design of the building roof. The height and location of the stacks must be reviewed and approved by the architect.

D. Housings and Outlet:
   1. Fan housing shall be manufactured of coated steel with a minimum of 4-6 mils of Hi-Pro polyester resin or Plastifer epoxy #ES90-ASB1. No uncoated metal fan parts will be allowed.
   2. A bifurcated fiberglass reinforced plastic (FRP) or coated steel discharge nozzle shall be supplied by the fan manufacturer and be designed to efficiently handle an outlet velocity of up to 7,200 FPM. The discharge shall include a venturi and wind band to induce ambient air up to 270% of fan capacity. Wind band shall have double wall, insulated construction for sound attenuation. Provide guy wire attachment points on wind band for attachment to building structure.
   3. Provide the manufacturer’s inline silencer as part of the stack and windband assembly. Silencer shall be a minimum of three feet long and shall have double wall construction.
   4. Provide housing drain with threaded connection, attached at the lowest point of the housing for water removal.
   5. Provide access door for impeller inspection and service. Coordinate access door location for installed fan access.
   6. All exhaust fans equipment (plenum, fan, and stack) shall be painted a color to be selected and approved by the architect.

E. Wheels
   1. Fan impeller for centrifugal fan shall use a backward curve blade design wheel with non-stall characteristics and non-overloading performance.
   2. Fan wheel shall be manufactured of steel and coated with a minimum of 4 mils of Hi-Pro polyester resin or Plastifer epoxy #E390-AS81.

F. Vibration Isolation:
   1. Provide individual fan base and plenum vibration isolation designed for unprotected rooftop installation.

G. Fan Inlet Plenum

1. Provide bypass air plenums as shown on drawings. The plenum shall be constructed of galvanealed steel, and coated with 4-6 mil epoxy coating as above, and mounted on the manufacturer's roof curb. Plenum shall have double wall, insulated construction with stainless steel interior liner. The top of the plenum will be sloped for 100% drainage.
2. The plenum shall be equipped with a minimum of two bypass air dampers and weatherhoods for introducing outside air at roof level upstream of the fan. Weatherhoods shall be designed to prevent the entrance of water into inlet plenum based on the highest anticipated air velocity encountered in the bypass air plenum.
3. Inlet plenum shall be provided with an enclosed bottom to separate the interior of the plenum from the building structure and roof system. Where ductwork is shown to enter the bottom of the bypass air plenum, manufacturer shall provide opening and coordinate opening sizes and locations with contractor. Bottom connection shall prevent any accumulated water within the plenum from draining into the duct when the fan is turned off.
4. Provide housing drain with threaded connection, attached at the lowest point of the housing for water removal.
5. Provide sufficient plenum access doors to allow personnel maintenance access and for the visual inspection of all isolation dampers, bypass dampers and fan inlets. The plenum access doors shall be located so that the damper and entire fan inlet and isolation damper may be viewed without having to enter the plenum.
6. Isolation and bypass dampers should be removable and serviceable from the exterior of the plenum. Plenum and damper frames shall be designed to not trap and hold water on debris.
7. The plenum and dampers will be constructed to prevent any water from accumulating on the top of the any section of the plenum or the damper frames. Drilling of weep or drain holes will not be acceptable.

H. Fan Motors and Drives
1. Motors to be premium efficiency, inverter duty, TEFC, with a 1.15 service factor. A factory mounted NEMA 3R disconnect switch shall be provided for each fan. Motor maintenance shall be accomplished without fan wheel removal or requiring maintenance personnel to access the contaminated exhaust components.
2. Drive belt and sheaves shall be sized for 200% of the fan operating brake horsepower, and shall be readily and easily accessible for service, if required.
3. Shaft to be ANSI C-1045 steel and be protected with TECTYL 822B protective coating.
4. Fan shaft bearing to be selected according to bearing manufacturers recommendations and be sized for an L-10 life of 200,000 hours. Bearing shall be ball or spherical pillow block type, sealed to retain lubricant and exclude duct and air.

I. Control Dampers
1. Fume Exhaust Fan Shut-off Dampers:
   a. Electrically operated, 304 stainless steel construction, flanged connection, grease lubricated ball bearings, continuous shaft with seal, suitable for maximum temperature 250°F, approach velocity 6000 fpm, and differential pressure of 13" WG.
   b. Air foil blade design, 16 gauge minimum.
   c. Furnish dampers with neoprene blade seals.
   d. Furnish dampers with fail open electric actuator.
   e. Damper to be sized to not restrict fan inlet.
   f. Damper selection criteria and performance to be included with submittal. The manufacturer shall also provide with the submittal, the operation torque rating required to open, close and seal the dampers at operating condition.
   g. The manufacturer shall provide isolation dampers that close and seal sufficiently to prevent reverse air flow through idle fans and fan back wheeling.
2. Exhaust System Outside Air Bypass Dampers:

a. Electrically operated, opposed blade design, 304 stainless steel construction, flanged connection, grease lubricated ball bearings, continuous shaft with seal, suitable for maximum temperature 250°F, approach velocity 6000 fpm, and differential pressure of 13" WG.
b. Air foil blade design, 16 gauge minimum and 12" maximum width.
c. Furnish with flexible jamb seals, EPDM, silicone or neoprene blade seals.
d. Damper selection criteria and performance to be included with submittal. Damper to be low-leakage Class 1 design to allow a maximum of 4 CFM per Ft2 of damper at 1” SP WG.
e. Dampers shall be sized to provide system static pressure control across the entire range of static pressures and exhaust system flow rates. Each individual bypass damper, in the full open position, shall provide a significant fraction of the system pressure in order to be sized properly and provide system control. The size and quantity of outside air bypass dampers shall be designed to allow for bypass air flow equal to the total flow of one individual exhaust fan at a velocity of 2,000 fpm across all dampers in the full-open position.

J. Roof Curb or structural steel support frame:
1. Provide manufacturer's insulated, weight-supporting curb or galvanized structural steel support frame. Insulation shall be minimum one inch thick and shall have a minimum density of six pounds per cubic foot.
2. Curb or frame shall be a single platform that supports inlet plenum and all fans with their associated motors.
3. Furnish common mounting rails for fan and motor as appropriate for fan arrangement indicated.
4. Structural steel frame shall be designed and constructed to allow roofing installation and maintenance around and under the frame.
5. Curb cap shall be 316 stainless steel for corrosion resistance.
6. Curb shall be a minimum of 24” tall.

2.02 POWER ROOF EXHAUSTERS

A. Manufacturers: Twin City, Greenheck, PennBarry, Jenn-Air, Cook, ACME or Carnes
B. Construct housings of spun aluminum.
C. Exhauster wheels shall be centrifugal, solid (single-thickness) backward inclined (BI), non-overloading type with full inlet cones to reduce air turbulence.
D. Provide units with single phase motors with factory mounted and wired NEMA standard disconnect switches.
E. Units shall be listed and bear UL 705 Label.
F. Mount units on factory installed vibration isolators.
G. Furnish units with bird screens.
H. Provide gravity backdraft dampers for fans when control dampers or motorized dampers are not scheduled or specified.
I. Units shall be furnished with factory fabricated curb and extended base, as required for mounting minimum of12” above roof.
J. Curbs shall be constructed of galvanized steel or extruded aluminum with continuous welded corner seams, treated wood nailer, minimum 1-1/2” thick, 3 lb density, rigid mineral fiberboard insulation with metal liner.

2.03 IN LINE DUCT FANS

A. Manufacturers: Twin City, Greenheck, PennBarry, ACME.
B. Fan housing shall be designed for installation in straight run of duct with transitions as indicated. Housing shall be designed for complete access to fan and motor without removing fan assembly from ductwork.

C. Wheels shall have backward inclined blades. Motor or drive compartment shall be isolated from airstream and be externally ventilated. Bearings shall be prelubricated and sealed and designed for minimum life of 40,000 h operation (ABMA L-10).
D. Paint fan parts with prime coat after metal cleaning and surface preparation. In addition, apply second coat of paint to exterior surfaces.
E. Fan to be provided with a factory wired, non-fused disconnect switch in a NEMA 1 enclosure.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install units as shown on drawings, and according to manufacturer's installation instructions. On units provided with drain connection, install drain valve and hard copper pipe per details.
B. Verify lubrication of motor and fan bearings and lubricate properly in accordance with manufacturer’s recommendation and Section 20 0000, Part 3 under LUBRICATION.
C. Perform field mechanical balancing, if necessary, to meet vibration tolerance specified in Section 23 0550 - Vibration Isolation.
D. Fume exhaust fan to be installed per the installation details. Coordinate the installation of the fan with mechanical and architectural details.
E. Where shown, provide inlet fabric duct vibration isolation section a minimum of 12” upstream of the fan inlet. The vibration inlet section is not to be used for duct misalignment and must be installed in a straight duct section. The fabric isolator is to be mounted on the exterior of the duct and may not restrict the air flow within the duct and may not enter the duct OD by more that ¼”.
F. Fume exhaust system manufacturer shall coordinate the duct size and location entering the plenum bottom with the mechanical contractor, with this information to be clearly shown in the fan system submittal. The fan manufacturer is to approve the duct inlet design.

END OF SECTION

SECTION 233600
AIR TERMINAL DEVICES

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 23 0901A - Control Systems Integration
B. Section 23 3114 - Ductwork (Support)
C. Section 23 3314 - Ductwork Specialties (Access Doors)
D. Section 23 8214 - Heating and Cooling Terminal Devices

1.02 SUBMITTALS

A. Shop Drawings including, but not limited to, the following:
   1. Manufacturer's name and model number
   2. Identification as referenced in the documents
   3. Capacities/ratings
   4. Materials of construction
   5. Sound rating data
   6. Dimensions
   7. All other appropriate data
B. LEED Submittal:
   1. Product Data for IEQ Prerequisite 1: Documentation indicating that units comply with ASHRAE 62.1 – 2010, Section 5 – “Systems and Equipment.”

1.03 QUALITY ASSURANCE

A. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70 by qualified testing agency and marked for intended location and application.
B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1 – 2010, Section 5 – “Systems and Equipment” and Section 7 – “Construction and System Start-Up.”

1.04 DESIGN CRITERIA

A. Where any of air terminal devices are indicated on drawings to control space conditions in conjunction with reheat coil, that reheat coil may be furnished as integral part of or standard accessory to devices specified below. See related work above.
B. When air terminal devices are furnished with reheat coils, either integrally or remotely mounted, control panels of terminal devices shall be mounted on the same side of air terminal device as reheat coil piping connection.
C. Unless otherwise stated, units shall be system pressure independent and maintain air volume within ± 5% of required airflow regardless of system air pressure. Inlet velocity pressure sensor shall be multi-point center averaging type and be capable of amplifying pressure signals.
D. Unless otherwise stated, unit casings shall be constructed of galvanized steel or aluminum meeting SMACNA or ASHRAE Standards, but not lighter than 0.861 mm(22 ga).
E. Joints and seams of air terminal devices shall be sealed with appropriate sealant to minimize casing air leakage.
F. Unit leakage test shall comply with ASHRAE Standard 130 – Laboratory Methods of Testing Air Terminal Units.
G. Unit performance shall be certified in accordance with AHRI Standard 880 including sound rating data certified for both casing discharge and radiated sound levels from 125 through 4000 Hz.
H. Supply air units shall be capable of operating from minimum inlet static pressure scheduled to 750 Pa(3” WG).
I. Air valve leakage shall not exceed 1% of maximum inlet rated airflow at 750 Pa(3” WG) inlet pressure.
J. Casing leakage rates shall not exceed the following maximum values:

Unit Size	Max. Casing Leakage (cfm)	
	0.5" Ps(0.5" WG)	1.0" Ps(1.0" WG)
4, 5, 6	2	3
7, 8	2	3
9, 10	2	3
12	2	3
14	2	3
16	3	4

L. Provide supply air units with internal thermal insulation faced with minimum 0.0254 mm(0.001") thick aluminum foil. Insulation shall be compressed glass fiber with minimum 19 mm(3/4") thick, 64 kg/m^3(4 lb/ft^3) density with R-value of 0.62 [W/(m^2·°C)](3.5[(h·ft^2·°F)/Btu]). Insulation and facing shall meet requirements of UL 181 (Air Erosion, Mold growth and Humidity), and NFPA 90A (Flame 25/Smoke 50) and ASTM C665 (Fungi Resistance). Secure liner with full-seam-length, galvanized steel angles or Z-strips, which enclose and seal all edges. Tape or adhesive will not be acceptable. Liner assembly shall be similar to Titus Steri-Loc.

M. Supply air units shall be lined with engineered polymer foam insulation, minimum 19 mm(3/4") thick, 24 kg/m^3(1.5 lb/ft^3) density and thermal conductivity not more than 0.036 [W/(m^2·°C)] at 24°C(0.25[(h·ft^2·°F)/Btu] at 75°F). Insulation shall meet requirements of UL 181 (Air Erosion, Mold Growth and Humidity), NFPA 90A (Flame 25/Smoke 50) and ASTM C665 (Fungi Resistance).

N. Sound attenuators, where specified or required to meet sound performance specified for air terminal devices, shall be constructed of all metal or sound attenuating fiber material with erosion protection liner as required to meet sound requirement specified. Refer to Section 23 3314 - Ductwork Specialties for sound attenuators and erosion protection.

O. Unit manufacturer or manufacturer's designated representative will be required to verify air terminal device performance and adjust or replace device within warranty period when it is determined that problem exists in area served by device.

P. Air consumption of each pneumatic control assembly shall not exceed 9.6 mL/s(35 scim (1.2 scfh)).

Q. Room sound levels due to discharge and/or casing radiation from units when operating from minimum pressure scheduled to 500 Pa(2" WG) inlet static pressure shall not exceed noise criteria (NC) values in any spaces as indicated below. If units exceed sound level specified, provide terminal sound attenuators to comply with the noise criteria stated below. Refer to Section 23 3314 - Ductwork Specialties for sound attenuating devices.

Type of Room	Noise Criteria (NC)
All spaces unless otherwise indicated	35
Computer Rooms	40
Laboratories and Support Spaces	50
Patient Rooms	30
Libraries and Conference Rooms	30

1.05 CONTROLS COORDINATION

A. Unit manufacturer shall provide unit inlet flow sensor, pneumatic tubing and control enclosure for Control Contractor's use.

B. Control Contractor shall furnish all actuators, linkages if required, differential pressure transmitters, controllers and any other devices required for unit control that are not provided by

unit manufacturer for unit manufacturer's factory mounting. Unit manufacturer and Control Contractor shall coordinate for proper factory installation.

C. Unit manufacturer shall factory install devices furnished by Control Contractor to result in complete functioning unit. Unit manufacturer shall be responsible for reviewing compatibility of devices furnished by Control Contractor with units being provided.
D. Unit manufacturer shall perform preliminary calibration based on scheduled airflow rates.
E. Control Contractor shall be responsible for calibrating actuators and controllers through TAB work for scheduled airflow rates.
F. Control Contractor's field mounting will be acceptable, provided Control Contractor coordinates proper installation with unit manufacturer. Control Contractor shall be responsible for complete functioning unit.

PART 2 - PRODUCTS

2.01 VARIABLE VOLUME AIR TERMINAL DEVICES (RTU-1 AND RTU-2 OFFICES)

A. Manufacturers: Titus, Price, Krueger, Enviro-Tec (ETI), Nailor, Carnes, Tuttle and Bailey, Metalaire, Trane, JCI or Carrier.
B. Units shall be suitable for 24 V electric control system. Control Contractor shall be responsible for wiring from control panels to each terminal unit.
C. Furnish units with reheat coils having capacities as indicated in schedules.
D. Provide access doors for all air terminal devices with reheat coils at inlet side of coils. Refer to Section 23 3314 - Ductwork Specialties for access doors. Unit manufacturer's standard access doors are acceptable, provided that access doors are appropriately sized and internally lined with same materials as unit casing. If access doors are provided in separate sections as extension of units, these sections shall be internally lined in same manner as units.
E. Provide access doors for all boxes with reheat coils at inlet side of coils. Reheat coils shall be shipped loose and field mounted. Provide sheet metal connecting section between units and reheat coils for mounting access doors. Refer to Section 23 3314 - Ductwork Specialties for access doors.

2.02 RETURN AIR TERMINAL DEVICES (RTU-2 OFFICES)

A. Units shall be suitable for 24 V electric control system. Control Contractor shall be responsible for wiring from control panels to each terminal unit. Units shall be similar to Titus Model ECV.
B. Return Air Terminals (tracking pair) to be used to maintain supply/return cfm offset for RTU-2 offices.
C. Units shall be capable of modulating to full closed position with maximum leakage of 1%.
D. Unit casing shall be minimum 0.861 mm(22 ga) galvanized steel unless otherwise specified.
E. Casing leakage shall not exceed 1.4 L/s(3 cfm) for inlet sizes 8 and smaller and 2.4 L/s(5 cfm) for inlet sizes 9 and larger at 375 Pa(1.5” WG) differential static pressure.
F. Damper shall be heavy gauge steel. Shaft shall be steel with bronze iolite self-lubricating bearings. Damper shall incorporate mechanical stop to prevent overstroking and synthetic seal to limit close-off leakage to 1.9 L/s(4 cfm) at 375 Pa(1.5” WG) differential pressure.
G. Unit casing, damper and shaft for [fume hood] [fume hood and BSC] exhaust shall be 316 stainless steel.
H. Unit shall incorporate multi-point, center averaging velocity sensor. Sensor shall provide signal measurable by controller at inlet velocities of 2.5 m/s(500 fpm). Sensor shall provide control signal accuracy of ±5%, with the same size inlet duct at any inlet condition.

2.03 VENTURI TYPE LAB AIR TERMINAL DEVICES

A. Reference Section 23 3614 Laboratory Temperature and Air Flow Control System

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install units as shown on drawings and according to manufacturer's installation instructions.
B. Install units with sufficient service space to unit control, actuators and access panels.

C. Provide minimum length of 3 times box inlet diameter of straight rigid duct at box inlet.
D. Provide access doors for terminal devices with reheat coils at inlet side of coils.
E. Provide access panels compatible with ceiling for all units located above non-accessible ceilings.
F. If venturi type air terminal devices are used for supply air application, provide external insulation in accordance with Section 20 0700 - Mechanical System Insulation.

END OF SECTION

SECTION 233614
LABORATORY TEMPERATURE AND AIRFLOW CONTROL SYSTEM

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 20 0700 – Mechanical Systems Insulation
B. Section 23 0595 - Air Systems Test Adjust Balance
C. Section 23 3314 - Ductwork Specialties
D. Section 23 8214 - Heating and Cooling Terminal Devices

1.02 DESCRIPTION

A. This Specification is for procurement and installation of laboratory temperature and airflow control system (LTAC), complete with air valves, electric transducers, air terminal controllers, control wiring, space temperature sensors, and all accessories required, except where otherwise specified, to provide complete and functional system.
B. Prepare Coordination Drawings as specified in Section 20 0000 - General Mechanical Requirements. As part of this effort, Contractor shall provide locations of control components to other trades, review schedule for preparation of Coordination Drawings as prepared by other contractors, attend meetings as required to assist in preparation of documents, and actively participate to resolve layout issues in timely manner.
C. This specification applies to all spaces indicated in the Variable Volume Air Valve schedules as having Laboratory air terminals which are and applies to lab control sequences as shown on drawings.
D. System shall be provided with independent, self-contained controls. There is no Building Automation System (BAS) included in the project design. The LTAC system contractor is responsible to provide a fully functioning system.
E. System shall maintain continuous operation of air flow setpoints at all times.
F. Coordinate delivery and installation schedule of air valve devices with other trades.

1.03 SUBMITTALS

A. Refer to Division 01 - Submittal Procedures
B. Submit Shop Drawings for all supply, general exhaust, and fume exhaust air terminals, actuators, controllers, master controllers, control wiring, pneumatic tubing, space temperature/humidity sensors and all accessories. Shop drawings shall be complete in all respects and shall include, but not be limited to the following:
    1. Manufacturer's printed product data sheets indicating name and model number of all pieces of equipment.
    2. Name, address and phone number of supplier.
    3. Name, address and phone number of local representative.
    4. Identification as referenced in documents.
    5. Capacity/ratings and dimensional data.
    6. Materials of construction and installation requirements.
C. Submit air valve size, valve airflow setpoints, minimum and maximum airflow capacity for each valve, and space differential airflow (offset airflow) for all valves in each lab space.
D. Bill of material identifying actual product model number used for each control device for each schematic drawing.
E. Control drawings with graphic representation of system components. Identify controlled devices as referenced on plans with unique valve and damper tag numbers.
F. Electrical characteristics indicating any field wiring which is to be performed by others, type of signal wiring, and installation methods including raceway type and grounding method.
G. Supply and exhaust air terminal certified sound data for both casing discharge and radiated sound levels from 125 through 8,000 Hz as tested in accordance with ASHRAE/ANSI Standard 130, S12.12 or AHRI Standard 880.

H. Instrument specifications.
I. Controller description.
J. System/network architecture configuration diagram showing all controller / control panel types and locations and interconnecting wiring and interface points.
K. Written control sequences describing method of control, alarms, setpoints referenced to tag number of device.
L. Outline drawing showing overall dimension, component location and spacing, and interfacing connections sizes and locations.
M. Identify setpoint or adjustable control range for each control device.
N. Submit Building Automation System integration point list indicating point types, point names, and read/write capability.
O. Shop Drawings and complete equipment and software descriptions shall be submitted in sufficient detail to assess equipment's conformance to this specification and physical size of equipment.
P. Organize submittal with table of contents and tabs for each section arranged by logical groups of devices.

1.04 DESIGN CRITERIA

A. Unit manufacturer or designated representative shall verify LTAC system performance and adjust or replace device(s) within warranty period if it is determined that problem exists in area served the by LTAC system or the associated device(s).
B. Actuators and linkages shall be furnished and factory installed by Laboratory Temperature and Airflow Control Manufacturer.
C. Actuator and its controller shall be calibrated at the factory, and then verified through TAB work for scheduled airflow rates. Air terminals shall be capable of field calibration and readjustment with external gauge taps.
D. Refer to Air Valve Device schedules for definition of minimum inlet static pressure requirement for each air terminal device as well as sizing criteria.
E. Provide all components not specifically indicated or specified, but necessary to make system function within intent of specification and in accordance with control sequences.
F. Size all control apparatus including all air terminals to provide stable control of systems and equipment served throughout specified operating range.
G. Any devices subject to corrosion, such as in fume hood exhaust ducts, shall be provided with appropriate corrosion protection.

1.05 CODES AND STANDARDS

A. All materials and workmanship described herein shall be in accordance with latest addition and addenda of codes and standards listed below:
   1. AMCA Air Movement and Control Association
   2. AHRI Air Conditioning, Heating, and Refrigeration Institute
   3. ASTM American Standards Testing and Materials
   4. NEC National Electrical Code
   5. NEMA National Electrical Manufacturers Association
   6. NFPA National Fire Protection Association
   7. UL Underwriters Laboratories
B. All work shall also comply with latest edition of the Florida Building Code.

1.06 FCC COMPLIANCE

A. All equipment furnished under this Contract shall have been tested and made to comply with limits for Class A computing device pursuant to Subpart J of part 15 of FCC Rules, which are designed to provide reasonable protection against interference when operated in commercial environment. Literature shall so note and all equipment shall be so labeled to show this compliance.

1.07 ADJUSTMENT, PERFORMANCE TEST AND CERTIFICATION

A. Conduct complete performance test for all systems to assure compliance with Contract Documents. Any components on systems found defective or not performing satisfactorily shall be readjusted and retested after necessary corrective measures are performed. Corrective measures may include modification or addition of equipment and devices, control strategies and/or software program.

B. Provide written certification signed by applicable person(s) for incorporation in O&M manuals stating date when successful completion of performance tests is achieved. Letter shall verify all controls are installed and software programs have been completely exercised for proper equipment operation.

C. Demonstrate functionality to Commissioning Agent.

D. Each air valve shall be factory calibrated to job specific airflows as detailed on plans and specifications using NIST Traceable Air Stations and instrumentation having combined accuracy of at least ±1% of signal over entire range of measurement.

E. Air valves shall be individually marked with air valve specific model number, and quality control inspection numbers. Information shall be stored electronically by manufacturer for future retrieval or for hard copy printout to be included with as-built documentation.

1.08 GUARANTEE

A. Guarantee all work, materials, equipment, and controls against defects in workmanship and material per General Conditions. Warranty shall commence upon the date of shipment and extend for a period of 60 months. During this period, any defects in material or critical or non-critical airflow control system performance shall be repaired or replaced by the supplier at no cost to the owner.

B. Replace any defective workmanship or material developing within that time as soon as possible at no charge to Owner.

C. After completion of installation, manufacturer shall regulate and adjust equipment provided in this contract prior to final acceptance.

1.09 OWNER TRAINING

A. Laboratory Temperature and Control System Contractor shall have designated representative available to monitor/modify lab control systems after systems have been started and are regularly used until Owner has completed on-site training specified.

B. Provide minimum of 12 hours of on-site training to Owner's representatives. Conduct training sessions during normal working hours after system start-up and acceptance by owner. Scheduling of training session(s) will be established by Owner and shall include both classroom and hands-on training. Portions of training may be performed before system is completely operational, but no sooner than 1 month before system is planned to be fully operational. Final training session shall be held after systems are complete, including all graphics programming.

C. Training sessions shall include, but not be limited to, the following topics:

1. Explanation of control sequences. Include which sensors are used and how output device operates.
2. Explanation of control drawings and manuals, including symbols, abbreviations, and overall organization.
3. Walk-through of Project to identify controller locations and general routing of network cabling.
4. Review of operation and maintenance of hardware devices including controllers, instruments, and sensors. Include schedule for routine maintenance.

D. Instructions on how to monitor and operate system hardware and software, and how to change system set points, flow rates, etc and respond to alarms.

E. Review interface for troubleshooting using operator interface device.

F. Training sessions shall be conducted during separate visits to site from site visits for system adjustment, performance test and certification.
G. Operation and maintenance manuals, including as-built wiring diagrams and component lists, shall be provided for each training attendee.

1.010 OPERATING AND MAINTENANCE MANUALS

A. Refer to Division 01 - General Requirements
B. Operating and maintenance manuals shall provide descriptions of maintenance on all system components including sensors and controlled devices. These shall include Control Contractor's completion check list, inspection requirements, periodic preventative maintenance, cleaning methods and materials, troubleshooting guide, calibration instructions and tolerances, repair parts lists, and manufacturer representative's name, address, and phone number.
C. O&M Manuals shall also include interconnection wiring diagrams with identified and numbered system components and devices.

1.011 RECORD DRAWINGS

A. Refer to Division 01 - General Requirements
B. Submit revised Shop Drawings indicating all changes made during project including any changes to operating sequences or setpoints.
C. Update control diagrams to include all tuning parameters and setpoints applicable to systems as depicted as of date of system completion. This information shall be incorporated with sequence of operation of each system.
D. Record actual locations of control components including control units, temperature/humidity sensors, air terminals and any controlled devices on As-Built ductwork/piping plans provided by Mechanical Contractor.

1.012 COORDINATION

A. Coordinate final supply, general exhaust, and fume exhaust air flow setpoints for valves in spaces with fume hoods with the fume hood manufacturer and the approved fume hood submittal.
B. Design and drawings are based on one of acceptable manufacturers listed in this Specification. Where requirements of equipment provided differ from equipment on which design is based, the Contractor shall be responsible for coordinating requirements of equipment with other Contractors involved. The Contractor shall be responsible for any additional cost incurred due to such requirements.
C. Contractor shall be responsible for all costs required for all revisions necessary to provide LTAC that meets the intent of the contract documents. Revisions include, but are not limited to additional Test, Adjust, and Balance work, ductwork revisions, insulation of supply air valves, power modifications, integration costs, etc.

PART 2 - PRODUCTS

2.01 GENERAL

A. Manufactures: Phoenix Controls, Siemens, Price, or Tek-Air. Basis of design is Phoenix Controls.
B. Materials shall be new and unused and free from defects and imperfections.
C. LATC system shall be fully stand-alone for each individual laboratory or laboratory support space. System shall not use or rely on information from controllers in other laboratory areas or from outside laboratory space to control functions within its laboratory.
D. Electrically actuated air valves shall be pressure independent with airflow accuracy of ±5% over airflow range of terminal. Air terminal units shall be balanced to conform to requirements of Section 23 0595 – Air Systems Test Adjust Balance.
E. Laboratory airflow control system shall use volumetric offset to maintain room pressurization. Offset airflow is indicated for each lab on Air Valve Device schedule.

F. Fume hood controllers will be provided by the fume hood manufacturer and are not included in this specification.
G. Control wiring shall meet requirements of Division 25. Control panels shall be located near entry to each lab zone. Coordinate location of control panel with all trades to provide access to panel for maintenance. Provide communications jack as part of or adjacent to space temperature sensor to allow communication between laptop computer and control panel. Provide one control panel to allow for stand-alone control of each lab zone.

2.02 LABORATORY CONTROLS SYSTEM

A. Air Valve Devices - General:
   1. Air terminals shall be venturi-type (Low-Pressure type), pressure independent over a 0.3 to 3.0 inches WG drop across the air terminal. Valves shall be the Low-Speed type with BacNet based controls. An integral pressure independent assembly shall respond and maintain specific airflow within 60 seconds of a change in duct static pressure irrespective of the magnitude of pressure and/or flow change or quantity of airflow controllers on a manifold system.
   2. Airflow accuracy shall be ±5% of airflow (not velocity pressure) over an airflow turndown range of no less than 10 to 1.
   3. Response time to vary air flow from its minimum to maximum value or vice versa shall be less than 60 seconds for supply/general exhaust tracking pair valves (Low-Speed type).
   4. Include necessary instruments to maintain air flows at design conditions at all times.
   5. Sound: Radiated and discharge sound power levels shall be no greater than published values for the basis of design air valves.
   6. All supply and general exhaust valves shall be furnished with a galvanized steel sound attenuator designed specifically by the air valve manufacturer to mitigate the valve generated sound.
B. Supply and General Exhaust Air Valves:
   1. Air valves for non-corrosive airstreams, such as supply and general exhaust air, shall be constructed of uncoated 16-gauge aluminum or 20 ga galvanized steel. The air valve's shaft and shaft support brackets shall be made of 316-stainless steel. The pivot arm and internal mounting brackets shall be made of a combination of aluminum and stainless steel. The pressure independent springs shall be of combination 302 and 316 stainless steel. All shaft bearing surfaces shall be made of a Teflon or Celenex composite.
   2. Furnish manufacturer's two-bolt band clamp. Band clamps shall have stepped design to accommodate nominal differences in duct diameter and valve diameter. Band clamp shall be galvanized steel with Volora Type AFR gasket conforming to UL94 for foamed plastics. Bands shall be provided with PTFE tape with silicone adhesive.
   3. Supply valves and general exhaust valves shall be factory insulated with closed cell foam insulation.
   4. Furnish supply valves with controls for HHW duct reheat coils (Ref Section 23 8214). Provide proper duct transitioning from the air valve to the sound attenuator to the reheat coil. Include a duct access door between the air valve and the coil for coil servicing.
C. Fume Exhaust Air Valves:
   1. Air valves for corrosive airstreams, such as fume hood, snorkel, flammable storage cabinet and equipment exhaust shall be either 316 stainless steel or minimum 16 ga aluminum with two baked-on coats of Heresite P-403, 5 mils minimum thickness. Air valve's shaft and shaft support brackets shall be made of 316-stainless steel. Pivot arm and internal mounting brackets shall be made of a combination of aluminum and 316L stainless steel. Pressure independent springs shall be of combination 302 and 316 stainless steel. All shaft bearing surfaces shall be made of Teflon or Celenex composite.
   2. Furnish manufacturer's two-bolt band clamp. Band clamps shall have stepped design to accommodate nominal differences in duct diameter and valve diameter. Band clamp shall

be galvanized steel with Volora Type AFR gasket conforming to UL94 for foamed plastics. Bands shall be provided with PTFE tape with silicone adhesive.

D. Air Valve Actuators
   1. Furnish actuators for all air valves (including constant volume). For VAV operation, electric actuator shall be factory mounted to air valve. Loss of main control power shall cause exhaust air valves to fail to the last position. Actuators and all controls shall be all Native BacNet. Variable volume air valves are to be Phoenix Traccel Model MAV or EXV (low-speed actuators), or approved equal.

E. Air Valve Controllers:
   1. Controller shall use electronic-based, closed loop control to regulate airflow.
   2. Supply air valve controller shall control the general exhaust air valve to maintain the constant room offset.
   3. Supply air valve controller shall control the fume exhaust air valve and include that flow rate into the room offset equation.
   4. The room temperature sensor shall provide an input to the supply air valve controller. The controller shall then control the reheat coil control valve to maintain room temperature conditions.
   5. The controller shall communicate with the BAS via a native BacNet communication interface. The BAS will then be able to observe all internal points and be able to input setpoint changes such as temperature and room cfm offsets into the valve controller.

F. Laboratory Temperature and Airflow Control System Control Unit:
   1. Minimum Requirements:
      a. Ambient Temperature; 35° F -120° F
      b. Humidity: 10%-90%
      c. Analog Outputs: 0-10VDC or 4-20ma
      d. Room Temperature Control: 0.5° F
   2. Laboratory controller shall maintain proper room pressurization by maintaining constant design offset (adjustable) between sum of room's total exhaust and make-up/supply airflows.
   3. Provide control of the HHW reheat coil to maintain space temperature. Provide devices as required to interface with reheat controls.
   4. Controller shall use electronic-based, closed loop control to regulate airflow. Each laboratory shall operate independent and on a stand-alone basis. There shall be no communication with a central controller.
   5. Sequences shall be field customized by adjusting parameters such as control algorithm gains, temperature setpoint, alarm limits, air flow differential setpoint, and pressurization mode.
   6. Include a communication jack to allow remote programming of laboratory temperature and airflow control system via laptop computer.
   7. Controller shall include all inputs and outputs necessary to perform specified control sequences.

G. Room Temperature Sensors:
   1. Sensor shall include communication jack to allow remote programming of CCU via laptop computer. Minimum requirements include:
      a. Temperature Coefficient of Resistivity (TCR): .00385 ohm/ohm/°C
      b. Accuracy: ± 0.5° F
      c. Conformance: DIN-IEC 751
      d. Operating Range: 32 to 122°F
         0 to 95% RH

H. Fume Hood Monitor:

a. By others, furnished by the lab hood manufacturer. No communication with the BAS or air valve controls is to be provided.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install all supply, general exhaust, and fume exhaust air valves in accordance with the manufacturer's installation instructions, including upstream and downstream straight duct lengths as required. Coordinate with other work to provide appropriate duct configuration to allow for accurate measurement and control of airflow as required for each device.
B. Do not cover the Air Valve Information Tag with duct insulation, tape or mastic.
C. Provide all low voltage transformers and control wiring and 24 VAC power supplies.
D. Air Valves and Reheat Coils:
   1. Coordinate with other trades to install air valves, sound attenuators, reheat coils and access doors as shown on drawings and according to manufacturer's instructions, including reheat coil controls and access doors and necessary ductwork transitions as required for mounting equipment.
   2. Mount air valve actuators on same side of air terminal device as reheat coil controls to ensure service access.
   3. Connect air terminals to ductwork with removable type joints as detailed.
   4. Transition from supply air terminal to reheat coil shall not exceed 15° per side.
   5. Provide access doors for supply air terminals with reheat coils. Mount access door at inlet side of coil. Refer to Section 23 3314 - Ductwork Specialties for access door requirements.
   6. Air terminal devices used for supply air and general exhaust applications shall be provided with external insulation in accordance with Section 20 0700 – Mechanical Systems Insulation.
E. Sound Attenuating Devices
   1. Coordinate installation of sound attenuating devices with other trades where provided separate from valves.
F. Control and Power Wiring:
   1. Provide control wiring from laboratory control panel to and between other laboratory control system components as required for complete and proper functioning, including but not limited to air terminals, reheat control controls, sensors, transducers, controllers, panels, and interface modules.
   2. Division 26 is to provide required conduit, wire, junction boxes, disconnect switches and circuit breakers according to Division 26 specifications as required to wire electrical power to each laboratory control panel. Division 26 will provide one 120-volt circuit to each lab zone as required.
G. Laboratory Control Panels and Power Supplies:
   1. Mount laboratory control panels and power supplies in accessible location within laboratory rooms. Provide a properly sized and fused 24 Vac transformer suitable for NEC Class II wiring for each lab zone control system as defined in the previous section.
   2. Coordinate location of electrical power panels with Division 26 Contractor.
H. Laboratory Control System Start-up:
   1. System startup shall be provided by factory authorized representative of system manufacturer.
   2. Coordinate timing of start-up with Mechanical Contractor to confirm HVAC Systems are operating as specified.
   3. Startup shall be performed on complete laboratory temperature and air flow control system and shall include calibration of each laboratory control system component; check out of air valves, actuators, sensors, thermostats, and verification that each system operates in compliance with specified control sequences.

4. Measure and set up fume hood average face velocity. Coordinate with and work in conjunction with TAB Contractor.
5. Set up system supply, general exhaust, and fume exhaust air flows in cooperation with TAB Contractor. Refer to Section 23 0595 - Air Systems Test Adjust Balance for air flow measurements.
6. Provide a visual demonstration that the laboratory airflow systems are maintaining specified containment performance requirements for fume hoods and room to room air directional offset. If the performance requirements cannot be demonstrated, Contractor shall be responsible for any costs and labor necessary to meet minimum performance requirements. Coordinate with and work in conjunction with TAB Contractor.
7. Demonstrate that, with specified room offset, system maintains proper room directional air flows under both static and dynamic operating conditions under all air flow conditions. The fume hood and snorkel units are constant volume, so air balance is to be maintained by the offset between the supply and general exhaust valves. Verification shall be provided by temporary visual indication, using smoke wand. If performance requirements cannot be demonstrated, Contractor shall be responsible for any costs and labor necessary to meet minimum performance requirements. Coordinate with and work in conjunction with TAB Contractor.

I. Draw Bands:
   1. Draw bands for air valves shall be manufactured and supplied by air valve manufacturer. Ductmate quick sleeve or approved equal will be acceptable. Contractor fabricated band clamps are not allowed. Provide each valve with manufacturer's teflon gasket/tape to seal between clamp and seal.

END OF SECTION

SECTION 233713
DIFFUSERS, REGISTERS AND GRILLES

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 23 3600 - Air Terminal Devices

1.02 REFERENCE

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

1.03 SUBMITTALS

A. Shop Drawings including, but not limited to, the following:
   1. Manufacturer's name and model number
   2. Identification as referenced in the Documents
   3. Capacities/ratings
   4. Materials of construction
   5. Sound ratings
   6. Dimensions
   7. Finish
   8. Color selection charts where applicable
   9. Manufacturer's installation instructions
   10. All other appropriate data

1.04 DESIGN CRITERIA

A. Performance data shall be based on tests conducted in accordance with ASHRAE Standard 70.

B. Screw holes on surface shall be counter sunk to accept recessed type screws.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Titus, Price, Carnes, Nailor, Anemostat, or Krueger

B. Acceptable manufacturers for specialty products are listed under each item.

2.02 CEILING DIFFUSERS

A. Diffusers shall be aluminum construction unless otherwise indicated, and furnished with frame type appropriate to installation. Furnish diffusers with equalizing grids where it is not possible to maintain minimum 2 times duct diameter straight duct into diffuser. Equalizing grids shall consist of individually adjustable vanes designed for equalizing airflow into diffuser neck and providing directional control of airflow.

B. Diffuser models, sizes and finishes shall be as shown on drawings and/or as scheduled. Unless noted otherwise, diffusers shall have baked enamel finish with color selected by Architect.

2.03 REGISTERS AND GRILLES

A. Registers and grilles shall be aluminum unless otherwise indicated, and furnished with frame type appropriate to installation.

B. Supply registers and grilles shall be double deflection type blades to provide for air deflection adjustment in all directions.

C. Return and exhaust registers and grilles shall have fixed blade core.

D. Registers shall be furnished complete with opposed blade volume control dampers, operable from face.

E. Register and grille models, sizes and finishes shall be as shown on drawings and/or as scheduled. Unless noted otherwise, registers and grilles shall have baked enamel finish with color selected by Architect.

F. Interior of perforated face grilles shall be finished in flat black.

2.04 ADJUSTABLE LINEAR DIFFUSERS

A. Linear diffusers shall be extruded aluminum and furnished with frame type appropriate to installation with diffuser elements being removable from frame. Diffuser vanes shall provide both air pattern and flow rate adjustment with air pattern having full 180° adjustment. Diffuser vanes of single slot shall be segmented on 2 or 3 ft centers.

B. Diffuser models, lengths and slot sizes shall be as shown on drawings and/or as scheduled. Unless otherwise indicated, frame face shall have baked enamel finish with color selected by Architect. Diffuser vanes and frame interior shall be finished in flat black.

2.05 WIRE MESH GRILLES

A. Grilles shall be 2 X 2 mesh (1/2") galvanized steel or aluminum hardware cloth in spot welded galvanized steel frame with 1-1/2" width.

PART 3 - EXECUTION

A. Install grilles, registers and diffusers as shown on drawings and according to manufacturer's instructions.

B. Unless otherwise indicated, size ductwork drops to diffusers or grilles to match unit collar sizes. Where diffuser or grille has square neck, provide round-to-square duct transition to allow connection of flexible duct.

C. Seal connections between ductwork drops and diffusers/registers/grilles air tight.

D. Blank off unused portion of linear diffusers and grilles.

E. Where diffusers, registers and grilles cannot be installed to avoid seeing inside duct, paint inside of duct with flat black paint to reduce visibility.

F. Protect diffusers, registers and grilles from construction dirt. Clean or replace those soiled or stained prior to turnover to Client.

G. Install wire mesh grilles on fan coil unit discharge openings and open-ended supply ducts on fan coil units.

END OF SECTION

SECTION 234114
FILTERS

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 23 36 00 - Air Terminal Devices
B. Section 23 37 13 – Diffusers, Registers and Grilles
C. Section 23 7323 – Factory Fabricated custom Air Handling Units
D. Section 23 7400 – Packaged Rooftop Air Handling Units

1.02 REFERENCE

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

1.03 SUBMITTALS

A. Shop Drawings including, but not limited to, the following:
   1. Manufacturer's name and model number
   2. Identification as referenced in the Documents
   3. Capacities/ratings; cfm, area, face velocity
   4. Efficiencies and initial/final pressure drop
   5. Materials of construction
   6. Dimensions
   7. Filter gauges data
   8. Manufacturer's installation instructions
   9. All other appropriate data
B. LEED Submittals:
   1. Product Data for IEQ Prerequisite 1: Documentation indicating that units comply with ASHRAE 62.1-2007 Section 5 – “Systems and Equipment”.
   2. Product Data for IEQ Credit 4.1: For adhesives and sealants, including printed statement of VOC content.

1.04 DESIGN CRITERIA

A. Filters shall have UL, Class I or Class II Listing.
B. Holding frames or housings specified in this Section may be furnished by filter manufacturers listed below, or where applicable, as part of factory packaged air handling units.
C. Filter sizes shall be 16x20, 20x20, 20x25, or 16x25.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. American Air Filter, Camfil/Farr, Flanders Precisionaire, Glasfloss, Airguard or Filtration Group unless otherwise noted under individual filter.

2.02 DISPOSABLE PANEL FILTERS (OA ROUGHING FILTER – ALL RTUS)

A. Similar to Farr 30/30 or Flanders Precisionaire PrePleat 40.
B. Filter size, capacity, and efficiency shall be as scheduled.
C. Media shall be non-woven, fine fibered material laminated to rigid backing to hold pleat formation, having minimum efficiency MERV 8 based on ASHRAE Test Standard 52.2 (average dust spot efficiency of 30 to 35% based on ASHRAE Test Standard 52.1).
D. Filter housing shall consist of air handling or cabinet fan unit manufacturer's low velocity filter section, or holding frame, as scheduled. When holding frame is indicated, it may be furnished by, filter manufacturer or it may be contractor fabricated.
E. Clean filter pressure drop shall not exceed 0.31" WG (70Pa) based on 500 fpm (153m/m) face velocity.

2.03 DISPOSABLE RIGID CARTRIDGE TYPE AIR FILTERS

A. Similar to Camfil Farr Durafil ES RIGA-FLO or Flanders Precisionaire
B. High performance deep pleated, rigid, disposable type filters. Each filter shall consist of high efficiency media, enclosing frame, contour stabilizers on both air entering and exiting sides and support grilles. Filters shall be designed to withstand minimum differential pressure of 6" WG without structural damage to filter frame, seals or media.
C. Filter thickness, size and capacity shall be as scheduled.
D. Filters shall have minimum efficiency MERV 11 based on ASHRAE Test Standard 52.2 (average efficiency of 60-65% based on ASHRAE Test Standard 52.1). Initial resistance at 500 fpm face velocity shall not exceed 0.31 WG. (OA Final Filter – All RTUs)
E. Filters shall have minimum efficiency MERV 13 based on ASHRAE Test Standard 52.2 (average efficiency of 80-90% based on ASHRAE Test Standard 52.1). Initial resistance at 500 fpm face velocity shall not exceed 0.50 WG. (Supply Final Filter – All RTUs)

2.04 FILTER HOLDING FRAMES

A. Frames shall be minimum 16 ga (1.6mm) stainless steel construction with provisions for assembly in a bank. Frames shall be suitable for filters scheduled and incorporate gaskets and spring clips to prevent air bypass.

2.05 LOW VELOCITY FILTER SECTIONS

A. Provide for factory packaged, air handling units and cabinet fans as indicated.
B. Housing shall consist of modular steel section with hinged access doors for filter replacement. Each housing shall be internally insulated by manufacturer or externally insulated in the field. Factory applied internal insulation shall have thermal resistance equivalent to that specified for duct in which housing is located, shall have internal vapor barrier, and shall have flame spread and smoke developed ratings as specified in Section 20 0700 - Mechanical Systems Insulation.

2.06 FILTER PRESSURE DROP GAUGES

A. Dwyer Series 2000 Magnehelic pressure gauge.
B. Unless otherwise indicated below, select scale range to be most appropriate to clean and dirty filter pressure drops.

Filter Type	Scale Range - inch WG (Pa)
Throwaway filters	0 - 0.5 (0-125Pa)
Filters with 25 to 30% efficiency based on atmospheric dust spot test	0 - 1.0 (0-250Pa)
Filters with 31 to 99% efficiency based on atmospheric dust spot	0 - 2.0 (0–500Pa)
HEPA filters	0 - 4.0 (0–1000Pa)
ULPA filters	0 - 4.0 (0–1000Pa)

C. Provide gauges for each filter bank, including gauges across each individual filter bank in built-up rack assemblies, suitable for flush mounting in a panel, including air filter gauge accessory package for use with 1/4" (6.5mm) OD copper tubing.
D. Provide 3/4" (19mm) spacer at one 2' x 2' (0.6m x 0.6m) filter section between filter elements in built-up rack, adjacent to unit wall for placement of intermediate pressure probe.

2.07 ADDITIONAL FILTER MEDIA

A. For Disposable Panel filters, enough media for 3 filter changes shall be provided for each air handler. Media used during construction shall be replaced when system is air balanced. Third set of media not used shall be turned over to Owner as spare.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install filters as shown on drawings and according to manufacturer's instructions.
B. Provide supports as required and necessary clearance for changing filters.

C. Provide structural supports, outside casing and blank-off materials for all field assembled filter banks, and filter banks where housings are not furnished by filter manufacturer.

3.02 FILTER PRESSURE DROP GAUGES

A. Mount gauge near each filter bank and install static pressure sensors according to manufacturer's instructions.

3.03 FILTER HOLDING FRAMES

A. Provide frames for all filter banks as required. Install built-up filter banks in accordance with manufacturer's installation instructions.

END OF SECTION

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SECTION 235100
SMOKESTACK, BREECHING AND VENT PIPING

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 23 5214 – Primary Heating Equipment

1.02 SUBMITTALS

A. Shop Drawings including, but not limited to, the following:
   1. Manufacturer's name.
   2. Pressure/temperature ratings.
   3. Materials of construction.
   4. Dimensions and weights.
   5. Thermal characteristics.
   6. Erection and supporting methods.
   7. Finish.
   8. Manufacturer's installation instructions.
   9. All other appropriate data.

1.03 DESIGN CRITERIA

A. All products, fabrication and installation shall comply with requirements of NFPA 211 together with State and Local Codes.

PART 2 - PRODUCTS

2.01 FACTORY-BUILT BOILER VENT SYSTEM FOR CONDENSING BOILERS

A. Manufacturers: Metal-Fab, HeatFab, ProTech Systems or Schebler equal to HeatFab SAF-T Vent or SAF-T CI Vent.
B. Smokestack shall be factory-built double wall type with minimum 5/32” air space between walls. Stack shall be listed by UL 1738/ULS S636 listed for continuous operation at 550°F.
C. Inner pipe shall be AL-29-4C superferritic stainless steel in 0.015” minimum thickness for sizes through 12” ID and 0.024” minimum for sizes over 14 through 24” ID.
D. Outer jacket shall be Type 304 or Type 430 stainless steel.
E. Provide stack system complete with all necessary accessories including flashing, counterflashing, storm collar, ventilated roof thimbles, fitting, cleanout and drain section, base anchor lugs and necessary supports.
F. When specifically allowed by the manufacturer of the condensing boiler, Schedule 40 Polyvinyl Chloride (PVC) Piping with ASTM D2665 solvent weld PVC fittings may be used for the outside combustion air intake and the boiler exhaust venting in place of the metal venting systems listed above.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install stack, breeching, vents and expansion devices as shown on drawings, details and in accordance with manufacturer's recommendations and code requirements for minimum heights and distances. Coordinate carefully with General Contractor.
B. Support vents and combustion air ducts adequately from building structure with provisions for breeching expansion and contraction.
C. The vent pipes shall be installed in such a manner that provides a positive draining of condensate liquids or water that has accumulated in the vent pipe.
D. The vent pipes shall be installed per local codes for height and separation. Provide wind bracing or guy wires where required.
E. When PVC pipe is used for venting, use cleaning procedures and solvent cements as recommended by pipe and fitting manufacturers for the particular material being used. Install PVC piping in strict accordance with pipe and fitting manufacturer's recommendations,

including support spacing, compensation for thermal expansion and contraction and solvent cementing.

END OF SECTION

SECTION 235214
PRIMARY HEATING EQUIPMENT

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 20 0700 – Mechanical Systems Insulation
B. Section 23 0901A - Control Systems Integration
C. Section 23 2118 - Valves
D. Section 23 2120 – Piping Specialties
E. Section 23 5100 – Smokestack, Breeching, and Vent Piping

1.02 SUBMITTALS

A. Shop Drawings for all items in this Section including, but not limited to, the following:
   1. Manufacturer's name and model number
   2. Identification as referenced in the documents
   3. Capacities/ratings
   4. Materials of construction
   5. Dimensions and weights
   6. Temperature/pressure ratings
   7. ASME Construction and Stamp
   8. Wiring diagrams
   9. Manufacturer's installation instructions
   10. All other appropriate data

1.03 DOCUMENTATION

A. As the equipment is being constructed, the manufacturer shall record all component information such as model numbers and serial numbers for all replaceable components including motors, fans, control components. In addition, all sensors shall be listed in a table with associated model number and calibration certifications.
B. The information requested above shall be forwarded to the owner and engineer (2 copies each) prior to the arrival of the equipment.

1.04 CERTIFICATES

A. Secure all registration and installation permits required by State and Local Authorities and complete these requirements before system is placed in operation.

1.05 REFERENCE STANDARDS

A. Boilers shall be constructed, tested and stamped in accordance with the latest ASME Boiler and Pressure Vessel Code and must receive authorized boiler inspection in factory.
B. Boiler shall be constructed, installed and tested in accordance with ASME CSD-1 2009, Controls and Safety Devices for Automatically Fired Boilers.

1.06 STARTUP, TESTING, TRAINING, AND OPERATION AND MAINTENANCE DATA

A. Boilers:
   1. General: Boiler manufacturer shall provide services of factory-trained field representative/technician to approve installation, conduct start-up, test and adjust for proper operation, pre-test, conduct witnessed testing, and instruct and train Owner’s representative in operation and maintenance of equipment. Boiler manufacturer shall submit résumé for representative/technician(s) actually conducting these services. Representative/technician(s) shall have at least 5 yrs of experience commissioning condensing boiler systems. All procedures shall be conducted for each boiler and the integrated boiler system as specified herein.
   2. Boiler Startup: Boiler manufacturer’s representative shall conduct startup of boilers per manufacturer’s recommended startup procedures. Startup shall include the following in addition to manufacturer’s recommended startup procedures:

a. Complete inspection of installation and boiler condition
b. Fireside and waterside inspections
c. Verification of installation of field installed components, connections, wiring, and mountings. This verification shall include remote-mounted burner controller panel and interconnections to boiler skid components, and stack sensors. Verify that control panels are at mounting height allowing easy readability, access, and keyboard manipulation from floor level.
d. Verification of boiler mounting to achieve seismic restraint and allow for boiler thermal expansion
e. Verify strainers are clean and watertight
f. Setup of gas and fuel trains
g. Setup of combustion air system including complete VFD setup
h. Setup of all operating parameters

3. Boiler Pre-Testing: After startup is complete, boiler manufacturer's representative shall conduct testing of boiler functional operations per manufacturer's recommended testing procedures. All testing shall require detailed, written procedures and shall be submitted to Engineer for approval prior to testing. Boiler manufacturer's representative shall provide all temporary testing equipment and instrumentation required for startup and commissioning. Testing shall include the following in addition to manufacturer's recommended test procedures:
   a. Coordinate and assist Building Automation System (BAS) Contractor and/or third-party integrator in installation and verification of all boiler controls/DDC controls interface functions. Testing shall not be considered complete until all interface functions are verified to operate correctly.
   b. Verify operation of all boiler safeties including gas limits, flame safeguards including timings, low water cutout, auxiliary low water cutout, proof of air pressure/flow, high limits, relief valves, indication of correct fault messages/codes at boiler controller, indication correct alarm reporting through communications to BAS, etc.
   c. Verify operation of combustion process including timings.
   d. Testing of boiler combustion air/fuel ratios and emissions analysis throughout firing range and for each fired fuel. Flue gas analysis report shall include measurements of the following throughout the firing range:
      1) % oxygen
      2) % carbon dioxide
      3) % carbon monoxide
      4) stack temperature
      5) % combustion efficiency
      6) NOX mg/L(ppm)
      7) SOX mg/L(ppm)
      8) Verification of boiler turndown.
4. Final Report:
   a. Upon completion of these services, boiler manufacturer's representative shall submit complete report, signed by manufacturer's service representative, including start-up and test log. Final test report shall include reports for all startup/commissioning tests and procedures. Final completed commissioning functional test procedures shall be signed-off from manufacturer's technician. Report shall document all setpoints and user-adjustable parameters as configured on each boiler.

1.07 OPERATION AND MAINTENANCE DATA

A. Owner Training:
   1. Provide 16 hours of training on-site as scheduled with Owner. Provide one additional 8 hour training session at a later date to be scheduled with Owner. Training shall be for up to

8 people. Training shall include basic system descriptions and operations, safety procedures, maintenance procedures, controls functions and operations, and diagnostic/trouble-shooting procedures.

B. Operation and Maintenance Manuals:
   1. Provide Operation and Maintenance (O&M) Manuals including cut-away drawings of boilers, boiler piping diagrams including fuel trains, complete boiler electrical wiring diagrams with interface points, controls sequences and schematic diagrams with interface points, component cut-sheets, complete spare parts lists, maintenance procedures/intervals, inspection procedures, safeties testing procedures, and trouble-shooting procedures.

1.08 COORDINATION

A. Design and drawings are based on one of acceptable manufacturers listed in this Specification. Where requirements of equipment provided differ from equipment on which design is based, this Contractor shall be responsible for coordinating requirements of equipment with other Contractors involved.
B. This Contractor shall be responsible for any additional cost incurred due to such requirements.

1.09 WARRANTY PERIOD FOR CONDENSING BOILERS

A. Provide 1 year non-prorated parts warranty on all burner components
B. Provide 10-year non-prorated heat exchanger warranty for failure due to thermal stress and corrosion. Failure due to improper water treatment is not covered in this warranty.
C. Warranty period begins at the date of equipment startup.

PART 2 - PRODUCTS

2.01 BOILER-BURNER UNITS (CONDENSING HHW BOILERS)

A. General:
   1. Units shall be one of the following manufacturer's models with capacity and operating characteristics indicated on schedules: Lochinvar FTXL (Basis of Design) Aerco Benchmark, or Cleaver Brooks.
B. Furnish units complete with boiler, burner, forced draft fan, combustion controls, safety controls, wiring, insulated jacket, boiler trim, drain valve, and assembled on structural steel base frame. Unit shall be ready for connection to fuel, electrical sources, and water piping.
C. The boilers shall be installed on a concrete housekeeping pad of sufficient height (minimum 4” or higher) to allow the gravity draining of condensate liquids through the condensate trap, condensate neutralization unit, and height to allow gravity draining to the nearest floor drain.
D. Boiler:
   1. Boilers shall be constructed and stamped in accordance with the latest ASME Code for 150 psi working pressure and must be inspected by Authorized Boiler Inspection Agency and registered with National Board.
   2. Combustion chamber shall be sealed and completely closed with ceramic fiberboard insulation.
   3. Boiler shall operate at minimum 97% thermal efficiency at 120°F return water temperature when fire tested at 100% of rated capacity and at a minimum of 93% thermal efficiency at 120°F return water temperature when fire tested at 25% of rated capacity.
E. Burner:
   1. The boiler burner shall be capable of a minimum 7:1 turndown ratio of the firing rate without loss of combustion efficiency.
   2. Factory mounted and constructed of stainless steel or ceramic.
   3. Sealed combustion type suitable for firing natural gas. All fuel trains and controls shall conform to UL requirements, be designed in accordance with FM, and be factory assembled, wired, mounted and tested.

4. Unit manufacturer shall provide pressure regulators at each boiler to reduce natural gas pressure a suitable level for proper burner operation.

F. Emissions
   1. Boiler burner shall produce NOX emissions level of no more than 20 ppm corrected to 3% O2.

G. Electrical and Controls:
   1. Furnish unit with electrical entrance cabinet, NEMA 1, to accept single service of 120 V, 1 Ph, 60 cycle power to accommodate motors and control circuit power. Furnish unit with control cabinet, NEMA 1A enclosure with lock and exterior resets for blower motor starter and flame failure.
   2. Boiler manufacturer shall furnish remote shutdown switch. Switch shall be red mush-room button or Push-to-Activate type with safeguard feature against tampering and easily readable identification marking. The switch is to be installed in a location that complies with code requirements.
   3. Control cabinet to include magnetic motor starters with thermal overload protection, electronic flame safeguard, programming timer for pre-purge and post-purge, burner switch, control circuit switch and fuse, necessary switching relays, low water and flame failure alarm, manual automatic selector switch, indicating lights for major operations, numbered terminal strips, numbered wiring and engraved nameplates.
   4. Controls shall include high limit (manual reset), operating limit (auto reset), frost control, high and low gas pressure switches, blocked condensate drain switch and combustion air switch.
   5. Controls to be interlocked to cause 100% automatic shut-off of fuel flow to burner in event of failure of electric power, burner flame, pilot flame, low water, combustion air, or any other condition, which might prove hazardous.
   6. Furnish unit with all necessary controls for fully-modulated firing with proved low fire start.
   7. Provide controls to restart automatically on emergency power or power restoration after power outage.
   8. Provide auxiliary contacts to allow the BAS to enable/disable the operation of the boilers and provide status and alarm indication to Building Automation System (BAS). Alarm condition shall be reported to BAS whenever alarm condition is indicated at boiler packaged control panel.
   9. Provide a BAS Gateway for a BACnet interface.
   10. Furnish unit with lead-lag and efficiency optimization sequence controls. The control panel with digital operating controls and LCD display shall be of controlling up to five boilers. The controller shall automatically control the operation of one or both boilers as needed to maintain the consistent supply temperature of the heating hot water system. The HHW system shall be a variable flow design with a BAS controlled bypass to maintain a minimum water flow through the HHW system.
       a. Control shall include assured low fire cutoff.
       b. Furnish temperature sensor required for boiler capacity control and flow sensor required for lead-lag control.
       c. Boiler controller shall sequence lead-lag boilers to maintain supply temperature setpoint field-adjustable supply water temperature setpoint. Boiler controller shall operate as many boilers as possible any load at the lowest stable firing rate. Boilers shall be staged on, operating in parallel to maintain hot water supply temperature setpoint. Once all boilers are operating, boiler controller shall modulate firing rates in unison. A lag boiler shall be sequenced off and its associated isolation valve closed whenever firing rate falls below a field-adjustable threshold. Whenever a lag boiler is turned off, boiler lead-lag controller shall monitor supply temperature and firing rates of the operating boilers, and sequence the lag boiler(s) back on whenever that boiler can

be activated without reducing firing rates of any individual boiler below a field-adjustable threshold.

d. The boilers shall be furnished with motorized isolation valves and the boiler controls shall control the operation of the respective isolation valve for each boiler. An end-switch shall indicate the closed position of the valve to the boiler controls. The boiler shall not be allowed to operate when the valve position is closed.

e. Provide the remote access connectivity option (CON-X-US Lochinvar or equal).

H. Insulation and Jacket:

1. Units shall be factory insulated with enameled steel jacket.

I. Combustion Air Intake:

1. Use stainless steel duct for combustion air intake pipe; seal joints and seams with silicone caulk.
2. When specifically allowed by the manufacturer of the condensing boiler, Schedule 40 Polyvinyl Chloride (PVC) Piping with ASTM D2665 solvent weld PVC fittings may be used for the outside combustion air intake in place of the metal ducting systems listed above.
3. Combustion air intake and exhaust venting will be from the roof above the mechanical room (direct vent vertical) where the boilers are to be located. Roof openings and curbs to be coordinated with the architect.
4. Provide manufacturer’s transition or adapter as required for connection to combustion air intake pipe.
5. Air intake piping shall be constructed of -4” pressure class as required in Section 23 3114 - Ductwork

J. Venting:

1. Refer to Section 23 5100 – Smokestack, Breeching and Vent Piping for venting requirements.
2. Boiler smokestack exhausts will be located above the mechanical room where the boilers are to be located. Roof openings and curbs to be coordinated with the architect.

K. Boiler Trim (Each Boiler):

1. Furnish complete water trim including:
   a. ASME Safety Relief Valve set according to the boiler’s working pressure rating.
   b. Combustion pressure-temperature gauge
   c. Operating temperature controls
   d. High limit control
   e. Low Water Cut Out - LWCO to be operationally testable
   f. Stack thermometer
   g. Air pressure switch
   h. Water flow switch
   i. High gas pressure switch
   j. Low gas pressure switch
   k. Blocked condensate drain switch
   l. Actuated isolation valves with end-switches
   m. HHW system supply and return water sensors to be installed in wells by the mechanical contractor and connected to the boiler controller.
   n. Individual boiler outlet water temperature sensors to be connected to the boiler controller.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install units as shown on plans, as detailed, and according to manufacturer's installation instructions.

B. Install all items shipped loose by equipment manufacturer under supervision of equipment manufacturer's field service personnel.

C. Provide all field electrical wiring required in this Section of the specification. Install wiring in metal conduit and in accordance with Division 26 of this Specification and applicable Electrical Codes.

3.02 BOILER-BURNER UNITS (CONDENSING HHW BOILERS)

A. After piping system has been flushed, manufacturer shall provide test, start-up, and adjust procedure as recommended by boiler manufacturer.
B. Manufacturer shall verify in writing that boilers have been cleaned according to their recommendations and are ready for operation.
C. Pipe vents from gas train to atmosphere. Size of each vent shall not be less than connection size to device.
D. Pipe boiler drains to nearest floor drains.
E. Install gas pressure gauges at downstream of gas pressure regulators.
F. Provide remote shutdown switches inside and outside of boiler room where shown and wire into boiler control/safety circuit to shut off fuel or energy supply when activated in accordance with ASME CSD-1.

END OF SECTION

SECTION 237214
HEAT RECOVERY EQUIPMENT

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 23 7323 – Factory Fabricated Custom Air Handling Units
B. Section 23 7400 - Packaged Rooftop Air Handling Units
C. Section 20 0513 – Motors

1.02 REFERENCE

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

1.03 VERIFY INCLUSION AND TERMINOLOGY WITH LEAD DESIGN FIRM.SUBMITTALS

A. Shop Drawings including, but not limited to, the following:
   1. Manufacturer's name and model number
   2. Capacities/ratings/efficiencies
   3. Pressure/temperature rating
   4. Materials of construction
   5. Dimensions and weights
   6. All other appropriate data
   7. Rotor media test reports

1.04 CHECK, TEST AND START

A. Rotary type heat exchanger manufacturer shall provide services of factory trained service engineer to supervise installation and start-up of heat exchangers, and to field measure purge air quantity, seal leakage and heat transfer efficiency. Service engineer shall also instruct Owner's representative in operation and maintenance of unit. Before acceptance by Owner, unit manufacturer's representative shall approve, and certify in writing, the complete installation including ductwork, wiring connections and proper functioning of all operational controls, and unit performance including heat transfer efficiency and air leakage quantities. Start-up shall not be performed until start-up date has been approved by Architect/Engineer.

1.05 WARRANTY

A. In addition to standard warranty, provide factory trained service personnel one year after start-up heat recovery equipment to verify specified heat transfer efficiencies and specified quantities of purge and seal leakage.
B. If at this time energy recovery equipment is not operating in strict accordance with above criteria, manufacturer shall repair or replace non-conforming equipment and/or furnish and install similar equipment and components to replace functions of heat recovery equipment.

PART 2 - PRODUCTS

2.01 AIR-TO-AIR HEAT EXCHANGERS (ROTARY TYPE ENTHALPY WHEEL)

A. General:
   1. Manufacturers: Semco, Thermotech, Novelaire Flakt Woods or Klingenburg.
   2. Unit capacities, efficiencies and operating characteristics shall be as scheduled.
   3. The enthalpy wheel shall recover both sensible and latent heat and be AHRI 1060 certified.
   4. Refer to drawings for dimensions of unit.
   5. Units shall be complete with energy transfer wheels, permanently lubricated bearings, shafts, purge sectors, air-seals, wheel drive motors, motor speed reducers, drive belts, all enclosed in steel casing. Units shall be factory assembled, tested and shipped as one piece.
   6. Unit shall be capable of transferring sensible and latent heat at approximately the same efficiencies and be tested in accordance with ASHRAE 87-78P.

7. The ERM shall include economizer wheel bypass to reduce fan energy usage when energy recovery is not required.
8. The energy recovery section shall feature a rotary energy recovery wheel mounted within a rigid, extruded aluminum framed module containing the wheel drive motor, drive belt, wheel seals, and maintenance free bearings. The module shall be able to slide out for servicing.

B. Transfer Media:
1. Construct transfer media of non-asbestos material and in accordance with NFPA ruling, pass UL 900 flame and smoke tests.
2. The enthalpy wheel shall recover both sensible and latent heat and be AHRI 1060 certified.
3. The matrix shall be a minimum of 8'' thick to achieve optimal performance and be constructed from a corrugated aluminum alloy. The corrugation shall be uniform to obtain minimum pressure drops through the wheel. Wheels with varying flute sizes are not acceptable. Wheels with non-metallic matrices will not be considered for this application.
4. Wheel shall be washable with detergent or alkaline coil cleaner and water. Desiccant shall not dissolve nor deliquesce in the presence of water or high humidity.
5. Design transfer media for laminar airflow and capability of passing solids up to 300 microns.
6. Transfer media shall, when exchanging energy at efficiency listed in schedule, run dry to touch and not require condensate drain for summer or winter operation.
7. Rotor media shall be made of aluminum, which is coated to prohibit corrosion. Media surfaces shall be coated with non-migrating solid absorbent layer prior to being formed to ensure that all surfaces are coated and that adequate latent capacity is provided.
8. Construct rotor of corrugated aluminum treated with inorganic compounds and strengthened with radial spokes for rigidity. Desiccant coating shall be bacteriostatic, non-toxic and non-corrosive. Desiccant carryover shall be limited by coating surface of the aluminum wheel with a polymer coating.
9. Desiccant media shall utilize a specifically treated and coated with Silica Gel desiccant to assist and enhance latent heat transfer or a 3A molecular sieve certified by manufacturer to have internal pore diameter distribution which limits absorption to materials not larger than critical diameter of water molecule, 3.0 angstroms. Rotor media shall be supplied with acid resistant face coating to prevent corrosion.
10. Rotor media shall be provided in segments to allow for field erection or replacement of one section of media at a time without side access. No external pullers or other special tooling shall be required for field assembly or replacement. Media shall be machined to fit in between primary and secondary spoke and guiding flange of outside rim. Each media segment shall be compressed independently of other segments during manufacturing without causing any angular deformation and resulting misfits between spokes and media parts. Results shall be wheel with flatness of ± 1/32". No adhesive or silicone shall be necessary to secure media in place.
11. The structural frame and casing shall be designed and manufactured to allow a maximum rotor deflection of ± 1/32", as measured at the outer radius, during maximum rated airflow and differential pressure conditions.
12. Shaft shall be machined as to provide a shoulder against the bearings for a positive locked position to eliminate any lateral movement of the rotor due to axial bearing loads. Grease fittings shall be easily accessible.
13. Rotor media shall be tested in accordance with ASHRAE Standard 84-91 and ARI Standard 1060-05 by a qualified independent testing laboratory. Testing shall confirm published performance and document that the desiccant material does not transfer pollutants typically encountered in the indoor air environment.

C. Purge and Seals:
1. Furnish units with built-in purge sections, allowing maximum cross contamination of particulates of 0.2% and maximum exhaust air carryover of 0.04% by volume.

2. Provide casing seals on periphery of rotor, as well as on duct divider and purge section.
3. Seals shall be adjustable and constructed on neoprene, held in place with clips fastened to stud welded bolts and compressed by retaining band. Required seal clearance shall be factory set and checked at installation.
4. Rotor seal shall be Labyrinth non-contact seals. Multi-pass seal shall utilize 4 labyrinth stages for optimum performance. Seal system shall be able to withstand pressure differential up to 12” WG without deflecting or causing excessive air leakage. Seals shall be adjustable and set within 0.05” of rotor surface.

D. Drive Assembly and Controls:
1. Units shall be capable of variable speed operation to maintain constant design or scheduled supply air discharge temperature.
2. Manufacturer shall furnish units with all components necessary for control of variable speed operation including drive assembly. The control of the wheel drive shall be integral to the RTU controller. The ERM shall have a dedicated microprocessor controller that is networked to the packaged rooftop unit microprocessor controller.
3. External tapered roller bearings with double set screw locking collars shall be provided and sized for a minimum L-10 life of 219,000 h of operation, and shall be changeable without complete disassembly of the rotor.
4. Wheel speed shall not rotate faster than 20 RPM. Any rotational speed above 20 RPM will be unacceptable since this will reduce the efficiency of the purge section.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install units as shown on drawings, and in accordance with manufacturer's installation instruction.

3.02 AIR-TO-AIR HEAT EXCHANGERS (ROTARY TYPE)

A. Provide solid air separation between the two air streams so that air leakage does not occur through casing. Adjust seals to recommended clearance before operating fans for any purpose.
B. Provide proper filtration of all air streams to protect the operation and cleanliness of the energy recovery wheel.
C. Adjust the wheel seals to provide the scheduled bypass air cfm.

END OF SECTION

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SECTION 237323
FACTORY FABRICATED CUSTOM AIR HANDLING UNITS

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 20 0513 - Motors
B. Section 20 0514 - Variable Frequency Drive (VFD) System
C. Section 20 0529 - Mechanical Supporting Devices
D. Section 20 0700 - Mechanical Systems Insulation
E. Section 23 0550 - Vibration Isolation
F. Section 23 0901A - Control Systems
G. Section 23 2116 - Pipe and Pipe Fittings
H. Section 23 2118 - Valves
I. Section 23 2120 - Piping Specialties
J. Section 23 3314 - Ductwork Specialties
K. Section 23 3400 - Fans
L. Section 23 4114 – Filters
M. Section 23 7214 – Heat Recovery Equipment
N. Section 23 8216 - Coils
O. Section 26 0519 - Low-Voltage Electrical Power Conductors and Cables
P. Section 26 0533 - Raceway and Boxes for Electrical Systems
Q. Section 26 2726 - Wiring Devices
R. Section 26 2816 - Enclosed Switches and Circuit Breakers
S. Section 26 5000 - Lighting

1.02 REFERENCE

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

1.03 SUBMITTALS

A. Shop Drawings for all equipment including, but not limited to, the following:
   1. Appropriate identification
   2. Complete drawings showing plans and sections including details of construction
   3. Overall unit dimensions and individual components and sections dimensions
   4. Shipping and operating weight of unit and/or sections
   5. Structural design load
   6. Details of component support
   7. Capacities/ratings
   8. Materials of construction
   9. Thermal and acoustical performance of wall, roof and floor panels
   10. Pressure ratings and leakage ratings
   11. Thermal break construction details and performance calculations or test data
   12. Each component manufacturer's name, model number and data. (Refer to each component section for submittal requirements.)
   13. Air leakage rates and test data
   14. Wiring diagrams and terminal points for control panels provided with units
   15. Manufacturer’s installation instructions
   16. Air handling unit manufacturer’s local representative and phone number

1.04 DESIGN CRITERIA

A. For housings and floors operating under positive pressure (fan discharge side), maximum allowable deflection shall not exceed 1/200th of any span in any direction at ± 10" WG.

B. For housings and floors operating under negative pressure (fan inlet side), maximum allowable deflections shall not exceed 1/200th of any span in any direction at ± 10" WG.
C. Air handling unit manufacturer shall install all equipment furnished by others and provide all other equipment as specified to result in complete and operational unit. Unit manufacturer shall assume single source responsibility for all air handling unit components and accessories.
D. Furnish units complete with factory controls, fans, piping, valves, piping specialties, actuators, motors, coils, compressors, refrigerant condensing equipment, energy recovery wheels, drain pans, filter sections, damper sections and interior lighting, meeting configuration and as shown on drawings, specified and scheduled. All unit components shall meet this Section of Specification and all requirements specified in each section and division listed under Related Work. Internal control dampers shall be provided by unit manufacturer. External control dampers and actuators shall be furnished by Control Contractor and shall be field-installed by Mechanical Contractor.
E. All materials as applied shall meet NFPA 90A possessing flame spread rating of not over 25 and smoke developed rating of not over 50.
F. Unless otherwise indicated, galvanized steel shall be G90 according to ASTM A924 (formerly ASTM A525), A653 and ASTM A-90 and aluminum sheet shall be 3003-H14 alloy, conforming ASTM B209.
G. Each fan and motor combination shall be capable of delivering 110% of air quantity scheduled at scheduled static pressure without operating into motor service factor.
H. Motor furnished with fan shall not operate into motor service factor in any cases.
I. Where inlet and outlet ductwork at any fan is changed from that shown on drawings, submit scaled layout of the change and system effect factor calculations, indicating increased static pressure requirement as described in AMCA Publication 201. This Contractor shall be responsible for any motor drive and/or wiring changes required as result of duct configuration changes at fan.
J. Air handling unit static pressure to take into consideration actual static pressure loss of components furnished within unit.
K. Wire brush all welds with solvent and wipe clean all bare metal before painting.
L. Air handling unit shall be constructed for outdoor application and shall be designed for roof mounting on concrete curb provided by GC. For outdoor units, allow for snow and wind loading in accordance with the governing building code when calculating allowable deflections.

1.05 FINAL CLEANING

A. Outside and inside of each air handling unit shall be thoroughly cleaned. Use industrial grade cleaners to remove construction dust, sheet metal mill finish or grease. Unit openings shall then be covered with sheet metal or other proper material until ductwork is connected.

PART 2 - PRODUCTS

2.01 MANUFACTURERS (RTU-1)

A. Annex Air (Basis of Design), Haakon, Temtrol, Climate Craft, Ventrol, Climate Craft with operating characteristics as scheduled and physical dimensions as shown on drawings and/or detailed.

2.02 UNIT BASE

A. Unit base shall be fabricated from structural steel or fabricated steel.
B. Weld steel solid at connection points to assure rigidity. Size perimeter steel to allow for rigging and handling.
C. Locate and size base cross supports to support internal components.
D. Add lifting lugs to perimeter steel along the longest length of unit or unit module. Incorporate means of attaching cable or chain into each lug.
E. Lifting lugs shall be removable after placement of equipment.

F. Base shall be split in maximum size pieces to allow for economical shipment to jobsite and placement within building. Provide bolting structural steel on both sides of split for field joining.
G. Unit base shall be fully welded G-90 primed and finished with rust inhibiting epoxy paint.

2.03 UNIT FLOOR

A. Unit floor shall be constructed to meet the maximum allowable deflection, but constructed of no lighter than:
   1. 16 ga plate of galvanized steel or 3/16” aluminum plate with diamond-tread.
B. Floor joints and seams shall be sealed to meet allowable housing leakage rate specified. Use acrylic latex sealant meeting ASTM C834-76 (1981) or polyurethane sealant, ASTM C-920, Type S, Grade NS, Class 25, USDA Approved.
C. Provide recessed drain pans as integral part of unit floor in cooling coils, pre-heating coils section. Entire floor including base drain pans shall be insulated on underside to have same thermal and acoustical performance specified for unit housing. Insulation shall be supported by minimum 20 ga galvanized steel liner with joints sealed to provide continuous vapor barrier.
   1. Drain pans shall be constructed from minimum 16 ga 304 SS sheet with 304 SS drain pipes.
   2. Drain pan shall be double sloped; pitched down in direction of air flow and pitched sideways to drain connection.
   3. Locate drain connections at lowest point of pan, one on either end. Connections shall extend through perimeter base channel and be continuously welded to insure air-tight seal as well as eliminate requirement for backup wrench during field piping. Provide removable cap on each drain connection.

2.04 UNIT HOUSING

A. Unit housing shall be constructed of minimum 2" thick double wall panels meeting thermal, acoustical and structural requirements specified.
B. Panels shall utilize modular panel type construction. Panels may be self-supporting with internal support structure or supported by structural frame work.
C. Panel joints and seams shall be sealed with proper gasket and caulking to meet allowable housing leakage rate specified.
D. Outer face of panels shall be constructed of no lighter than 16 ga galvanized steel and solid inner face of panels shall be constructed of no lighter than 20 ga G90 galvanized steel.
E. Unit casing shall be insulated with minimum 2” thermos-composite foam with R-7 per inch foam insulation. Unit casing will have no exterior condensation at interior AHU temperatures down to 43F while unit exterior conditions are maintained at 95 F dry bulb / 85 F wet bulb.
F. Use solid inner surface for all sections.
G. Provide blank-off panels with proper gaskets and sealants to prevent air bypass around equipment such as filters, coils and energy recovery wheels. Blank-off panels shall be constructed of stainless steel no lighter than 16 ga unless otherwise noted. Blank-off panels at cooling coil sections shall be insulated with 3/4” thick insulation similar to AP Armaflex SA Duct Liner. Do not insulate blank-off panels between cooling coils located above drain pans.
H. Panel Sound Transmission Loss in accordance with ASTM E90 shall equal or exceed the following:

	Octave Band Center Frequency (Hz)					
	125	250	500	1000	2000	4000
Transmission Loss (dB)	19	23	33	43	52	57

I. Entire roof of outdoor units shall be constructed with standing seam water-tight joints and sloped 1/8" per foot.

2.05 ACCESS DOORS

A. Each unit section shall have minimum 20" x 72" access door, unless otherwise specified or shown differently on drawings. Access doors for filter and coil sections shall be minimum 24" x 72".
B. Fan section access door shall be sized to allow removal of fan wheel and motor through door, but not smaller than 30” x 72”. If access door needs to be wider than 36”, removable access panel may be provided.
C. Access doors and door frames shall have similar thermal break construction as specified under Unit Housing.
D. Access doors shall be same construction as housing panels.
E. Access doors shall be guaranteed tight closing through use of seals around entire periphery. Provide neoprene gasket between door frame and housing for air tight seal.
F. Each access door shall contain 1/4" thick wire glass or double glazed tempered glass window minimum size of 12" x 12" or 12" round. Window shall be double paned with vapor seal construction.
G. Each access door shall be furnished with corrosion resistant metal hinges or continuous piano hinge and shall have at least 2 stainless steel or aluminum alloy handles operable from either side.
H. Doors shall open against higher air pressure to effect seal.

2.06 REMOVABLE ACCESS PANELS

A. Removable access panels shall be provided as indicated on drawings and where equipment removal is not possible through access door. Removable panels shall be same construction as housing panels.

2.07 WEATHER HOODS

A. The outdoor intake weather hood shall be completely constructed in aluminum for corrosion resistance. The hood shall ship loose for field installation by the installing contractor. Painted galvanized hoods shall not be acceptable. The outdoor air hood shall be designed with a 4” extruded aluminum louver, bird screen and a plenum enclosure with drain holes. The louver blades shall be drainable type with a maximum 45-degree angle and curved with integral rain baffle. The louver design shall not allow more than 0.03 oz/ft2 water penetration when tested in accordance to AMCA 500. The pressure drop of the complete hood assembly shall not exceed 0.05” wc at a maximum 500 fpm face velocity. A Pre-filter rack system shall be installed within the weather hood enclosure to prevent outdoor air dust and debris from entering the damper and unit casing plenum. Pre-filters installed inside the unit casing plenum and downstream of the outdoor damper will not be acceptable as this will increase overall maintenance on the damper, reduce indoor air quality and promote mold and bacteria growth. Filter access in the hood shall be accomplished via the louver that is installed with a stainless-steel piano hinge and spring loaded latch. No tools or ladders shall be required to access the pre-filters in the weather hood assembly.

2.08 FILTER SECTIONS

A. Filters shall be provided as specified and scheduled. Holding frames shall be installed by unit manufacturer to raise filters off floor and to prevent leakage as specified by unit manufacturer.

2.09 REHEAT COIL SECTION

A. Provide heating hot water reheat coils, piping and internal piping as specified and indicated on drawings.
B. Terminate piping outside of unit casing for connection by Mechanical Contractor. Provide necessary pipe supports and hangers.
C. Each coil shall be supported by galvanized steel frame which is independent of unit casing. Support frame shall allow individual coil removal. Coils shall be removable through unit access doors. Blank-off panels shall be galvanized steel sheets with insulation as specified.

2.010 ENERGY RECOVERY SECTION

A. Refer to Section 23 7214 – Heat Recovery Equipment.
B. The energy recovery section shall feature a rotary energy recovery wheel mounted within a rigid, extruded aluminum framed module containing the wheel drive motor, drive belt, wheel seals, and maintenance free bearings. The module shall be able to slide out for servicing.
C. The energy recovery system shall include economizer wheel bypass dampers to reduce fan energy usage when energy recovery is not required. The air handler shall be furnished with an outside air intake enthalpy sensor that shall be connected to the unit controller to determine when the energy recovery wheel should be bypassed.
D. Wheel shall be washable with detergent or alkaline coil cleaner and water. Desiccant shall not dissolve nor deliquesce in the presence of water or high humidity.
E. The energy recovery system shall have a dedicated microprocessor controller that is networked to the packaged rooftop unit microprocessor controller.

2.011 AIR COOLED CONDENSING UNIT WITH VARIABLE SPEED COMPRESSORS

A. Provide an integral air cooled condensing section with variable speed compressors. The condensing section shall be factory piped, wired, and charged with R-410A refrigerant. The section shall be from the same manufacturer as the air handling unit. Factory mounting and piping an air cooled condensing unit, provided by a third party is not acceptable. The, the exterior cabinet of the air-cooled section shall be of the same construction and paint color as the air handling unit. Compressors shall be variable speed scroll type that can modulate from 25% to 100% capacity per compressor. Variable capacity compressors which do not modulate the speed of the scrolls are not considered equal to a variable speed scroll since they consume more energy at the same capacity output. Mechanically stepped scrolls which are unloaded via a digital signal to a solenoid valve, in a timed sequence, will not be acceptable for this application. The variable speed scrolls shall be operated via a factory supplied variable speed controller per compressor, and all tandem compressors will modulate in unison. Using a single variable speed controller on the lead circuit alone is not efficient during part load conditions, therefore will not be acceptable for this application. Each compressor and controller assembly shall be equipped with the following features: permanent magnet motor, electronic expansion valve, a crankcase heater function, anti-short cycling, built-in phase loss detector, EMC filter, oil return management system, and reverse rotation protection. All refrigeration parts, including the compressor and the speed controller will be located in a closed and vented service compartment, separate from the condenser coil airflow. Compressors located in compartments open to the outside are not acceptable. Compressors shall be mounted on rubber isolators to limit vibration transmission and shall include flexible hoses on both the suction and discharge refrigeration lines. Flexible hoses shall be pressure tested up to 620 psig. All air cooled condensing units above 18 tons will have a minimum of two compressors. Condenser fans shall have 7 air foil type blades with external mounted asynchronous motors that are Class F insulated, IP54 and 100% variable speed. Each condenser fan bank shall be provided with a variable voltage controller which modulates via refrigerant head pressure control for superior part load performance. All the condenser fans in a fan bank shall modulate in unison for each respective circuit. Staging condenser fans are not an acceptable mode of control for head pressure control. Protective guards shall be included on all condenser fans, and condenser coils. The coil protective guards shall be ideal to keep coil at maximum operating performance, protect the condenser from hail damage and allow for easy cleaning with quick release latches. The condenser coils shall be micro-channel design for maximum efficiency performance, consist of a single pass arrangement with integral receiver, and be pressure tested at 650 psig. Coil construction shall consist of aluminum alloys for the fins, tubes and manifolds. Copper tube, aluminum fin condenser coils are not acceptable as they require more refrigeration charge for the same capacity output. The following components shall be included in each

refrigeration circuit: Liquid line filter dryer, hi and low-pressure switch, hi and low-pressure transducers, suction and liquid lines shutoff valves and suction line accumulators. In addition, refrigeration piping must use Shrader type connections for all components, including but not limited to valves and transducers. Under no circumstances shall the units leave the factory without a complete run test and a copy of the QC report shall be provided upon request. Minimum (5) five-year compressor warranties shall be provided. Hot Gas reheat coil shall be installed down stream of direct expansion coil. The control for the hot gas reheat shall be full modulation type for humidity control. Receiver shall be provided and installed to store excess refrigerant in part load operation. Coil shall be same construction as heat pump air side coil.

2.012 DX COIL SECTIONS

A. Provide cooling coils, piping and piping specialties specified, and indicated on drawings.
B. Terminate piping outside of unit casing for connection by Mechanical Contractor. Provide necessary pipe supports and hangers.
C. Coils shall be factory installed in the unit. Coils shall be designed with respective circuits to match the design requirements. All coils shall have a distributor per circuit connection. Primary surface shall be round seamless (3/8” O.D.) copper tube staggered in the direction of airflow. Secondary surface shall consist of rippled aluminum plate fins for higher capacity and structural strength. Fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Tubes shall be mechanically expanded into the fins to provide a continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates. Casing shall be constructed of continuous 304 stainless steel. Coils shall be circuited for counter-flow heat transfer to provide maximum mean effective temperature difference for maximum heat transfer rates. Headers shall have intruded tube holes to provide a large brazing surface for maximum strength and inherent flexibility. The complete coil shall be tested with 315 pounds air pressure under warm water and be suitable for operation at 250 psig working pressures. Maximum finned coil height shall be 60” and shall not exceed 500 FPM face velocity. Drain pan shall be provided on cooling coils. Cooling coils shall sit on stainless steel tubular support rails, which shall stand a minimum of (2) two inches above the highest point of the floor drain pan. Stacked coils shall be provided for larger airflows and intermediate drain pans shall be provided for each coil bank. Drain pans shall be stainless steel with 1.5” stainless steel drain connections on one side only. Pan shall be sloped in two planes. All coils shall be certified in accordance with ARI standard 410.
D. Each coil shall be supported by a 304 stainless steel frame which is independent of unit casing. Support frame shall allow individual coil removal. Coils shall be removable through unit access doors or removable access panels. Blank-off panels shall be 304 stainless steel sheet with insulation as specified.
E. Each coil support shall include minimum 16 ga 304 stainless steel all welded condensate drain pan extending minimum 6”, but no more than 12" downstream of coil face. Each drain pan shall have sufficient depth to hold condensate water but not less than 2”. Drain pan shall be sloped in 2 directions (pitched down in direction of airflow and pitched sideways to drain connection) for self-drainage at minimum 1/4"per foot slope. Drain pan shall be individually piped down to drain pan located below, and bottom drain pan to be piped to hub drain at exterior of unit. Drain connection opening shall be flush with bottom of pan. Side pan connection located at lowest point of pain may be used only where bottom pan connection cannot be used. Drain pipe shall be 304 stainless steel with sufficient size, but not less than 1-1/2”.
F. Instead of drain pan under bottom coil, recessed pan, integral with unit floor may be used. It shall be constructed as specified above including thermal insulation and drain lines, and shall incorporate required drain trap height. The drain pan shall be of sufficient length downstream from the coil to collect all condensate water that leaves the cooling coil.

2.013 FAN SECTION

A. Fan and motor shall be provided as scheduled and meet requirements of appropriate specification sections.
B. Fan and motor shall be factory mounted on vibration isolation equipment meeting requirements of Section 23 0550 - Vibration Isolation. Vibration base shall include integral adjustable motor base.
C. Vibration isolation base shall have seismic restraints capable of containing fan in all directions with up to 1G of force applied.
D. Provide track in fan section suitable for use with trolley-type winch, to be used for removing fan motor. Track shall be centered with fan section access door.
E. Unit manufacturer shall provide flexible connection between fan and discharge wall. Unit manufacturer shall provide 1 set of additional sheaves as required to balance unit. Installation of any additional sheaves shall be responsibility of Balancing Contractor.
F. The fans shall be carefully positioned and installed at an optimal distance to respect uniform airflow across the heat exchanger & coil(s).
G. Plenum Fans ER model: Fans shall be direct drive radial centrifugal fans with free running impeller.
H. Fan array will require to be operated by one VFD per fan, and each fan shall be provided with a backdraft damper that shall close in the event of a fan failure. Individual fan VFDs are not required to be provided with bypass starters.
I. Plenum fan shall come equipped with guard grilles for the air intake side.

2.014 DISCHARGE AIR SECTION

A. Provide with framed discharge opening or spun bellmouth fitting conforming to size and configuration of the ductwork.

2.015 FLOOR OPENING PROTECTION

A. Floor shall have safety grates using 1” x 1/8” steel bar stock on 1-1/4” center spacing. Grates shall have same finish as floor. Provide 1-1/2” lip of galvanized steel at entire perimeter of opening.

2.016 ROOF CURB

A. Curbs shall be Mason, Type RSC or equal
B. Construct roof mounting curb to mate and seal with unit casing base. Curb to have minimum height of 12”.
C. Construct curb to support perimeter of entire unit. Form top curb members to provide counter flashing.
D. Curb mounted roof top equipment shall be flexibly ducted. Units shall be supported by spring isolation curb, lower member of which is rigid steel tube or specially formed steel section containing adjustable and removable steel springs that support upper floating section. Upper frame must provide continuous support for equipment and must remain captive when resiliently resisting wind and seismic forces. Directional neoprene snubber bushings must be minimum of 1/4” thick. Steel springs shall rest on 1/4” neoprene acoustical pads. Hardware must be cadmium or zinc electroplated and springs similarly plated or provided with approved rust resistant finish. Springs shall have minimum 2-1/2” deflection. Spring type isolators shall be free standing and laterally stable without any housing. Mountings shall have leveling bolts rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of compressed height of spring at rated load and shall have minimum additional travel to solid equal to 50% of rated deflection. Ratio of lateral to vertical stiffness of vibration isolators shall not be less than 0.8 or greater than 2.0.
E. Curb's waterproofing shall consist of continuous galvanized flexible counterflashing nailed over lower curb's waterproofing and joined at corners by EPDM bellows. Spring locations shall have

access ports with removable waterproof covers. Lower curbs shall have provision for 2" insulation.

~~A. Unit manufacturer shall furnish roof curb. Roof curb shall be 18" high and constructed from minimum 12ga galvanized steel. At each of 4 corners, curb shall be joined together with corner post that is welded to one section of curb and then field bolted to adjacent section. Wood nailer shall be attached to inside flange of curb for field attachment of flashing and roof membranes.~~

~~B. Roof curb and anchoring system shall be designed to comply with state and local building and wind load requirements.~~

~~C. Curbs to be approved by National Roofing Contractors Association and shall be designed to meet local and state wind load requirements.~~

~~D. Insulation: The roof curb shall be fully insulated with 1-1/2 inch, 3 lb. density acoustical and thermal insulation. The insulation shall be fiberglass with a foil face.~~

~~E. Gasketing: Curb gasketing shall be furnished with the curb and is to be affixed to the curb immediately before mounting of the rooftop unit to provide an air seal.~~

2.017 CONTROLS

A. The unit shall be delivered with factory installed control system. Under no circumstances shall the unit controls be provided by other than the manufacturer of the AHU equipment. Field installed control package will not be acceptable. The control system shall consist of a microprocessor with LCD display, 7-day time clock, 20-day holiday schedule, occupied/unoccupied mode switch, warm up mode, cool down mode, hi-lo limit discharge control, fan status, temperature and humidity sensors when applicable, scroll buttons to change settings as required and alarm history. The control system main purpose will be as specified on the Sequence of Operation.

B. Supply air temperature and humidity sensors shall be provided and be field mounted in the supply duct and wired by others. Space temperature and humidity wall mount sensors shall be provided, field mounted and wired by others as part of the BAS controls. Terminals for remote control shall be provided for entire unit ON/OFF, OCCUPIED/UNOCCUPIED mode selection and alarm contact. Refer to the Sequence of Operation and control schematic for detailed description and options.

C. The control microprocessor shall communicate with the BAS with a Bacnet MS/TP interface.

D. Control devices, will be furnished by Control Contractor and shall be factory installed by unit manufacturer as shown on plans and as described in control section of specifications.

E. Control devices will be provided by Control Contractor. Unit manufacturer shall coordinate with Control Contractor and provide sleeved openings on unit housing for control devices as required and as shown on drawings.

F. VFDs - VFDs will be used to set or regulate the fan speed and airflow for these units. The VFDs will modulate fan speed to maintain setpoint duct static pressures as measured by duct mounted pressure sensors. The VFD shall also have PID function for constant flow applications. The VFDs will be installed with integral brake transistor, overload protection, and adjustable pulse-width modulation (PWM). The VFD shall use Insulated Gate Bipolar Transistor (IGBT) technology to convert three phase input power to coded PWM output and have 4-20mA analog output terminals that are fully programmable for variable flow applications. The VFD shall be equipped with a keypad with status indicators, easy access functions, and monitoring functions during motor operation. In the event of a momentary power failure or fault the VFD shall read the inverter speed and direction of a coasting motor and shall automatically restart the motor smoothly. Technical support will be provided by the VFD manufacturer. VFDs shall be installed as shown on drawings with contactors, relays, and all specified accessories. Fan array VFDs will be installed without a bypass.

2.018 TESTING

A. Owner and/or Owner's representative may elect to witness tests. Notify Owner and/or Owner's representative of test date at least 2 weeks in advance. Submit certified test data to Engineer for approval.
B. Unit manufacturer shall provide factory tests to verify casing leakage after units are assembled.
C. Unit manufacturer and installing contractor shall jointly provide field tests to verify casing leakage after units are installed at jobsite. Coordinate with Electrical Contractor for power to unit test fan.
D. Casing leakage tests shall verify that unit casing leakage is less than 1% of design air flow at 10" WG static pressure.

2.019 ELECTRICAL SERVICE

A. Provide adequate lighting and switching so equipment can be observed and maintained in safe manner. Combination lighting and convenience outlet circuit is required for each section of unit. Each access section shall contain a minimum of one light fixture. Sections wider than 12 ft shall have multiple light fixtures with maximum spacing of 6 ft.
B. Lights, switches, convenience outlets, wiring and conduit shall meet requirements of appropriate specification sections of Division 26.
    1. Provide one central light switch with pilot light for all sections. Locate switch near power connection point.
    2. Provide timer for light switch to automatically turn off lights after preset time. Timer shall be similar to Intermatic Model FF2H with 0-2 hr range and hold feature to override automatic shut-off function.
C. Wiring and conduit inside of unit shall be provided by unit manufacturer meeting requirements of appropriate Specification Sections of Division 26.
    1. Provide junction box for each fan motor at outside of unit wall for 3-phase, 480 V power connection and separate junction box for single-phase, 120 V power connection.
    2. Provide two points of power connection, one for 3-phase, 480 V and one for single-phase, 120 V power connection.
D. POWER AND SAFETY CONTROL
    A. The power and control center shall be integral to the unit housing and rated equivalent to NEMA 3R. Under no circumstances shall any wiring or parts be field installed. Panels that are externally mounted to the unit shall not be accepted, regardless of the NEMA rating they may have. A separate access door shall be provided with an approved locking device. All electrical components contained in the panel shall be UL/CSA certified and labeled. The unit shall be complete with VFDs, fuses, overloads; one VFD per fan w/backdraft isolation dampers on the fan inlets, relays, phase protection for compressorized units, terminals for main ON/OFF and step-down transformer. All components shall be factory wired for single point power connection by the manufacturer of the unit. A non-fused safety disconnect switch shall be factory installed for ON/OFF servicing. An electrical pipe chase for power and control feeding shall be provided next to the control panel. Any power or control wiring that is field installed shall not be accepted under any circumstances. The Short Circuit Current Rating (SCCR) is 5kA rms symmetrical, 600V maximum.

2.020 UV (ULTRA VIOLET) - C EMITTERS:

A. Manufacturers: Steril-Aire, Inc., UVDI, or American Ultraviolet. Assembly shall be equal to Steril-Aire Model DE.
B. Provide UVC emitters at downstream side of coiling coils and above drain pans in air handling units as scheduled to control airborne and surface microbial growth and transfer.
C. Emitters shall comply with UL Standard 1995 as applicable to usage of UVC emitters in HVAC equipment.

D. Emitters shall be independently tested under typical HVAC conditions and in accordance with ANSI/ASQCZ1.4. Total output per 25 mm(1") arc length shall not be less than 9 μW/cm^2 at one meter in 2.0 m/s(400 fpm) airstream of 32ºC(50ºF) air.
E. UVC emitter and fixture shall consist of housing, power source, reflector, emitter sockets and emitter tube and shall be constructed to withstand HVAC environments.
F. Housing shall be constructed of 304 or 316 stainless steel with 13 mm(1/2") electrical knockouts on both ends to simplify gang wiring and wiring to power. It shall incorporate components into one integral assembly that maximizes serviceability and radiant flux.
G. Reflector shall be constructed of heavy gauge, spectral finished aluminum alloy with minimum 85% reflectance at 254 nm UVC energy.
H. Emitter shall be of high output, hot cathode, T5 (15 mm) diameter, medium bi-pin type, capable of producing 95% of energy at 254 nm in air flow velocity to 5.0 m/s(1000 fpm) at temperature of 1ºC to 66ºC(35°F - 150°F). UVC emitters shall produce no ozone or other secondary contamination. Useful emitter life shall not be less than 9000 h, with no more than 40% output loss at end of one year of continuous use.
I. Irradiance: Provide UVC lamps and fixtures in sufficient quantity to irradiate coil surfaces and air stream with no shadows and with minimum UVC irradiance at every point along face of coil at not less than 1225 μW/cm^2 at design cooling conditions with bulb mounted 300 mm(12") from coil face.
J. UVC Monitoring: Provide NIST traceable UV Radiometer consisting of solid state photodiode UV sensor and externally mounted controller with visual indicators of UVC output and contacts for BAS communication. Controller must have ability to read real-time UVC energy levels by display module with minimum 89 mm(3.5") digit LCD screen/panel. Irradiance range shall be 0-1999 (x10) μW/cm^2 with resolution of 10 μW/cm^2. Calibration wavelength shall be 254 nm with accuracy ±10%.

2.021 PIPED SERVICE

A. All piping and equipment installation shall be complete. Piping shall be installed and tested per appropriate specification section. Unit manufacturer shall be responsible for any leaks, which occur in unit during system testing which occurs before system startup.
B. AHU manufacturer to provide an internal pipe chase for HHW piping to enter the casing through the inside of the roof curb.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Units shall be assembled in modules in unit manufacturer's plant to allow for testing of complete unit.
B. Unit manufacturer shall supervise and be responsible for all field joining of the modules, including sheet metal, electrical and piping. Local trades may provide labor for unit assembly and installation.
C. Joints in floor between modules shall be air and water tight.
D. Unit manufacturer shall provide and install all equipment within unit as specified including fans, motors, coils, humidifiers, dampers, sound attenuating devices, piping, piping specialties, ductwork specialties, lights, switches and all equipment necessary to complete air handling equipment contained within housings. Mechanical and electrical connections (i.e., piping and conduit) shall be stubbed through housing so that appropriate contractor may provide service to air handling unit. Electrical wiring and control wiring shall terminate in junction boxes on accessible side of unit.
E. Provide structural steel sub-base as required. Refer to Unit Base in Part 2.
F. Field mounting of any equipment on housing walls or roof is not allowed without prior approval of Engineer.

G. Unit manufacturer and Installing Contractor shall coordinate with other trade Contractors, all necessary requirements to assure proper air handling unit installation.

3.02 PROTECTION OF OPENINGS

A. Protect openings on housings during construction against entry of foreign matter and construction dirt.

3.03 FIELD TESTING

A. Unit manufacturer and Installing Contractor shall jointly perform field casing leakage tests on each completed housing assembly as previously specified and shall be responsible for repair of all leaks. Submit certified test data to Engineer for approval.

3.04 UVC EMITTERS

A. Install UVC Emitters at outlet of cooling coils and above drain pans in accordance with manufacturer's instructions of installation, placement, wiring and testing.

B. Provide interlock switch on access door to UVC Emitters to turn Emitters off when access door is opened.

END OF SECTION

SECTION 237400
PACKAGED ROOFTOP AIR HANDLING UNITS

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 20 0513 – Motors
B. Section 20 0514 – Variable Frequency Drive (VFD) System
C. Section 23 0550 - Vibration Isolation
D. Section 23 7214 – Heat Recovery Equipment
E. Section 23 0901A – Controls Systems

1.02 SUBMITTALS

A. Shop Drawings including, but not limited to, the following:
   1. Manufacturer's name and model number
   2. Identification as referenced in the documents
   3. Capacities/ratings
   4. Materials of construction
   5. Inlet and discharge sound power levels
   6. Filters; size, efficiency
   7. Fans; type, drives
   8. Motor data (refer to Section 20 0513 - Motors)
   9. Power and control wiring diagrams
   10. Vibration isolation furnished with units
   11. Dimensions and weights
   12. Manufacturer's installation instructions
   13. All other appropriate data
B. Fan curves shall include a series of curves indicating relationship of cfm and static pressure for various rpm and brake hp curves. Indicate design operating point clearly on fan curves.

1.03 DESIGN CRITERIA

A. Design units specifically for outdoor rooftop application.
B. Units to be completely factory assembled and run tested, piped, internally wired, fully charged with refrigerant and compressor oil when specified, and shipped in one piece. Provide factory wired non-fused disconnect switch.
C. All units shall be factory run tested to check cooling operation, fan and blower rotation and control sequence.
D. Furnish units complete with all components, accessories, and operating and safety controls to provide the intended performance as specified in this section, as shown on drawings and/or as scheduled.
E. V-belt drives shall be designed for 150% of motor rating.
F. Insulation and liners to meet NFPA-90A requirements.
G. Unit shall be UL Listed and carry UL Label.
H. Cooling and/or heating coils to be rated in accordance with AHRI Standard 410.
I. Each fan and motor combination shall be capable of meeting both of the following conditions while maintaining stable fan performance:
   1. Deliver 110% of air quantity scheduled at scheduled static pressure.
   2. Unit static pressure shall take into consideration actual static pressure loss of components furnished within unit.
J. Fan motor shall not operate into motor service factor in any case. Drive efficiency shall be considered in motor selection according to manufacturer's published recommendation, or according to AMCA Publication 203, Appendix L.
K. Where inlet and outlet ductwork at any fan is changed from that shown on the drawings, submit scaled layout of the change and system effect factor calculations, indicating increased static

pressure requirement as described in AMCA Publication 201. This Contractor shall be responsible for any motor, drive and/or wiring changes required as result of duct configuration changes at fan.

1.04 TEST REPORTS

A. Manufacturer or manufacturer's representative shall field check, test and start all units after they have been properly installed. Component systems to be run and adjusted to perform quietly and efficiently at capacities scheduled.

B. Manufacturer or his representative shall provide services to field instruct and check unit operation and control of complete system. Instruction shall not take place until HVAC system has been field checked, tested, started and balanced. Manufacturer shall establish instruction dates, and give Engineer and Owner 10 days written notice of the time. Instruction shall be deemed completed when affidavit of instruction has been signed by representative of manufacturer and Owner.

1.05 OPERATION AND MAINTENANCE DATA

A. Refer to Section 20 0000 - General Mechanical Requirements

1.06 GUARANTEE

A. Manufacturer and Contractor shall provide an extended warranty on rooftop units for a period of 5 yr after acceptance by Owner.

B. Warranty shall include all cost of parts and labor for any and all work unit manufacturer and/or contractor has to accomplish to repair malfunctioning unit or piece of equipment furnished by unit manufacturer. Warranty shall not cover normal maintenance such as changing of filters, cleaning of coils, and replacement of belts and lubrication of bearings.

PART 2 - PRODUCTS

2.01 PACKAGED ROOFTOP AIR HANDLING UNITS~~, (RTU-2)~~

A. Manufacturers:

1. Modine, Aaon, Addison, Valent, or Desert Aire
2. Equal to manufacturer's model with capacity and operating characteristics as scheduled.
3. Provide manufacturer’s non-prorated five-year extended warranty.
4. Packaged rooftop unit shall include complete system controls, motor VFDs, electric heating section, refrigerant cooling, hot gas reheat section, filters, supply fans, dampers, exhaust fans, and energy recovery wheels as scheduled.
5. Unit shall be provided with bottom discharge and exhaust/return air openings as shown on plans. All openings through the base pan of the unit shall have upturned flanges of at least 1/2 inch in height around the opening.

B. Casings:

1. Casing, access doors, and roof shall be completely weatherproof and constructed of heavy 18-gauge exterior, 20-gauge interior, double-wall galvanized or phosphatized zinc-coated steel with baked enamel finish and thermal break design at panel frames, joining mullions, base, corners, and access doors.
2. Casing panels, access doors, and roof shall be insulated with 2-inch thick, 2 pound per cubic foot glass fiber or rigid polyurethane foam insulation. Casing panels, access doors, and roof shall have minimum thermal resistance of R-13. All products as applied shall meet the requirements of NFPA 90A, possessing flame spread rating of not over 25 and smoke developed rating of not over 50.
3. Access doors shall be provided for access to filters, dampers, coils, fans, energy recovery wheels, and electrical and controls components. Access doors shall be double wall, heavy gauge galvanized steel complete with full-length corrosion-resistant piano hinges and stainless steel, aluminum, or zinc fasteners to secure door. Access doors and removable panels shall have neoprene gaskets.

4. Cabinet base to be constructed to mate and seal with the roof mounting curb. Provide sealing gasket for positive, waterproof seal when unit is installed on curb.
5. Unit roof shall be sloped for positive drainage.
6. Furnish access doors, exhaust and outside air hoods with rain gutters to protect openings.
7. Outside air openings shall be provided with 1-inch aluminum mesh screens and rain hoods to prevent entry of water.

C. Supply and Return/Exhaust Fans:
1. Backward curved plenum type with adjustable motor sheaves, statically and dynamically balanced and factory tested.
2. Entire fan and drive assemblies to be mounted on a common base and be completely isolated from the unit by factory mounted vibration isolators.
3. Mount fan wheels on solid steel shafts having self-aligning 200,000 h average life permanently lubricated bearings.
4. Fan motors shall be Open Drip Proof (ODP), inverter duty rated for use with Variable Frequency Drives (VFD), and shall meet the requirements of Section 20 0513 - Motors. Motor horsepower and voltage shall be as scheduled.
5. VFDs furnished shall meet the requirements of Section 20 0514 Variable Frequency Drives.

D. Return-Exhaust Air Section:
1. Unit shall include ~~100% outside air economizer consisting of~~ a motor operated outside air damper and return air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge seals and aluminum end seals. Damper blades shall be gear driven and designed to have no more than 20 cfm of leakage per sq ft. at 4 in. w.g. air pressure differential across the damper. Low leakage dampers shall be Class 2 AMCA certified, in accordance with AMCA Standard 511. Damper assembly shall be controlled by spring return actuator. Unit shall include outside air opening bird screen, outside air hood, and barometric relief dampers.

E. Filters:
1. Filters to be integral part within unit and to be easily accessible from unit via hinged access doors.
2. Filters to be of size, thickness, and capacity scheduled.
3. Unit shall include 2-inch or 4-inch thick, filters with a MERV-11 rating for all outside air intake and return air filters ahead of the energy recovery wheel, and a MERV-13 final filter upstream of the cooling coil and the energy recovery wheel.
4. Unit shall include a clogged filter switch and a Magnehelic gauge mounted in the controls compartment.
5. In addition, furnish 2 sets of filters to be used during construction and initial startup periods.

~~F. Energy Recovery Sections~~
~~1. Refer to Section 23 7214 – Heat Recovery Equipment.~~
~~2. The energy recovery section shall feature a rotary energy recovery wheel mounted within a rigid, extruded aluminum framed module containing the wheel drive motor, drive belt, wheel seals, and maintenance free bearings. The module shall be able to slide out for servicing.~~
~~3. The ERM shall include economizer wheel bypass to reduce fan energy usage when energy recovery is not required.~~
~~4. Wheel shall be washable with detergent or alkaline coil cleaner and water. Desiccant shall not dissolve nor deliquesce in the presence of water or high humidity.~~
~~5. The ERM shall have a dedicated microprocessor controller that is networked to the packaged rooftop unit microprocessor controller.~~

~~G.~~F. Refrigerant Cooling:
1. Direct expansion type, factory charged with R-410A refrigerant and fully tested. System to include refrigeration compressors, evaporator coil, air cooled condenser assembly, thermal

expansion valves, liquid line valves, sight glass, filter drier, liquid and suction line service valves, and insulated interconnecting refrigerant piping.

2. Evaporator coils to be of non-ferrous construction with seamless copper tubes mechanically bonded to configurated aluminum fins mounted in a 304 stainless steel frame. Furnish adequate refrigeration circuits, each with thermostatic expansion valve and solenoid valve for proper system part load operation.
3. Furnish unit with fully insulated drain pan fabricated from minimum 16-gauge 3014 stainless steel with an additional coat of insulating sealer. Extend drain pan into fan section.
4. Compressor to be hermetic scroll, or semi-hermetic type, designed to operate 1750 rpm.
5. Compressors shall be isolated from the base pan with the compressor manufacturer's recommended rubber vibration isolators, to reduce any transmission of noise from the compressors into the building area.
6. Unit shall include a variable capacity scroll compressor on the lead refrigeration circuit which shall be capable of modulation from 25-100% of its capacity.
7. Condenser coils shall be seamless copper tubing mechanically bonded to heavy-duty configurated aluminum fins. Condenser coils of aluminum tubes and aluminum fins constructed with Microchannel coil technology will be acceptable. Condenser fans to be propeller type with exposed fan and shaft surfaces suitably weatherproofed. Fan motors to be furnished with normal and current overload protection.
8. Refrigeration operating on safety controls to include high and low pressure cutout, oil pressure cutout, non-recycling pump down; manual lockout reset relay, compressor overload protections, magnetic contractors and low voltage control transformer.
9. Furnish each unit with fully automatic compressor cylinder unloading capacity control system.
10. Lead refrigeration circuit shall be provided with hot gas reheat coil, modulating valves, electronic controller, supply air temperature sensor and a control signal terminal which allow the unit to have a dehumidification mode of operation, which includes supply air temperature control to prevent supply air temperature swings and overcooling of the space.
11. Vibration Isolation: Compressor(s) shall be mounted on the compressor manufacturer's recommended rubber vibration isolators to reduce transmission of vibration to the building structure.
12. Internal Overload Protection: Compressor(s) shall include internal thermal overload protection to protect against excessive motor temperatures.
13. Crankcase Heater: Compressor(s) shall include a crankcase heater to protect against liquid flood-back and the elimination of oil foaming on startup.

~~H.~~G. Condensers:

1. Weatherproof vertical discharge, direct drive propeller condenser fans with permanently, lubricated ball bearings and built-in thermal overload protection.
2. Condenser fans shall be VFD driven variable speed for condenser head pressure control. Factory provided and factory programmed VFDs shall continuously modulate the fan air flow to maintain head pressure at acceptable levels. Cooling operation shall be allowed down to 35°F with adjustable compressor lockouts.
3. Coils shall be multi-pass and fabricated from aluminum microchannel tubes or coils shall be constructed of copper tubes with aluminum fins mechanically bonded to the tubes and aluminum end casings.
4. Condenser Coil Orientation: The condenser coil shall be sloped approximately 60° from horizontal to protect the coil from hail damage.
5. Condenser Coil Coating: The micro-channel aluminum fin/tube condenser coil will have a flexible epoxy polymer e-coat uniformly applied to all coil surface areas with no material bridging between fins. The coating process will ensure complete coil encapsulation and a

uniform dry film thickness from 0.6 – 1.2 mils on all surface areas including fin edges and meet 5B rating cross-hatch adhesion per ASTM B3359-93. Corrosion durability will be confirmed through testing to no less than 5,000 hours salt spray resistance per ASTM B117-90 using scribed aluminum test coupons. Coils subjected to ultraviolet (UV) exposure will receive a spray-applied, UV-resistant urethane mastic topcoat to prevent UV degradation of epoxy e-coat film.

~~I. Electric Heating Section:~~

~~1. The heating section shall be complete with fuses, a high temperature limit switch, and fully modulating SCR (Silicon Controlled Rectifier) capacity control. An airflow proving switch is monitored to ensure proper airflow before the heating circuit is energized.~~

~~J.~~H. Dampers

1. Provide factory mounted and wired motorized isolation dampers for return air, outside air, and exhaust air streams. Damper assemblies shall have extruded aluminum, hollow core, airfoil blades with rubber edge seals and aluminum end seals. Damper blades shall have maximum leakage of 4 cfm per sq. ft. of damper area when subjected to 1 inch WG air pressure differential across the damper. Damper assembly shall be controlled by spring-return fail closed actuator and a field wired control signal.

~~K.~~I. Roof Mounting Curbs:

1. Curbs shall be Mason, Type RSC or equal
2. Construct roof mounting curb to mate and seal with unit casing base. Curb to have minimum height of 12".
3. Construct curb to support perimeter of entire unit. Form top curb members to provide counter flashing.
4. Curb mounted roof top equipment shall be flexibly ducted. Units shall be supported by spring isolation curb, lower member of which is rigid steel tube or specially formed steel section containing adjustable and removable steel springs that support upper floating section. Upper frame must provide continuous support for equipment and must remain captive when resiliently resisting wind and seismic forces. Directional neoprene snubber bushings must be minimum of 1/4" thick. Steel springs shall rest on 1/4" neoprene acoustical pads. Hardware must be cadmium or zinc electroplated and springs similarly plated or provided with approved rust resistant finish. Springs shall have minimum 2-1/2" deflection. Spring type isolators shall be free standing and laterally stable without any housing. Mountings shall have leveling bolts rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of compressed height of spring at rated load and shall have minimum additional travel to solid equal to 50% of rated deflection. Ratio of lateral to vertical stiffness of vibration isolators shall not be less than 0.8 or greater than 2.0.
5. Curb's waterproofing shall consist of continuous galvanized flexible counterflashing nailed over lower curb's waterproofing and joined at corners by EPDM bellows. Spring locations shall have access ports with removable waterproof covers. Lower curbs shall have provision for 2" insulation.

~~1. The unit shall be supplied with a fully assembled, field installed roof curb with welded mitered corners and internal support channels. Construct roof mounting curb to mate and seal with unit casing base. Curb to have minimum height of 18".~~

~~2. Construct curb to support perimeter of entire unit. The curb shall be constructed of 14 gauge G90 galvanized steel and include 1" x 4" pressure treated wood nailing strips and 20 gauge galvanized steel sheet metal flashing. Form cross section of curb members to accept wood nailing strips and insulation. Form top curb members to provide counter flashing. The curb shall be designed for the pitch of the roof on which the unit is to be installed to provide a level unit.~~

~~3. Curbs to be approved by National Roofing Contractors Association and shall be designed to meet local and state wind load requirements.~~

~~4. Insulation: The roof curb shall be fully insulated with 1-1/2 inch, 3 lb. density acoustical and thermal insulation. The insulation shall be fiberglass with a foil face.~~

~~5. Gasketing: Curb gasketing shall be furnished with the curb and is to be affixed to the curb immediately before mounting of the rooftop unit to provide an air seal.~~

~~L.~~J. Electrical:

1. Furnish each unit with factory mounted disconnect device with short circuit and over current protection, and variable speed drives.
2. Power Connections: Control center shall be constructed to permit single-point high voltage power supply connections.
3. Wire Management: All wiring is to be run in conduit that is located between the unit ceiling liner and roof casing with drops from the ceiling to keep wires clear of other internal components, prevent accidental damage to wiring during service, and improve cleanliness of unit interior.
4. Wiring Diagram: The unit shall have a job specific wiring diagram affixed to the interior of the control compartment access door.
5. Convenience Outlet: Unit shall be provided with a factory installed and wired 115 volt, 13 amp ground fault service receptacle mounted on the exterior of the unit casing and powered by a 1.5kVA transformer with disconnect switch in the unit control panel.
6. Motor horsepower and voltages shall be as scheduled.
7. Unless otherwise indicated, units consisting of multiple fans and motors shall be factory pre-wired with the components listed herein. Each unit shall be designed to accept a single-point power connection for incoming line voltage power wiring.
8. Phase/Voltage Failure Relay: The unit shall be provided with an internally mounted phase measurement relay to monitor the 3-phase power supply for phase sequence, phase failure, asymmetry, under voltage and overvoltage.
9. Provide a NEMA 4X gasketed enclosure in a readily accessible location on the exterior of the unit. The enclosure shall contain:
   a. Power distribution block(s) configured to accept a single-point power connection.
   b. Wiring and additional power distribution block(s), as required, to break out the single-feeder incoming power wiring into multiple branch feeders to the multiple motors.
   c. Equipment grounding bus or lug.
   d. Factory Installed Deadfront Disconnect Switch: Unit shall be provided with a factory installed and wired, dead-front, non-fused disconnect switch.
   e. Separate motor branch circuit disconnect for each motor. Disconnects shall have permanent provisions for padlocking in the OFF position.
   f. Provide engraved, laminated plastic nameplate on cover of enclosure to identify motors served. Attach using screws or rivets; do not use adhesive.
10. Each branch feeder to an individual fan motor shall be designed and equipped to comply with the requirements of Article 430 of the National Electrical Code including:
    a. Motor circuit conductors – Article 430.21.
    b. Motor and branch-circuit overload protection – Article 430.32. Provide a separate overload device for each motor as required.
    c. Motor branch-circuit short-circuit and ground fault protection – Article 430.51.
    d. Motor overtemperature protection – Article 430.126. Provide separate overtemperature protection for each motor as required.
11. Overload and overtemperature devices may be contained in the enclosure described above or elsewhere in the unit as determined by the manufacturer.
12. Label all wiring and power distribution block positions according to factory wiring diagram furnished with unit.

13. All motor wiring for the unit fan section shall be completely pre-wired within unit at factory. The only field wiring connection required shall be the incoming line voltage power wiring to a single-point connection in the electrical enclosure.

~~M.~~K. Unit Controls:

1. Integral Factory-Provided Controller:
   a. Unit controller shall be capable of controlling all features and options of the unit. The programmable microprocessor controller shall be factory installed in the unit controls compartment and factory tested. Controller shall be capable of standalone operation with unit configuration, setpoint adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling available without dependence on a building management system.
   b. Control Panel: All components located in the panel shall be clearly marked for easy identification. All terminal blocks and wires shall be individually numbered. All electrical wires in the control panel shall be run in an enclosed raceway.
   c. Controller shall have an onboard clock and calendar functions that allow for occupancy scheduling.
   d. The controller shall monitor output from sensors within each unit subsystem and automatically adjust operating parameters to maintain programmed setpoints, strategies and sequences. The controller will be programmed to operate the unit in an energy efficient manner using pre-engineered control strategies.
   e. Controller shall include non-volatile memory to retain all programmed values without the use of a battery, in the event of a power failure.
   f. Cooling capacity shall modulate based on supply air temperature.
   g. With modulating hot gas reheat, unit shall modulate cooling and hot gas reheat as efficiently as possible, to meet outside air humidity loads and prevent supply air temperature swings and overcooling of the space.
   h. Heating capacity shall modulate based on supply air temperature.
   i. The controller shall contain LED's and/or LCD interface to indicate the power status, communications status, and fault conditions that arise during operation. Fault conditions indicated include but are not limited to supply air sensor failure, outdoor air sensor failure, space sensor failure, mechanical cooling failure, mechanical heating failure, low supply temperature alarm, high supply temperature alarm, and control temperature cooling or heating failure. The controller shall also monitor outside temperature for heating and cooling circuit lockout during mild conditions. If temperatures fall below the low supply temp alarm point, the unit shall be shut down.
2. Unit configuration, setpoint adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling shall be accomplished with connection to interface module with LCD screen and input keypad, interface module with touch screen, or with connection to PC with free configuration software. Controller shall be capable of connection with other factory installed and factory provided unit controllers with individual unit configuration, setpoint adjustment, sensor status viewing, and occupancy scheduling available from a single unit. Connection between unit controllers shall be with a modular cable. Controller shall be capable of communicating and integrating with a BACnet network.
3. Damper Controls: The damper controls subsystem shall be controlled by the microprocessor controller.
4. Variable-air-volume (VAV) Control for Supply and General Exhaust Fan Control:
   a. Control fan VFD to maintain duct static pressure setpoint(s).
   b. Provide duct static pressure sensors with 0-5 VDC output and 0-5" WG range.
   c. The variable frequency drive will operate the supply fan at a reduced speed during energy recovery wheel economizer by-pass operation. The reduction in fan speed during economizer bypass mode is to prevent a significant increase in airflow from the

reduction in system static pressure when the supply air by-passes the energy recovery wheel.

5. Temperature Controls: The temperature controls subsystem shall be controlled by the microprocessor controller as follows:
   a. Supply Air Temperature Control – The controller shall monitor and control the supply air temperature to maintain the desired supply air temperature.
   b. Dehumidification Control based on Outside Dewpoint – The controller shall monitor an outside temperature/humidity sensor and enter dehumidification mode if the outside air dew point exceeds the desired setpoint. In dehumidification mode, the controller shall monitor an evaporator coil suction line pressure sensor and calculate corresponding coil temperature. The controller shall then modulate the digital scroll compressor to maintain the desired coil temperature, based on suction line pressure, necessary to increase latent heat (moisture) removal. The hot gas reheat option is highly recommended to avoid overcooling the space.
   c. When equipped with the hot gas reheat option, the controller shall monitor a factory supplied, field installed supply air temperature sensor and control the modulating hot gas reheat valve to vary the flow of hot condenser gas through the reheat coil to maintain the desired supply air temperature setpoint and prevent temperature swings and overcooling of the space during dehumidification.
   d. The controller shall monitor the outside air temperature sensor and lockout each compressor at a preset adjustable temperature setpoint.
6. Energy Recovery Controls: The energy recovery controls subsystem shall be controlled by the microprocessor controller as follows:
   a. The energy recovery module wheel operation is controlled to rotate when energy recovery is maximized without causing a rise in latent loading to the mechanical cooling equipment.
   b. Economizer Bypass: The module shall include an economizer wheel bypass damper. To maximize energy recovery effectiveness, the energy recovery module bypass damper is closed when the wheel is rotating and to minimize supply fan energy consumption, the damper is open when the wheel is not rotating.
   c. Economizer Bypass Jog Mode: The module shall include energy recovery wheel start-stop-jog control to periodically rotate the wheel position during economizer mode to avoid wheel contamination from the airstream.
   d. Wheel Defrost Mode: The module shall include energy recovery wheel defrost control to periodically stop the wheel rotation to allow the warm exhaust air to defrost the wheel.
   e. Wheel Preheat: The energy recovery module shall include an optional electric preheat element. The control shall cycle the preheat element on or off based on the outside air temperature and indoor air temperature and relative humidity to ensure the temperature to the wheel exceeds the frost threshold setpoint.
   f. Wheel Rotation Sensor: When equipped with the optional wheel rotation sensor, the main unit controller shall monitor the sensor and initiate an alarm signal if wheel rotation is not sensed when energized.
   g. Wheel Pressure Drop Switch: When equipped with the optional wheel pressure drop switch, the main unit controller shall monitor the switch and initiate an alarm signal if the wheel pressure drop exceeds the switch setpoint of the switch. The wheel pressure drop can rise if the wheel is excessively dirty or if the wheel has frosted.
7. Make-up Air Control, For Return-Air Units
   a. Provide return air dampers, sensors, and controllers as required to control return air flow.

b. Unit shall modulate heating, cooling, and return air flow with variable outside air flow to meet ventilation outside air loads. Cooling capacity shall modulate based on supply air temperature.
c. Unit shall efficiently modulate cooling, return air, hot gas reheat and the internal reheat system, to meet space temperature and humidity loads and prevent supply air temperature swings and overcooling of the space. Space temperature and humidity sensors shall be provided.
d. The unit controls shall also monitor the outside air temperature and humidity conditions, the unit discharge supply air temperature, filter differential pressure, and refrigerant suction pressure.

8. Controls for 100% Outside Air Lab Units:
a. Unit shall control the heat recovery wheel and general exhaust fan to provide exhaust system pressure and flow capacity to the air valves.
b. Provide general exhaust and outside air filter differential pressure monitoring and outside air damper control.
c. Unit shall monitor the outside air temperature and humidity after the heat wheel but before the unit cooling coil. The unit shall efficiently control the heat wheel, cooling coil, hot gas bypass coil and natural gas reheat coil to provide unit supply air temperature and humidity setpoint conditions.
d. Unit shall also monitor the refrigerant suction pressure.

2.02 UV (ULTRA VIOLET) - C EMITTERS:

A. Manufacturers: Steril-Aire, Inc., UVDI, or American Ultraviolet. Assembly shall be equal to Steril-Aire Model DE.
B. Provide UVC emitters at downstream side of coiling coils and above drain pans in air handling units as scheduled to control airborne and surface microbial growth and transfer.
C. Emitters shall comply with UL Standard 1995 as applicable to usage of UVC emitters in HVAC equipment.
D. Emitters shall be independently tested under typical HVAC conditions and in accordance with ANSI/ASQCZ1.4. Total output per 25 mm(1”) arc length shall not be less than 9 $\mu W/cm^2$ at one meter in 2.0 m/s(400 fpm) airstream of 32ºC(50ºF) air.
E. UVC emitter and fixture shall consist of housing, power source, reflector, emitter sockets and emitter tube and shall be constructed to withstand HVAC environments.
F. Housing shall be constructed of 304 or 316 stainless steel with 13 mm(1/2”) electrical knockouts on both ends to simplify gang wiring and wiring to power. It shall incorporate components into one integral assembly that maximizes serviceability and radiant flux.
G. Reflector shall be constructed of heavy gauge, spectral finished aluminum alloy with minimum 85% reflectance at 254 nm UVC energy.
H. Emitter shall be of high output, hot cathode, T5 (15 mm) diameter, medium bi-pin type, capable of producing 95% of energy at 254 nm in air flow velocity to 5.0 m/s(1000 fpm) at temperature of 1ºC to 66ºC(35°F - 150°F). UVC emitters shall produce no ozone or other secondary contamination. Useful emitter life shall not be less than 9000 h, with no more than 40% output loss at end of one year of continuous use.
I. Irradiance: Provide UVC lamps and fixtures in sufficient quantity to irradiate coil surfaces and air stream with no shadows and with minimum UVC irradiance at every point along face of coil at not less than 1225 $\mu W/cm^2$ at design cooling conditions with bulb mounted 300 mm(12”) from coil face.
J. UVC Monitoring: Provide NIST traceable UV Radiometer consisting of solid state photodiode UV sensor and externally mounted controller with visual indicators of UVC output and contacts for BAS communication. Controller must have ability to read real-time UVC energy levels by display module with minimum 89 mm(3.5”) digit LCD screen/panel. Irradiance range shall be 0-

1999 (x10) µW/cm^2 with resolution of 10 µW/cm^2. Calibration wavelength shall be 254 nm with accuracy ±10%.

K. Electrical:
   1. Power source shall be 115 V, with power factor of 0.95 and power conversion of not less than 75%. It shall be designed to maximize photon production, radiance and reliability and suppress RF and line noise in airstreams of 5ºC to 56ºC(41°F -132°F) and airflows to 5.0 m/s(1000 fpm).
   2. Power consumption shall be no more than 13 watts/sf of treated, cross sectional plane.
   3. Provide interlock switch on access doors to turn UVC off when access doors are opened. Provide additional manual on/off switch (electrical disconnect) for UVC system service purposes.

L. Startup and Calibration Service: UV supplier shall provide services to startup, calibrate, monitor, verify output and certify that UVC energy output meets specified requirements.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install all units as indicated on plans and according to unit manufacturer's instructions and all applicable building codes.
B. General Contractor will set and install roof-mounting curb as integral member of building roof structure.
C. Install all ductwork, electrical and piping connections to unit as shown on drawings and as required to complete installation.
D. Provide all wiring between rooftop units, remote panels, time clocks and other temperature control devices.
E. Manufacturer and/or manufacturer's representative shall calibrate all control devices and adjust unit automatic dampers to insure proper operation of system.
F. Install space thermostats approximately 4’-0” above floor and as shown on drawings.

3.02 UVC EMITTERS

A. Install UVC Emitters at outlet of cooling coils and above drain pans in accordance with manufacturer's instructions of installation, placement, wiring and testing.
B. Provide interlock switch on access door to UVC Emitters to turn Emitters off when access door is opened.

END OF SECTION

SECTION 238140
VARIABLE REFRIGERANT FLOW SYSTEMS

PART 1 - GENERAL

1.01 REFERENCE

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

1.02 SUBMITTALS

A. Shop Drawings including, but not limited to, the following:
   1. Manufacturer's name and model number
   2. Identification as referenced in the documents
   3. Capacities/ratings/efficiencies
   4. Materials of construction
   5. Filters; size, efficiency
   6. Fans, type, drives
   7. Power and control wiring diagrams
   8. Dimensions and weights
   9. Manufacturer's installation instructions
   10. All other appropriate data

B. Fan curves to include a series of curves indicating relationship of CFM and static pressure for various RPM and brake horsepower curves. Indicate design-operating point clearly on fan curves.

1.03 DESIGN CRITERIA

A. All units shall meet or exceed the 2010 Federal minimum efficiency requirements and the proposed ASHRAE 90.1 efficiency requirements for VRF systems. Efficiency shall be published in accordance with the DOE alternative test procedure, which is based on the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Standards 340/360, 1230 and ISO Standard 13256-1.

B. Insulation and liners shall meet NFPA 90A requirements.

C. Units shall be Electrical Testing Laboratories (ETL) listed and carry ETL label.

D. Fan motor shall not operate into motor service. Drive efficiency shall be considered in motor selection according to manufacturer’s published recommendation, or according to AMCA Publication 203, Appendix L.

E. Where inlet and outlet ductwork at any fan is changed from that shown on drawings, submit scaled layout of the change and system effect factor calculations, indicating increased static pressure requirement as described in AMCA Publication 201. This Contractor shall be responsible for any motor, drive and/or wiring changes required as result of duct configuration changes at fan.

PART 2 - PRODUCTS

2.01 GENERAL

A. Acceptable Manufacturers:
   1. Mitsubishi, Lennox, LG, Daikin, Toshiba Carrier
   2. Contractor is responsible for providing piping cost based on which manufacturer they elect to use (three pipe versus two pipe). The piping cost provided with the contractor’s bid shall correspond to the requirements of the manufacturer’s system.

B. System Components:
   1. System shall include outdoor units, indoor units, refrigerant distribution units and controls required for complete functioning system.

2. Units shall be completely factory assembled and run tested, piped, internally wired, fully charged with refrigerant and compressor oil.
3. Furnish units complete with all components, accessories, and operating and safety controls to provide the intended performance as specified in this Section, as shown on drawings and/or as scheduled.

C. System Operation
1. System shall be capable of heat recovery to allow for simultaneous heating and cooling operation between indoor units.
2. System to operate with R-410A refrigerant.
3. Unit shall be factory run tested to check heating and cooling operation, fan and blower rotation.

D. Warranty:
1. Units shall be provided with manufacturer's five year warranty (from date of installation) on all components.
2. Provide outdoor unit compressor with manufacturer's seven year warranty (from date of installation).

E. Electrical:
1. Unit power shall be 208V/1Ph or 208V/3Ph unless indicated otherwise on schedules.
2. Furnish each unit with short circuit and over current protection motor starter, and contactors.
3. Each unit shall include low voltage control transformer.
4. Motor horsepower and voltage shall be as scheduled.
5. Provide units with a main power non-fused disconnect for field installation.
6. Disconnects shall have NEMA-1 rated enclosure for indoor installation and NEMA-3R rated enclosure for outdoor installation.

F. Controls:
1. Refrigeration safety controls to include high- and low-pressure cutout, oil pressure cutout, compressor overload protections, magnetic contractors and low voltage control transformer.
2. Provide system with necessary controls to maintain head pressure at ambient to 0°F.
3. Provide defrost controls for use during heating cycle.

2.02 OUTDOOR UNITS

A. General
1. Unit shall operate at outdoor ambient temperatures up to 105°F and down to 15°F.
2. Sound pressure rating of each unit shall not exceed 60 dBA.
3. Provide unit with an accumulator with refrigerant level sensors and controls, a high pressure safety switch, over-current protection, crankcase heater and DC bus protection.
4. Provide unit with oil separator and logic controls to ensure adequate oil volume in the compressor is maintained.

B. Casing:
1. Completely weatherproof and constructed of galvanized steel.
2. Unit shall have an engraved metal nameplate permanently attached to the housing. Nameplates shall provide at least the following information: manufacturer, model number, rated capacity, and rated efficiency.
3. Provide unit with manufacturer's corrosion resistant coating for casing components. Unit shall be salt spray tested in accordance with ASTM B117 to show no corrosion development after 720 hours of exposure.

C. Condenser Coil:
1. Direct expansion type, factory charged with R-410A refrigerant and fully tested.
2. Coil shall be of nonferrous construction with fins on copper tubing.

3. Provide coil with factory applied corrosion resistant coating.
4. Coil shall be leak tested at factory to ensure pressure integrity.
5. Condenser coil shall be factory coated with corrosion inhibitor conforming to performance criteria set forth in ASTMB-117 for 10,000- hr salt spray test. Field applied condenser coil coating are not permitted.

D. Condenser Fan:
1. Fan to be direct drive, variable speed propeller type.
2. Fan motor to be furnished with normal and current overload protection and permanently lubricated motor bearings.
3. Provide fans with a safety guard to prevent contact with moving parts.

E. Compressor:
1. Compressor shall be inverter driven hermetic type. If non-inverter driven type is provided, contractor shall include the cost of larger conductor and conduit sizes with their bid.
2. Provide compressor with internal over temperature and pressure protection.
3. Provide compressor with crankcase heater to prevent oil migration during low ambient conditions.
4. Compressor shall be capable of modulation down to 20% of rated capacity.

2.03 INDOOR UNITS – CEILING CONCEALED TYPE

A. General
1. Unit shall be ducted, ceiling mounted, concealed fan coil in horizontal configuration as shown on drawings.
2. Provide unit complete with all factory wiring, piping, expansion device, controls and fan motor.
3. Unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.

B. Cabinet:
1. Provide unit with ducted supply and return air connections.

C. Fan:
1. Statically and dynamically balanced and tested in factory.
2. Fan shall be 3-speed direct drive.
3. Fan motor bearing shall be permanently lubricated.

D. Filters:
1. Provide unit with 2-inch MERV 8 filter(s) and install at return grilles.
2. In addition, furnish one set of glass fiber throwaway filters to be used during construction and initial start-up periods.

E. Evaporator Coils:
1. Direct expansion type, factory charged with R-410A refrigerant and fully tested.
2. Evaporator coils to be of non-ferrous construction with copper tubes mechanically bonded to fins.
3. All tube joints shall be brazed with phos-copper or silver alloy.
4. Coil shall be leak tested at factory to ensure pressure integrity.
5. Provide unit with integral condensate drain pan below coil.
6. Unit to have internal pump to lift condensate a minimum of 20”.
7. Provide unit with water level switch. Unit shall shutdown upon activation of overflow switch.

2.04 INDOOR UNITS – WALL MOUNTED TYPE

A. General
1. Unit shall be wall mounted and furnished with integral wall mounting bracket and mounting hardware.

2. Provide unit complete with all factory wiring, piping, expansion device, controls and fan motor.
3. Unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.

B. Cabinet:
1. Cabinet shall be impact resistant and fully insulated.
2. Provide unit with integral filter.

C. Fan:
1. Statically and dynamically balanced and tested in factory.
2. Fan shall be 3-speed direct drive type.
3. Fan motor bearing shall be permanently lubricated.

D. Evaporator Coils:
1. Direct expansion type, factory charged with R-410A refrigerant and fully tested.
2. Evaporator coils to be of non-ferrous construction with copper tubes mechanically bonded to fins.
3. All tube joints shall be brazed with phos-copper or silver alloy.
4. Coil shall be leak tested at factory to ensure pressure integrity.
5. Provide unit with integral condensate drain pan below coil.
6. Unit to have internal pump to lift condensate a minimum of 16”.
7. Provide unit with water level switch. Unit shall shutdown upon activation of overflow switch.

2.05 REFRIGERANT DISTRIBUTION UNIT

A. General
1. Provide system with a refrigerant distribution unit which allows for simultaneous heating and cooling operations at indoor units.
2. Unit shall have be provided with minimum number of branches required to serve indoor units.

B. Casing & Cabinet:
1. Unit shall be constructed of galvanized steel.
2. Provide unit with liquid-gas separator and integral drain pan.

C. Valves
1. Provide unit with linear expansion valves and refrigerant branch control valves.
2. Provide isolation shut-off valves for each refrigerant branch. Valves to be:
a. Ball valve with forged brass body, Teflon seals and stem seal cap.
b. Brazed and pressure tested with Schrader valve for service
c. Rated for 300°F and 700 psig.

2.06 CONTROLS

A. General
1. Each VRF system shall be provided with a dedicated controller with communication drop from the LAN. Refer to floor plans for panel location and coordinate placement with owner’s representative prior to rough in.
2. All system condensers, air handlers, and space sensors shall be addressable from both the owners workstation located in the central chiller plant and at the building level controller(s).
3. Units shall be completely factory wired for 24V controls.
4. Microprocessor based unit controls shall contain all required algorithms to meet requirements of Controls Sequences.
5. Controller power and communications shall be through a common communications bus.

B. Wiring
1. Low voltage control wiring shall be 2-conductor, twisted, stranded, shielded wire.
2. Communications network wiring shall be CAT-5 with RJ-45 connection.

C. Building Level Controller
   1. Provide Building Level Controller for integration with campus Building Automation System (BAS).
   2. Device to communicate with BAS over local area network via BACnet or MODBUS protocol.
   3. Unit power supply to be 208V/1PH. Provide controller with low voltage transformer.
   4. Provide unit with NEMA 1 control panel enclosure.
   5. Controller shall allow the following system points to the modified remotely by the campus BAS.
      a. ON/OFF command
      b. Temperature setpoint
      c. Thermostat enable/disable
   6. Provide points lists for complete integration of systems. Integration shall allow BAS access to a minimum of the following points:
      a. ON/OFF status
      b. Operation mode
      c. Temperature setpoint
      d. Fan speed
      e. Filter status
      f. Space temperature
      g. Alarm status
      h. Error code and error address

D. System Central Controller
   1. Provide central controller that allows the system to be monitored and operated from a single location.
   2. Device shall be capable of communicating with Building Level Controller via network wiring to provide points from all VRF system units.
   3. Unit power supply to be 208V/1PH. Provide controller with low voltage transformer.
   4. Provide unit with NEMA 1 control panel enclosure.
   5. Controller shall be capable of configuring the following system settings for individual indoor units, group of units or all units collectively.
      a. Scheduling
      b. Operation status
      c. Night setback
      d. Operation mode
      e. Temperature setting
      f. Fan speed setting
      g. Thermostat enable/disable

E. Space Controllers and Sensors
   1. Thermostats
      a. Provide units with wall mounted wired thermostats.
      b. Thermostats shall be used for indoor unit operation in lieu of return air temperature sensor.
      c. Thermostats shall be capable of being disabled to limit User ability to adjust setpoints.
   2. Humidity Sensor
      a. Provide humidity sensors, additional controller and programming required to control in spaces where humidity sensors are shown on plans.
      b. Programming shall decrease indoor unit fan speed, keep unit in cooling mode and maintain space temperature setpoint during humidity control mode.

PART 3 - EXECUTION

3.01 GENERAL

A. Install all units as indicated on plans and according to unit manufacturer's instructions.
B. Control system start-up shall be completed by the manufacturer or an authorized representative.
C. Provide all necessary connections to unit as shown on drawings and as required to complete installation.
D. Install units to maintain manufacturer’s minimum clearance requirements.
E. Seal all refrigerant piping during storage.

3.02 OUTDOOR UNIT

A. Insulate both refrigerant lines from the outdoor unit to the refrigerant distribution controller according to the manufacturer’s instructions.
B. Outdoor unit panels and coil shall remain scratch free. If they are damaged during shipment or construction, contractor shall replace them to ensure corrosion resistant coating is maintained.
C. Structural support and evaluation of applied wind force per FBC shall be performed and provided by a state of Florida licensed engineer under this division. Signed and sealed drawings shall be submitted during the submittal phase to the AHJ or inspector for verification of code compliance by the installing contractor. Engineering services for this scope shall be provided by division 23 in the base bid.
D. New equipment shall be provided with approved mounting substrate and hardware for a complete and function installation. Existing pads shall not be re-used in any instance. Provide new support rails and / or concrete pads as required by the unit manufactures IOM.

3.03 INDOOR UNITS – CEILING CONCEALED TYPE

A. Insulate both refrigerant lines from the indoor unit to the refrigerant distribution controller according to the manufacturer’s instructions.
B. Connect drain piping to unit at condensate pump outlet connection and route piping away from unit as shown on floor plans.
C. Condensate drain piping size to be no less than unit drain connection size.
D. Install unit with field fabricated return air plenum where shown on plans.
E. Adjust factory static pressure setting to meet required design airflow rate during Test, Adjust & Balance.

3.04 INDOOR UNITS – CASSETTE TYPE

A. Insulate both refrigerant lines from the indoor unit to the refrigerant distribution controller according to the manufacturer’s instructions.
B. Connect drain piping to unit at condensate pump outlet connection and route piping away from unit as shown on floor plans.
C. Condensate drain piping size to be no less than unit drain connection size.
D. Adjust factory static pressure setting to meet required design airflow rate during Test, Adjust & Balance.

3.05 REFRIGERANT DISTRIBUTION UNIT

A. Install isolation shut-off valves at each refrigerant branch to indoor units within 5 feet of the refrigerant distribution unit. Valves shall allow maintenance of individual indoor units without disruption to the rest of the system.
B. Insulate isolation valves and connected piping. Valve shall be operable without removing insulation.
C. Pipe condensate drain pan and route piping to nearest floor drain.

3.06 CONTROLS

A. Integration
    1. Coordinate integration of VRF system with Campus Building Automation System (BAS) contractor.

2. System manufacturer shall include sufficient labor time in their cost to ensure integration with BAS is complete, correct and meets Owner's requirements. Integration shall be completed without the need for a computer workstation in the building.
3. Controls contractor shall integrate campus BAS with VRF system at manufacturer's Building Level Controller. Contractor to provide necessary equipment and labor to accomplish integration with the assistance of the manufacturer's representative.

B. Wiring
1. Install daisy chain low voltage wiring between indoor units, refrigerant distribution unit and outdoor unit.
2. Install wiring from remote controller (space temperature sensor) to indoor unit controller.

C. Thermostat setpoint adjustment feature shall be disabled before turning system over to Owner.

3.07 FUNCTIONAL TESTING

A. Controls contractor and manufacturer's representative shall be available to assist Engineer during functional testing of the system.

B. Controls contractor and manufacturer's representative shall make all adjustments necessary to the system to meet the design intent and Owner's operational needs.

END OF SECTION

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SECTION 238214
HEATING AND COOLING TERMINAL DEVICES

PART 1 - GENERAL

1.01 SUBMITTALS

A. Shop Drawings for all items in this Section including, but not limited to, the following:
   1. Manufacturer's name and model number
   2. Identification as referenced in the documents
   3. Capacities/ratings
   4. Materials of construction
   5. Dimensions and weights
   6. Color selection chart where applicable
   7. Wiring diagrams
   8. All other appropriate data

1.02 REFERENCE STANDARDS AND DESIGN CRITERIA

A. Electric Heaters: Shall be listed by UL, bear appropriate UL Label, contain the latest devices for protection of installation, and shall be installed in strict accordance with the latest revision of National Electric Code and other applicable State and Local Codes. Provide grounding lugs on all apparatus.

PART 2 - PRODUCTS

~~2.01 ELECTRIC REHEAT COILS (MOUNTED IN ROOFTOP AHUS)~~

~~A. Manufacturers: Indeeco, Singer, or Brasch~~
~~B. Heaters shall be UL Listed for zero clearance to combustible materials in horizontal air ducts and shall comply with all applicable provisions of the latest National Electric Code.~~
~~C. Heaters shall incorporate suitable combination of automatic reset disc type thermal cutouts for primary protection and manual reset line duty disc type thermal cutouts with external reset for secondary protection.~~
~~D. Heating elements shall be of 80% nickel and 20% chromium alloy wire supported by floating ceramic bushings in reinforced shelves spaced no more than 3-1/2" apart. Heater body shall be of galvanized steel of not less than 18 ga, suitably reinforced for full rigidity.~~
~~E. Heaters shall be rated for KW, voltage, phase and number of heating stages as scheduled.~~
~~F. Heaters shall have the following features:~~
   ~~1. Insulated frames and control box~~
   ~~2. Magnetic contactors~~
   ~~3. Control circuit transformer~~
   ~~4. SCR controller~~
   ~~5. Duct mounted thermostat~~
   ~~6. Fusing to comply with NEC~~
   ~~7. Fused disconnect switch with interlock handle~~
   ~~8. Airflow proving switch~~
   ~~9. Pilot light to indicate that heater supply is "on".~~
~~G. Controls shall be factory wired with terminal connections for power and thermostat.~~

~~2.02~~2.01 DUCT REHEAT COILS (HOT WATER)

A. Manufacturers: Carrier, Trane, McQuay, RAE, Marlo, Temtrol, or Heatcraft
B. Reheat coils furnished with air terminal devices will be acceptable, provided coils are meeting requirements specified in this section.
C. Coils shall be constructed of 0.4 mm(0.016”) minimum tube wall, 13 mm(1/2") or 16 mm(5/8") OD copper tubes with aluminum fins suitable for minimum working pressure to 1380 kPa(200 psig) and temperatures to 104°C(220°F).

D. Coils having steel nipples for connection are not allowed.
E. Coil fins shall be continuous serpentine or plate fin type.
F. Coil headers shall be heavy seamless copper with all tubes brazed to header.
G. Casing shall have G90 galvanized steel end supports and top and bottom channels of rigid construction with allowance for expansion and contraction of finned tube section.
H. Coil frame shall be suitable for drive slip or flange and gasket connection to ductwork.

~~**2.03 ELECTRIC UNIT HEATERS**~~

~~A. Manufacturers: Trane, Berko, Electromode, Modine, or Singer~~
~~B. Heating elements shall be corrosion resistant, installed to prevent noise of expansion and contraction. Units shall be designed for even distribution of air across heating element.~~
~~C. Units shall be furnished with necessary over-heat protection, reset devices, contactors, transformers and control as required for complete operation. Provide factory-installed, adjustable thermostatic control for operation of fan and heater.~~
~~D. Provide each unit with a disconnect interlocked to the control enclosure compartment.~~
~~E. Provide units with fan switches to maintain fan operation until all residual heat in elements has been dissipated.~~
~~F. Fans shall be statically and dynamically balanced. Fans and motors shall be mounted for vibration free operation.~~
~~G. Cabinets and casings shall be minimum 20 ga galvanized or stainless steel for corrosion resistance.~~
~~H. Provide corrosion resistant, protective grilles or louvers on inlet and outlet openings.~~
~~I. Fan motors shall be totally enclosed, permanently lubricated and shall be provided with corrosion resistant windings. Motors shall be factory wired to a NEMA 3, 3X, 4, or 4X enclosure. The entire assembly shall be UL listed.~~

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install units as indicated on drawings, and according to manufacturer's installation instructions.

3.02 DUCT REHEAT COILS

A. Comb out fins when bent or crushed before enclosing coils in ductwork. Clean dust and debris from each coil to ensure its cleanliness.
B. Seal or gasket coil connection to ductwork to meet maximum allowable leakage rate specified in Section 23 3114 - Ductwork, Part 3.
C. Protect units during construction against entry of foreign matter and construction dirt.
D. Unless otherwise specified, connect piping to coils with multiple rows for counter-flow arrangement. same side.
E. Provide inlet and outlet transitions per details.
F. Provide coil access door on the inlet and outlet of each reheat coil for cleaning and inspection. Doors are to be insulated, gasketed and have turn latches. Screwed plate doors are not acceptable.

END OF SECTION

SECTION 260000
GENERAL ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Intent of drawings and Specifications is to obtain complete systems tested, adjusted, and ready for operation.

B. Except as otherwise defined in greater detail, the terms "provide", "furnish" and "install" as used in Division 26 Contract Documents shall have the following meanings:
   1. "Provide" or "provided" shall mean "furnish and install".
   2. "Furnish" or "furnished" does not include installation.
   3. "Install" or "installed" does not include furnishing.

C. Include incidental details not usually shown or specified, but necessary for proper installation and operation.

D. Check, verify and coordinate work with drawings and specifications prepared for other trades. Include modifications, relocations or adjustments necessary to complete work or to avoid interference with other trades.

E. Included in this Contract are electrical connections to equipment provided by others. Refer to Architectural, Mechanical, Plumbing, and final shop drawings for equipment being furnished under other sections for exact locations of electrical outlets and various connections required.

F. Information given herein and on drawings is as exact as could be secured but is not guaranteed. Do not scale drawings for dimensions.

G. Where architectural features govern location of work, refer to Architectural Drawings.

H. Perform work in "neat and workmanlike" manner as defined in ANSI/NECA 1, Standard Practices for Good Workmanship in Electrical Contracting.

1.02 RELATED WORK

A. Utility Services:
   1. Determine utility connection requirements and include in Base Bid all costs to Owner for utility service.
   2. Include costs for temporary service, temporary routing of service or other requirements of a temporary nature associated with utility service.

B. Temporary Services:
   1. Division 01 - Temporary Facilities and Controls.

C. Continuity of Service:
   1. No service shall be interrupted or changed without permission from Architect and Owner. Obtain written permission before work is started.
   2. When interruption of services is required, Architect, Owner and other concerned parties shall be notified and shall determine a time.

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

E. Painting:
   1. Furnish equipment with factory-applied finish coats or paint equipment per Division 09 – Finishes unless specified otherwise.
   2. Furnish equipment with factory applied prime finish unless otherwise specified.
   3. If factory finish on equipment furnished by Contractor is damaged in shipment or during construction, refinish equipment to satisfaction of Architect.
   4. Furnish one can of touch up paint for each final factory-applied finish coat of product.

1.03 REQUIREMENTS OF REGULATORY AGENCIES

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

1.04 REFERENCE STANDARDS

A. Agencies or publications referenced herein refer to the following:
   1. AEIC Association of Edison Illuminating Companies
   2. ANSI American National Standards Institute
   3. ASME American Society of Mechanical Engineers
   4. ASTM American Society for Testing and Materials
   5. BICSI Building Industry Consulting Services International
   6. EIA Electronic Industries Association
   7. FIPS Federal Information Processing Standards
   8. FCC Federal Communications Commission
   9. ICEA Insulated Cable Engineers Association
   10. IEEE Institute of Electrical & Electronics Engineers
   11. IESNA Illuminating Engineering Society of North America
   12. NEC National Electrical Code
   13. NECA National Electrical Contractors Association
   14. NEMA National Electrical Manufacturers Association
   15. NESC National Electrical Safety Code
   16. NETA National Electrical Testing Association
   17. NFPA National Fire Protection Association
   18. NIST National Institute of Standards & Technology
   19. OSHA Occupational Safety and Health Administration
   20. TIA Telecommunications Industries Association
   21. UL Underwriters Laboratories, Inc.

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

1.05 LISTING

A. Install materials bearing UL label or UL listing, unless UL label or listing is not available for that type of material.

B. Other nationally recognized testing agencies, acceptable to AHJ, are approved.

1.06 ENCLOSURES

A. Typical NEMA Enclosures and Usage
   1. NEMA 1 - Indoors. Falling dirt.
   2. NEMA 2 - Indoors. Falling dirt. Falling liquids. Light splashing.
   3. NEMA 3 - Outdoors. Sleet, snow, rain. Windblown dust.
   4. NEMA 3X - Same as NEMA 3 plus corrosion resistant.
   5. NEMA 3S - Same as NEMA 3 plus mechanism operable when ice covered.
   6. NEMA 3SX - Same as NEMA 3S plus corrosion resistant.
   7. NEMA 3R - Outdoors. Rain, snow, sleet.
   8. NEMA 3RX - Same as NEMA 3R plus corrosion resistant.
   9. NEMA 4 - Indoors. Falling dirt. Falling and light splashing liquids. Flying dust, lint and fibers. Hose down.
   10. NEMA 4X - Same as NEMA 4 - Indoors plus corrosion resistant.
   11. NEMA 4 - Outdoors. Rain, sleet, snow. Wind blown dust. Hose down.
   12. NEMA 4X - Same as NEMA 4 - Outdoors plus corrosion resistant.
   13. NEMA 5 - Indoors. Falling Dirt. Falling Liquids. Settling dust, lint and fibers.

14. NEMA 6 - Indoors. Falling dirt. Falling and light splashing liquids. Flying dust, ling and fibers. Hose down. Temporary submersion.
15. NEMA 6P - Same as NEMA 6 - Indoors plus corrosion resistant. Prolonged submersion.
16. NEMA 6 - Outdoors. Rain, snow, sleet. Windblown dust. Hose down. Temporary submersion.
17. NEMA 6P - Same as NEMA 6 - Outdoors plus corrosion resistant. Prolonged Submersion.
18. NEMA 7 - Indoors. Class I, Division 1 or 2, Groups A, B, C or D. (Flammable gas).
19. NEMA 9 - Indoors. Class II, Division 1 or 2. Groups E, R, or G. (Combustible dust).
20. NEMA 12 - Indoors. Falling Dirt. Falling liquids. Flying dust, lint and fibers. Oil or coolant seepage.
21. NEMA 13 - Same as NEMA 12 plus oil or coolant spraying or splashing.

1.07 SUBMITTALS

A. Shop Drawings (Product Data):
   1. Refer to Division 01 - Submittal Procedures.
   2. Note that for satisfying submittal requirements for Division 26, "Product Data" is usually more appropriate than true "Shop Drawings" as defined in Division 01. However, the expression "Shop Drawings" is generally used throughout Specification.
   3. Submit shop drawings for equipment and systems as requested in respective specification sections. Submittals which are not requested may not be reviewed.
   4. Specifically mark general catalog sheets and drawings to indicate specific items submitted and its correlation to specific designation for product in drawings.
   5. Specifically indicate proper identification of equipment by name and/or number, as indicated in specification and shown on drawings.
   6. When manufacturer's reference numbers are different from those specified, provide correct cross-reference number for each item. Clearly mark and note submittal accordingly.
   7. Submit complete record of required components when luminaires, equipment and items specified include accessories, parts and additional items under one designation.
   8. Include wiring diagrams for electrically powered or controlled equipment.
   9. Submit electrical equipment room layouts drawn to scale, including equipment, raceways, accessories and required working clearances. Submit electrical equipment room layouts concurrently with electrical distribution equipment submittals.
   10. Where submittals cover products containing non-metallic materials, include "Material Safety Data Sheet" (MSDS) from manufacturer stating physical and chemical properties of components and precautionary considerations required.
   11. Submit shop drawings or product data as soon as practicable after signing contracts. Submittals must be approved before installation of materials and equipment.
   12. Submittals that are not complete, not permanent, or not properly checked by Contractor, will be returned without review.
   13. Bidders shall provide a full compliance review of specifications. Compliance review shall accompany submittals. Compliance review shall include paragraph-by-paragraph review of specifications with the following information “C”, “D”, “E” marked in the margin of the specification section. Unless a deviation or exception is specifically noted in the compliance review, it is assumed that Bidder is in complete compliance with plans and specifications. Lack of these requirements in the submittal shall result in rejection of submittal. Text shall be provided accompanying compliance review as follows:
      a. “C” – Comply with no exceptions
      b. “D” – Comply with deviations. For each of the deviations, provide numbered footnote with reasons for proposed deviation
      c. “E” – Exceptions; do not comply

B. Bookmarks:

1. Submitted documents greater than 50 pages in length shall include electronic bookmarks setup to quickly navigate and easily locate submitted information. Each major series of equipment shall have a bookmark.
2. Hyperlinks can be used to enhance bookmark tools but are not an acceptable substitute for electronic bookmarks. If hyperlinks are used, they should be clearly identifiable as a hyperlink by using a different color text similar to how MS Office identifies hyperlinks.

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

D. Operation and Maintenance Manuals:
1. Refer to Division 01 - Operation and Maintenance Data.
2. Upon completion of work but before final acceptance of system, submit to Architect for approval, 3 copies of operation and maintenance manuals in loose-leaf binders. If "one copy" is larger than 2” thick or consists of multiple volumes, submit only one set initially for review. After securing approval, submit 3 copies to Owner.
3. Organize manuals by specification section number and furnish table of contents and tabs for each piece of equipment or system.
4. Manuals shall include the following:
    a. Copies of shop drawings
    b. Manufacturer's operating and maintenance instructions. Include parts lists of items or equipment, with component exploded views and part numbers. Where manufacturer's data includes several types or models, designate applicable type or model.
    c. CD ROM's or flash/thumb drives of O&M data with exploded parts lists where available
    d. Phone numbers and addresses of local parts suppliers and service companies
    e. Internet/WEB page addresses where applicable
    f. Wiring diagrams
    g. Start up and shut down procedure
    h. Factory and field test records
    i. Additional information, diagrams or explanations as designated under respective equipment or systems specification section
5. Instruct Owner's representative in operation and maintenance of equipment. Instruction shall include complete operating cycle on all apparatus.
6. Furnish O&M manuals and instructions to Owner prior to request for final payment.
7. Include bookmarks as indicated above.

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

1.08 JOB CONDITIONS

A. Building Access:
1. Arrange for necessary openings in building to allow for admittance of all apparatus.

B. Coordination:
1. Equipment provided under other Divisions of these specifications.
    a. Motors
    b. Electrically powered equipment
    c. Electrically controlled equipment
    d. Starters, where specified
    e. Variable frequency drives, where specified

f. Control devices, where specified
g. Temperature Control wiring

2. Provide the following devices required for control of motors or electrical equipment, unless noted otherwise:
   a. Starters
   b. Disconnect devices
   c. Control devices:
      1) Pushbuttons
      2) Pilot lights
      3) Contacts
   d. Conduit, boxes and wiring for Power wiring
   e. Conduit, boxes and wiring for Control wiring, except for control wiring systems as defined in Section 23 0901A.
3. Connect and wire equipment complete and ready to operate according to wiring diagrams furnished by various trades.
4. Wire starters or other similar control devices furnished by others.
5. This contractor's drawings and/or specifications show number and hp rating of motors furnished by others, together with their actuating devices. Should any change in size, hp rating, voltage, or means of control be made to any motor or other electrical equipment after Contracts are awarded, Contractor responsible for change shall immediately notify this Contractor. Additional costs due to these changes shall be responsibility of Contractor initiating change.
6. Equipment and wiring shall be selected and installed for conditions in which it will be required to perform. (i.e., general purpose, weatherproof, rain tight, explosion proof, dust tight, or any other special type as required.)
7. Comply with local utility motor starting requirements and provide starters for motors furnished by others as specified herein or under various trade sections of those specifications.

C. Cutting and Patching:
1. Refer to General Conditions of the Contract and Division 01 - Cutting and Patching.
2. Perform cutting and patching required for complete installation of systems, unless otherwise noted. Patch and restore work cut or damaged to original condition. This includes openings remaining from removal or relocation of existing system components.
3. Provide materials required for patching unless otherwise noted.
4. Do not pierce beams or columns without permission of Architect and then only as directed. If openings are required through walls or floors where no sleeve has been provided, hole shall be core drilled to avoid unnecessary damage and structural weakening.
5. Where alterations disturb lawns, paving, walks, etc., replace, repair or refinish surfaces to condition existing prior to commencement of work. This may include areas beyond construction limits.

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

1.09 WARRANTY

A. Refer to Division 01 for general warranty requirements.
B. Refer to technical sections for warranty requirement for each system.
1. Where no warranty requirements are called out, warrant as called out in Division 01 equipment, materials, and workmanship to be free from defect.

C. Repair, replace, or alter systems or parts of systems found defective at no extra cost to Owner.
D. In any case, wherein fulfilling requirements of any guarantee, if this contractor disturbs any work guaranteed under another contract, this contractor shall restore such disturbed work to condition satisfactory to Architect and guarantee such restored work to same extent as it was guaranteed under such other contract.
E. Warranty shall include labor, material, and travel time.

PART 2 - PRODUCTS

2.01 PRODUCT SUBSTITUTIONS

A. Refer to Division 01 - Product Requirements.

PART 3 - EXECUTION

3.01 GENERAL

A. Verify elevations and dimensions prior to installation of materials.
B. Where conduits are shown on plans, they are shown for reference only. Conduit routes shown on plans may not show all required junction boxes, pull boxes, control conduits, or coordination with other trades. Contractor is responsible for coordination of all conduit routes with other trades, and providing junction boxes and pull boxes as required by code.

3.02 DELIVERY, STORAGE, AND HANDLING

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

3.03 FLOOR, WALL, ROOF AND CEILING OPENINGS

A. Coordinate location of openings, chases, furred spaces, etc. with appropriate Contractors. Provide sleeves and inserts that are to be built into structure during progress of construction.
B. Remove temporary sleeves, if used to form openings, prior to installation of permanent materials. Utilize minimum 24 ga galvanized sheet metal for permanent sleeves unless otherwise noted.
C. Provide Schedule 40 carbon steel pipe with integral water stop for steel sleeves required below grade or to exterior.
D. Submit to Structural Engineer for review and approval size and location of core-drilled holes prior to execution.
E. Submit product data and installation details for penetrations of building structure. Include schedule indicating penetrating materials, (steel conduit, PVC conduit, cables, cable tray, etc.), sizes of each, opening sizes and sealant products intended for use.
F. Where penetrations of fire-rated assemblies are involved, seal penetrations with appropriate firestopping systems as specified in Section 07 8400 – Firestopping.
G. Provide 2" clearance around penetration openings intended for raceways and cables. Where fire resistant penetrations are required, size openings in accordance with written recommendations of firestopping systems manufacturer.
H. Seal non fire-rated floor penetrations with non-shrink grout equal to Embeco by Master Builders, or urethane caulk, as appropriate.
I. Seal non-rated wall openings with urethane caulk.

J. Where penetrations occur through exterior walls into building spaces, use steel sleeves with integral water stop, similar to type "WS" wall sleeves by Thunderline Corporation. Seal annular space between sleeves and pipe with "Link-Seal" modular wall and casing seals by Thunderline Corporation, or sealing system by another manufacturer approved as equal by Engineer. Sealing system shall utilize Type 316 stainless steel bolts, washers and nuts.
K. Finish and trim penetrations as shown on details and as specified.
L. Provide chrome or nickel plated escutcheons where raceways pass through walls, floors or ceilings and are exposed in finished areas. Size escutcheons to fit raceways for finished appearance. Finished areas shall not include mechanical/electrical rooms, janitor's closets, storage rooms, etc., unless suspended ceilings are specified.

3.04 EQUIPMENT ACCESS

A. Install raceways, cable tray, junction and pull boxes, and accessories to permit access to equipment for maintenance. Relocate raceways or accessories to provide maintenance access at no additional cost to Owner.
B. Install equipment with sufficient maintenance space for removal, repair or changes to equipment. Provide ready accessibility to equipment and wiring without moving other future or installed equipment.
C. Access doors in walls, chases, or inaccessible ceilings will be provided under Division 08 - Access Doors and Frames, unless otherwise indicated. Access doors for equipment shall provide access for servicing, repairs and/or maintenance.
D. Provide necessary coordination and information to the Trade Contractor under Division 08 - Access Doors and Frames. This information shall include required locations, sizes and rough-in dimensions.
E. Provide access doors in walls, chases or inaccessible ceilings for equipment requiring access for servicing, repairs and maintenance, unless otherwise noted. Access frames and doors shall be as manufactured by Milcor, Incorporated, or similar, of style applicable to surface. Provide access doors used in fire-rated construction with UL label. Provide steel, prime-coated access doors in dry locations. Provide stainless steel access doors for use in ceramic tile walls, toilet rooms, locker rooms, and in areas subject to excessive moisture. Provide access doors of sufficient size to allow complete maintenance. Coordinate location of access doors with General Contractor and rough-in equipment accordingly.
F. Locate electrical outlets and equipment to fit details, panels, decorating or finish at space. Architect reserves right to make minor position changes of outlet locations before work has been installed.
G. Verify door swings before installing room light switch boxes. Install boxes on latch side of door unless otherwise noted

3.05 EQUIPMENT SUPPORTS

A. Provide supporting steel not indicated on drawings as required for installation of equipment and materials including angles, channels, beams, hangers, etc.
B. Provide steel shell with plug type concrete anchors for attaching equipment to concrete. Plastic, rawhide or anchors using lead are not allowed.
C. Do not support equipment or luminaires from metal roof decking.

3.06 SUPPORT PROTECTION

A. In occupied areas, mechanical and electrical rooms and areas requiring normal maintenance access, guard certain equipment to protect personnel from injury.
B. Provide minimum 1/2" thick Armstrong Armaflex insulation or similar product applied with Armstrong 520 adhesive on lower edges of equipment, including bus duct, cable tray, pull boxes and electrical supporting devices suspended less than 7 ft above floors, platforms or catwalks in these areas.

C. Protect threaded rods or bolts at supporting elements as described above. Trim threaded rods or bolts such that they do not extend beyond supporting element.

3.07 ELECTRICAL SYSTEMS IDENTIFICATION

A. Refer to Section 26 0553 – Electrical Systems Identification.

3.08 ACCEPTANCE TESTING

A. Contractor shall perform acceptance testing. Equipment to be tested is noted as "Testing by Electrical Contractor" in technical specification sections. Perform as outlined in technical specification sections.
B. When testing is to be witnessed by Architect/Engineer or Inspector, notify them at least 10 days prior to testing date.
C. When equipment or systems fail to meet minimum test requirements, replace or repair defective work or materials as necessary and repeat inspection and test until equipment or systems meet test requirements. Make repairs with new materials.
D. Contractor is responsible for certifying in writing equipment and system test results. Certification shall include identification of portion of system tested, date, time, test criteria and name and title of person signing test certification documents.
E. Maintain copies of certified test results, including those for any failed tests, at project site. At completion of project, include copies of test records and certifications in O&M Manuals.

3.09 START-UP

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

3.010 CLEANING

A. Clean systems after installation is complete.
B. Vacuum debris from panelboards, switchboards, motor starter and disconnect switch enclosures, junction boxes and pull boxes two weeks before energization and again prior to completion.
C. Where louvers are provided in switchgear or transformer enclosures, vacuum louvers free of dust and dirt.
D. Clean luminaire lenses and lamps at time of installation and clean lens exteriors just prior to final inspection.
E. Thoroughly clean equipment of stains, paint spots, dirt and dust. Remove temporary labels not used for instruction or operation.

END OF SECTION

SECTION 260516
OWNER-FURNISHED EQUIPMENT

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes electrical connection(s) to Owner-purchased pieces of equipment, which are required in construction.
B. Owner-furnished equipment requiring work by Contractor is specified in the following Sections:
C. Contractor shall be responsible for receipt of equipment from Owner, storage after receipt, installation, and electrical connection.
D. Owner-furnished equipment requiring work by the Contractor is shown on the drawings and schedules.
E. Owner-furnished, Contractor-installed equipment is labeled OFCI.

1.02 SUBMITTALS

A. Shop Drawings: Owner-supplied shop drawings of equipment furnished by Owner.
B. Manufacturer's Installation Instructions:
   1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

1.03 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. Comply with NFPA 70 for components and installation.
   2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory unopened packaging until ready for installation.

1.05 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.
B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.01 (NOT APPLICABLE TO THIS SECTION)

PART 3 - EXECUTION

3.01 INSTALLATION

A. Provide labor, materials and electrical connections for Owner-furnished equipment in accordance with contract drawings.
B. Install and connect Owner-furnished equipment as though it had been purchased by Contractor.
   1. This shall include:
      a. Receiving equipment at jobsite
      b. Rigging and setting equipment in place
      c. Making electrical connections
      d. Starting
      e. Testing
C. Coordinate with owner equipment provider and start-up technician as required for a complete and working installation.

D. Install equipment in accordance with manufacturer's installation instructions.
E. Maintain equipment until facility is accepted by Owner.
F. Review Owner-supplied shop drawings of Owner-furnished equipment to ascertain that necessary labor and materials have been provided to install equipment and complete the system it serves.

END OF SECTION

SECTION 260519
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 26 0529 - Hangers and Supports for Electrical Systems
B. Section 26 0533 - Raceway and Boxes for Electrical Systems
C. Section 26 0553 - Electrical Systems Identification

1.02 DESCRIPTION

A. Section includes conductors and cables rated 600 V and less, connectors, splices, and terminations rated 600 V and less, sleeves and sleeve seals for cables.
B. Conductor and conduit sizes in these contract documents are based on copper wire, and only copper wire shall be used.

1.03 REFERENCE STANDARDS

A. ASTM B 1 – Standard Specification for Hand-Drawn Copper Wire.
B. ASTM B 8 – Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
C. NEMA WC 70 – Non-Shielded Power Cable 2000 V or less for the Distribution of Electrical Energy (ICEA S-95-658).
D. NFPA 70 – National Electrical Code.
E. UL 44 – Thermoset-Insulated Wires and Cables.
F. UL 83 – Thermoplastic-Insulated Wires and Cables.
G. UL 486A-486B – Wire Connectors.
H. UL 486C – Splicing Wire Connectors.
I. UL 486D – Standard for Insulated Wire Connector Systems for Underground Use or in Damp or Wet Locations.
J. UL 486E – Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors.
K. UL 1569 – Standard for Metal-Clad Cables.

1.04 SUBMITTALS

A. Product Data: For each type of product indicated.
B. Manufacturer’s Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation.
C. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
D. Closeout Submittals:
    1. Project Record Documents:
        a. Record actual locations of components and circuits.
    2. Operation and Maintenance Data:
        a. Include manufacturer’s recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.

1.05 QUALITY ASSURANCE

A. Regulatory Requirements:
    1. Comply with NFPA 70 for components and installation.
    2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
    3. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space

in paragraph (b)(2): “The articles listed in FAR 25.104(a) that are acquired as construction materials.”

B. Wire and cable boxes and reels shall bear the date of manufacture.
   1. Date of manufacture shall not precede contract date by more than one year.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Protect from dirt, fumes, water, corrosive substances, and construction debris.

1.07 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.
B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. General Cable Corporation
B. Cerrowire
C. Southwire Company
D. Encore Wire Corporation
E. Approved equal

2.02 DESCRIPTION

A. NEMA WC 70; single copper conductor insulated wire; 600 V rated insulation; 90°C maximum operating temperature for dry and wet or damp locations.
   1. Thermoplastic-insulated wires and cables: NEMA WC 70, UL 83; Type THHN, THWN, THHW, THWN-2.
   2. Thermoset-insulated wires and cables: NEMA WC 70, UL 44; Type XHHW, XHHW-2.
B. Multi-conductor Cable: NEMA WC 70; for metal-clad cable, Type MC with ground wire.
C. Metal-clad cable, Type MC; UL 1569:
   1. Impervious, corrugated, continuous, seam welded metal sheath.
   2. Single grounding conductor.
   3. Listed for cable tray use

2.03 REMOTE CONTROL AND SIGNAL CIRCUITS

A. Class 1
   1. Copper conductor, single insulated wire.
   2. Insulation type THHN or THHW rated 90°C, 600 V insulation class.
   3. Type XHHW for ambient temperature less than 32°F.
   4. UL 83 listed, ASTM B 1 for solid conductors; ASTM B 8 for stranded conductors.
B. Classes 2 and 3
   1. Copper conductor, multiple twisted conductors covered with an overall non-metallic jacket unless otherwise noted.
   2. Insulation type XLPE, rated 105°C, 300 V insulation class.
   3. UL listed for use in space in which circuits will be installed.

2.04 CONNECTORS, SPLICES, AND TERMINALS

A. Manufacturers:
   1. AFC Cable Systems, Inc.
   2. Hubbell Power Systems, Inc.
   3. O-Z/Gedney; EGS Electrical Group LLC.
   4. 3M; Electrical Products Division

5. Tyco Electronics Corp.

B. Description: UL 486A-486B, UL 486C, UL 486D, UL 486E; factory-fabricated connectors, splices, and terminals of size, ampacity rating, material, type, and class for application and service indicated.

2.05 TERMINATIONS

A. Compression set, bolted or screw type lug, or direct to bolted or screw type terminal.

2.06 PLASTIC CABLE TIES

A. Nylon or approved; locking type; metallic ties not permitted.

PART 3 - EXECUTION

3.01 INSTALLATION OF CONDUCTORS AND CABLES

A. Install conductors in a raceway system, unless otherwise specified or indicated.
B. Install conductors only after:
   1. Building interior is enclosed and weather tight
   2. Mechanical work likely to damage conductors has been completed
   3. Raceway installation is complete and supported
C. Pull conductors into raceway at same time.
D. Neatly train and lace conductors inside boxes, equipment, and panelboards.
E. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
F. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
G. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
H. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible. Protect exposed cables from damage.
I. Support cables above accessible ceiling using plastic cable ties to support cables from structure. Do not rest cable on ceiling panels.
J. Support cables and conductors in vertical raceways per requirements in Section 26 0529 - Hangers and Supports for Electrical Systems.
K. Identify and color-code conductors and cables according to Section 26 0553 - Electrical Systems Identification.
L. Wiring at Outlets: Install conductor at each outlet, with minimum 6" of slack.
M. Limit conduit fill to a maximum of 9 current-carrying conductors.
N. Install stranded conductors where conductors terminate in crimp type lugs. Do not place bare stranded conductors directly under screws.
O. Install VFD input wiring, output wiring and control wiring in their own separate conduit systems.
P. Provide dedicated neutrals for branch circuits unless otherwise noted on drawings.

3.02 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Solid or stranded for #10 AWG and smaller; stranded for #8 AWG and larger.
B. Branch Circuits: Copper. Solid or stranded for #10 AWG and smaller; stranded for #8 AWG and larger.
C. Minimum conductor sizes shall be as follows:
   1. #12 AWG – Branch circuits of any kind.
   2. #14 AWG – Fire alarm system.
   3. #16 AWG – Remote control and signal systems.
D. Branch wiring length limitations:

1. Where wire sizes are shown on project drawings and do not indicate they have been adjusted for voltage drop based on circuit length, they shall be increased as noted below depending on contractor routing.
2. 208Y/120 V circuits over 75’ in length: Increase wire size one size for each 75’ of length. Increase conduit size as required.
3. 480Y/277 V circuits over 150’ in length: Increase wire size one size for each 150’ of length. Increase conduit size as required.

3.03 CONDUCTOR INSULATIONS AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN/THWN-2 or XHHW-2, rated 90°C for wet locations, single conductors in raceway.
B. Exposed Feeders: Type THHN/THWN-2, rated 90°C for wet locations, single conductors in raceway.
C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, rated 90°C for wet locations, single conductors in raceway.
D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, rated 90°C for wet locations, single conductors in raceway.
E. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, rated 90°C for dry and wet or damp locations, single conductors in raceway.
F. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, rated 90°C for dry and wet or damp locations, single conductors in raceway.
G. Motor Circuit Branch Wiring and Associated Control Wiring: Type THHN, rated 90°C for dry and damp locations, single conductors in raceway, stranded.
H. Motor Circuit Branch Wiring Between Motor and VFD: XHHW-2
    1. Requirements for raceway installation when VFD cable is not used:
        a. Tighten all raceway fittings and connections per manufacturer’s requirements.
        b. Bond and secure raceways to junction boxes.
        c. Set screw connectors are not permitted.
        d. Install equipment grounding conductor to be continuous between supply and load.
        e. Install fittings to provide proper 360° connection between raceway and enclosure at concentric knockouts.
        f. Remove paint from any surfaces between bond of enclosure, fittings and raceway.
        g. Provide grounding bushings at enclosures.
        h. Re-torque all fittings and terminations prior to building turnover.
I. Wiring in Light Fixture Channels: Type THHN/THWN-2, rated 90°C for dry and damp locations, single conductors.
J. Branch Circuits Single Conductors in Raceway: 90°C rated conductors sized at 75°C rating for connection to equipment and devices.
K. Circuits 100A and less, utilize 60C for ampacity (unless both sides of the circuit are listed for 75C). Circuits 100A and over use 75C for ampacity. If the wire insulation ratings are higher, they may be utilized for de-rating purposes only and wire size shall be increased if the de-rated insulation rating is less than the required load current.
L. Metal-clad cable, Type MC, use for the following:
    1. Feeders from VFDs to motors
    2. Recessed and semi-recessed lighting fixtures
M. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

3.04 REMOTE CONTROL AND SIGNAL CIRCUITS

A. Sizing – #16 AWG minimum.
B. Installation:

1. Install cables in cable tray and cable rings.
2. Provide protection for exposed cables where subject to damage.
3. Support cables above accessible ceilings; do not rest on ceiling tiles.
4. Use suitable cable fittings and connectors.

3.05 CONNECTORS, SPLICES, AND TERMINALS

A. Connectors:
   1. Except where equipment is furnished with bolted or screw type lug, use compression set pressure connectors with insulating covers. Use compression tools and die compatible with connectors being installed.
   2. Use bolt or compression-set type with application of insulating tape, pre-stretched or heat-shrinkable insulating tubing for splices and taps of #8 AWG conductors and larger. Install with hydraulic compression tool.
   3. Use pre-insulated “twist-on” connectors with integral spring for splices and taps of #10 AWG conductors and smaller.
   4. Tighten electrical connectors and terminals according to manufacturer’s published torque-tightening values. If manufacturer’s torque values are not indicated, use those specified in UL 486A-486B.
   5. Terminate aluminum conductors with tin-plated, aluminum-bodied compression connectors only.
   6. Install suitable reducing connectors or mechanical connector adaptors for connecting aluminum conductors to copper conductors.

B. Splices:
   1. Splice wires and cable only in accessible locations such as within junction boxes.
   2. Make splices to carry full capacity of conductors with no perceptible temperature rise.
   3. Make below-grade splices in manholes and handholes watertight with pre-stretched or heat-shrinkable insulating tubing, or resin-filled insulator.
   4. Use electrical tape to build up insulation level equivalent to cable insulation and cover with not less than two half-lapped layers of plastic electrical tape, for joints, taps, and splices of #1 AWG conductors and larger.
   5. Plastic snap-on splice insulators are not allowed.
   6. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
   7. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.

C. Terminals:
   1. Insulate ends of spare conductors with electrical tape and identify spare circuit number where appropriate.
   2. Eye type crimped terminal for removable screw type terminal. Forked torque terminal when screw terminal cannot be removed.
   3. Train wires to eliminate fanning of stands, crimp with proper tool and die.
   4. Torque screw termination per manufacturer’s recommended values.

3.06 CABLE TIES

A. Neatly bundle conductors and cables together for support. Size cable ties sufficiently to accommodate the multiple cables being supported.

3.07 FIELD QUALITY CONTROL

A. Perform electrical acceptance testing on all 600 volt conductors and cables serving switchboards and service entrance equipment.
   1. Verify tightness of accessible bolted connections by calibrated torque wrench.
   2. Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential to be 1000 volts DC for one minute. Minimum insulation

resistance values shall not be less than 50 megohms. Investigate and correct any deviations between adjacent phases and values below minimum.

3. Perform continuity test to ensure correct cable connection.

B. Interpret test results in writing and submit to Engineer.

C. Replace conductors and cables that are found defective, at no expense to Owner.

END OF SECTION

SECTION 260526
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 26 0533 – Raceway and Boxes for Electrical Systems
B. Section 26 0533.13 – Surface Raceway Systems
C. Section 26 2200 – Low-Voltage Transformers
D. Section 26 2416.13 – Lighting and Appliance Panelboards
E. Section 26 2416.16 – Distribution Panelboards
F. Section 26 2726 – Wiring Devices
G. Section 26 2816 – Enclosed Switches and Circuit Breakers
H. Section 26 2913 – Enclosed Controllers
I. Section 26 3213 – Engine Generators
J. Section 26 4113 - Lightning Protection for Structures
K. Section 26 4300 – Surge Protective Devices (SPD)
L. Section 26 5000 – Lighting
M. Section 27 1000 - Structured Cabling
N. Section 27 1100 - Communications Equipment Room Fittings
O. Section 27 1300 - Communications Backbone Cabling
P. Section 27 1500 - Communications Horizontal Cabling

1.02 DESCRIPTION

A. Section includes methods and materials for grounding systems and equipment, as required by State Codes, NFPA 70, applicable portions of other NFPA codes, as indicated herein, plus the following special applications:
   1. Common ground bonding with lightning protection system.
B. Maximum resistance to ground shall be less than 25 ohms.
C. Refer to Grounding Riser Diagram.

1.03 REFERENCE STANDARDS

A. TIA-607-B – Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
B. ASTM B 3 – Specification for Soft or Annealed Copper Wire
C. ASTM B 8 – Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard or Soft
D. ASTM B 33 – Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes
E. IEEE C2 – National Electrical Safety Code (ANSI)
F. IEEE 857 – Standard for Qualifying Permanent Connections Used in Substation Grounding
G. NETA MTS – Maintenance Testing Specifications
H. NFPA 70 – National Electrical Code
I. NFPA 70B – Recommended Practice for Electrical Equipment Maintenance
J. NFPA 780 – Lightning Protection Systems
K. UL 96 – Lightning Protection Components
L. UL 467 – Grounding and Bonding Equipment

1.04 TELECOMMUNICATIONS GROUNDING SYSTEM DEFINITIONS

A. Grounding Equalizer (GE): Conductor that interconnects elements of telecommunications grounding infrastructure.
B. Telecommunications Bonding Backbone (TBB): Conductor that interconnects telecommunications main grounding busbar (TMGB) to telecommunications grounding busbar (TGB).

C. Telecommunications Bonding Conductor: Conductor that interconnects telecommunications bonding infrastructure to building's service equipment (power) ground.
D. Telecommunications Grounding Busbar (TGB): Interface to building telecommunications grounding system, common point of connection for telecommunications system and equipment to ground, and located in telecommunications room or equipment room.
E. Telecommunications Main Grounding Busbar (TMGB): Busbar placed in convenient and accessible location and bonded by means of bonding conductor for telecommunications to building service equipment (power) ground.

1.05 SUBMITTALS

A. Product Data: For each type of product indicated.
B. Other Informational Submittals:
   1. Plans showing dimensioned as-built locations of grounding features, including the following:
      a. Test wells
      b. Ground rods
      c. Ground rings
      d. Grounding arrangements and connections for separately derived systems
      e. Grounding for sensitive electronic equipment
C. Field Quality-Control Test Reports:
   1. Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
   2. Test reports of resistance to earth. Each test report shall include:
      a. Date of test, soil moisture content, and soil temperature
      b. Test operator
      c. Instrument or other test equipment used
      d. Electrode designation or location
      e. Ground impedance in ohms
      f. Assumptions made - if required
D. Closeout Submittals:
   1. Operation and Maintenance Manuals: Include the following:
      a. Instructions for periodic testing and inspection of grounding features at test wells, ground rings, and grounding connections for separately derived systems based on NFPA 70B.
         1) Instructions to perform tests to determine if ground resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if they do not.
         2) Include recommended testing intervals.

1.06 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70.
   2. Comply with UL 467 for grounding and bonding materials and equipment.
   3. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): "The articles listed in FAR 25.104(a) that are acquired as construction materials."

1.07 DELIVERY, STORAGE, AND HANDLING

A. Store products in clean, dry space. Protect from dirt, fumes, water, corrosive substances, and construction debris.

1.08 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.
B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.01 CONDUCTORS

A. Insulated Conductors: Copper or tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction, insulation color: green.
B. Bare Copper Conductors:
   1. Solid Conductors: ASTM B 3.
   2. Stranded Conductors: ASTM B 8.
   3. Tinned Conductors: ASTM B 33.
   4. Bonding Cable: 28 kcmil, 14 strands of #17 AWG conductor, 1/4” in diameter.
   5. Bonding Conductor: #4 AWG or #6 AWG, stranded conductor.
   6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8” wide and 1/16” thick.
   7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8” wide and 1/16” thick.
C. Grounding Bus: Horizontal rectangular bars of annealed copper, 1/4” by 2” in cross section; with insulators.

2.02 CONNECTORS

A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.
B. Bolted Connectors for Conductors and Pipes: Electro-tin plated copper or copper alloy, bolted pressure-type, with at least two bolts.
   1. Pipe Connectors: Clamp type, sized for pipe.
C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
D. Compression Connectors: Irreversible type.

2.03 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; 3/4” in diameter by 10 ft in length.

2.04 TELECOMMUNICATIONS BUSBARS

A. Material: Copper
   1. 1/4” thick
B. Pre-drilled
   1. 3/8” diameter
   2. Hole spacing per ANSI Joint Standard TIA-607-B
   3. Hole pattern shall accommodate two-hole lugs
C. Insulators and stand-off brackets shall electrically isolate busbar from wall or other mounting surface.
D. Provide busbars listed by nationally recognized testing laboratory.
E. Size:
   1. Telecommunications Main Ground Busbar (TMGB) – 20” x 4” (minimum)
   2. Telecommunications Grounding Busbar (TGB) – 12” x 2” (minimum)

2.05 TELECOMMUNICATIONS GROUNDING CONDUCTORS

A. Material: Stranded copper
B. Provide insulated bonding conductors.
   1. Green Jacket or Black Jacket marked with Green Tape or Green adhesive labels per NEC Guidelines.
C. Size:
   1. Bonding Conductor for Telecommunications (BCT; TMGB to Grounding Electrode): as indicated on drawings
   2. Telecommunications Bonding Backbone (TBB; TMGB to TGB): as indicated on drawings

Table 1 –TBB conductor size vs length

TBB/GE linear length m (ft)	TBB/GE size (AWG)
less than 4 (13)	6
4 – 6 (14 – 20)	4
6 – 8 (21 – 26)	3
8 – 10 (27 – 33)	2
10 – 13 (34 – 41)	1
13 – 16 (42 – 52)	1/0
16 – 20 (53 – 66)	2/0
20 – 26 (67 – 84)	3/0
26 – 32 (85 – 105)	4/0
32 – 38 (106 – 125)	250 kcmil
38 – 46 (126 – 150)	300 kcmil
46 – 53 (151 – 175)	350 kcmil
53 – 76 (176 – 250)	500 kcmil
76 – 91 (251 – 300)	600 kcmil
Greater than 91 (301)	750 kcmil

2.06 TELECOMMUNICATIONS GROUNDING CONNECTIONS

A. Mechanical Connectors:
   1. Connector Body:
      a. High-strength, high-conductivity cast copper alloy
      b. 2-bolt type
   2. Bolts, nuts, washers, and lock-washers: 300 series stainless steel
      a. Supplied as part of connector body
      b. Split-bolt connector types are not allowed.
   3. Connector:
      a. Meet or exceed UL 467
      b. Clearly marked with catalog number, conductor size, and manufacturer
B. Compression Connectors:
   1. Connector Body: Pure wrought copper.
   2. Conductivity shall be no less than 99% by IACS Standards.
   3. Connector:
      a. Meet or exceed performance requirements of IEEE 837, latest revision.
      b. Filled with an oxide-inhibiting compound.
      c. Clearly marked with manufacturer, catalog number, conductor size, and required compression tool settings.
   4. Connection shall be irreversible.

PART 3 - EXECUTION

3.01 APPLICATIONS

A. Conductors: Install solid conductor for. #8 AWG and smaller, and stranded conductors for #6 AWG and larger, unless otherwise indicated.
B. Underground Grounding Conductors: Install copper or bare-tinned copper conductor. No. #2/0 AWG minimum.
   1. Bury at least 24” below grade.
C. Grounding Bus: Install in electrical and communications rooms.
   1. Install bus on insulated spacers 1”, minimum, from wall; 6” above finished floor.
   2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down to specified height above floor, and connect to horizontal bus.
D. Conductor Terminations and Connections:
   1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors
   2. Underground Connections: Welded connectors, except at test wells and as otherwise indicated
   3. Connections to Ground Rods at Test Wells: Bolted connectors
   4. Connections to Structural Steel: Welded connectors

3.02 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with feeders and branch circuits.
   1. Install a single insulated equipment ground conductor for each branch circuit conduit originating from panelboards.
B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
   1. Feeders and branch circuits
   2. Lighting circuits
   3. Receptacle circuits
   4. Single-phase motor and appliance branch circuits
   5. Three-phase motor and appliance branch circuits
   6. Flexible raceway runs
   7. Armored and metal-clad cable runs
C. Air-Duct Equipment Circuits: Install a separate insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping. Ground ductwork of fans serving flammable liquid storage rooms or fume hoods. Install continuous ground around any flexible connections in this ductwork system. Bond lower end of exhaust ducts, vent stacks, etc., which pass through roof.
D. Metallic Cable Tray: #6 AWG to every tray section, or submit UL Listed tray connectors suitable for electrical continuity
E. Metallic Sleeves: Minimum #6 AWG
F. Water Heater and Heat-Tracing Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
G. Duplex receptacles and light switches of any amperage: Install separate jumper between grounding terminal on device and metallic box.
H. Size of equipment grounding conductors for branch circuits: As indicated in NEC-70, except minimum size shall be #12 AWG.
I. Size of branch panel feeder originating at main service equipment: As indicated in NEC-70, except in no instance smaller than #8 AWG.

J. Signal and Communication Equipment: For alarm and other communication equipment (see Telecommunications Grounding System Installation section below for voice and data systems), install #4 AWG minimum grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
   1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor as indicated on drawings.
   2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

K. Install grounding conductor from each standby-emergency generator to grounding electrode system. Provide flexible jumper between base and isolated generator.

L. Install equipment grounding conductor from secondary side of each transformer to grounding electrode system as required for separately derived system.

M. Install grounding for service entrance equipment room consisting of ground bus, ground conductors, and grounding rods.
   1. Ground bus shall be horizontal copper bar as indicated on drawings. Bolt to wall with 1" stand-offs at each bus support.
   2. Install ground bus per details on drawings.

N. Install grounding conductor to luminaires hanging from conduit swivel hangers.

O. Metal Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors to pole base. Grounding Conductor: Same size as phase conductors, but not smaller than #10 AWG.
   1. Install at each pole or standard a concealed driven 3/4" x 10'-0" ground rod, ground clamp and No. 3 stranded copper conductor concealed and attached to pole and base.

3.03 SEQUENCING, SCHEDULING

A. Permanently attach service grounds before permanent building service is energized.

B. Permanently attach equipment grounds prior to energizing equipment.

3.04 INSTALLATION

A. Contractor shall take photographs of all underground grounding and bonding connections prior to covering. Furthermore, contractor shall coordinate with the Authority Having Jurisdiction to confirm approval of installation prior to covering.

B. Connections: Exposed and visible for inspection at all times. Do not install insulation over ground connections.

C. Identify all grounding conductors by system and room number of termination at building grounding electrode point.

D. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

E. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96A when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

F. Ground Rods: Drive rods until tops are 2" below finished floor or final grade, unless otherwise indicated.
   1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.
   2. For grounding electrode system, install at least 3 rods spaced at least one rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

G. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes shall be at least 12” deep, with cover.
   1. Test Wells: Install at least one test well for each service, unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

H. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
   1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
   2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
   3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

I. Grounding and Bonding for Piping:
   1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building’s main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Water pipe, by itself, is not an adequate grounding electrode and must be supplemented by another electrode system. Bond system together.
   2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
   3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
      a. Confirm application with local gas and electric utility ordinances and notify the engineer if restrictions do not allow bonding as required by the project documents.

J. Grounding Electrode Conductor installed in metal conduit or sleeves, shall be bonded at each end using grounding hubs. The bonding conductor shall be the same size as the grounding electrode conductor. Conduits terminated to grounding enclosures, shall be secured to enclosure using grounding locknuts.

K. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned copper bonding jumper to bond across flexible duct connections to achieve continuity.

L. Make grounding connections on surface that has been cleaned of paint, dirt, oil, etc., so that connections are bare metal to bare metal contact.

M. Make grounding connections tight with UL listed grounding devices, fittings, bushings, etc.

N. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod, extending around the perimeter of building.
   1. Install copper or tinned copper conductor not less than #2/0 AWG for ground ring.
   2. Bury ground ring not less than 24” from building foundation and 30” below grade.

O. Equipment Grounding Conductor: Terminate in panelboard at green wire ground bus.

P. Multiple Conductors on Single Lug: Not permitted. Terminate each grounding conductor on its own terminal lug.

Q. Flexible Metallic Conduit, Non-Metallic Rigid Conduit, or Liquid Tight Flexible Conduit: Install green wire grounding conductor with phase conductors in conduit.

3.05 TELECOMMUNICATIONS BONDING AND GROUNDING SYSTEM INSTALLATION

A. Provide required elements and miscellaneous hardware necessary to establish Telecommunication Bonding and Grounding infrastructure as specified.

B. Install products in accordance with manufacturer's instructions. Install Compression Connectors with compression, tool-and-die system, as recommended by manufacturer of connectors.
C. Telecommunications Bonding Conductor, Telecommunications Bonding Backbone (TBB), and Grounding Equalizer (GE): Compression or Exothermic type connections.
D. Locate TGBs and TMGB per drawings.
E. Telecommunications Bonding Backbone (TBB) shall be continuous and not interrupted by Telecommunications Grounding Busbars (TGB).
    1. TGBs shall be bonded to TBB via tap off of TBB. Exception: "last" TGB on TBB (e.g., furthest from TMGB).
    2. Grounding Equalizer(s) (GE) shall connect to TGBs to be interconnected.
F. Insulate busbars from their support.
G. Coordinate with Sections 27 1000, 27 1100, 27 1300 and 27 1500.

3.06 FIELD QUALITY CONTROL

A. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
    1. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal and at ground test wells. Make tests at ground rods before any conductors are connected.
B. Inspect completed system by commissioning authority, prior to backfilling.

END OF SECTION

SECTION 260529
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 26 0533 – Raceway and Boxes for Electrical Systems
B. Section 26 2200 – Low-Voltage Transformers
C. Section 26 2416.13 – Lighting and Appliance Panelboards
D. Section 26 2416.16 – Distribution Panelboards
E. Section 26 2816 – Enclosed Switches and Circuit Breakers
F. Section 26 2913 – Enclosed Controllers
G. Section 26 3213 – Engine Generators
H. Section 26 3623 – Automatic Transfer Switches
I. Section 26 5000 – Lighting

1.02 DESCRIPTION

A. Section includes the following:
   1. Manufactured hangers and supports for individual raceways and cables, slotted channel and angle systems for multiple conduit runs, and most electrical equipment that is not floor mounted.
   2. Construction requirements for concrete housekeeping pads for floor-mounted electrical equipment.

1.03 REFERENCE STANDARDS

A. AWS D1.1/D1.1M – Structural Welding Code-Steel.
B. ASTM A 36/A 36M – Carbon Structural Steel.
C. ASTM F3125/F3125M – Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength.
D. ASTM A 780 – Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
E. MSS SP-58 – Pipe Hangers and Supports - Materials, Design and Manufacture.
F. MSS SP-69 – Pipe Hangers and Supports - Selection and Application.
G. MFMA-4 – Metal Framing Standards Publication.
H. NECA 1 – Standard Practices for Good Workmanship in Electrical Construction.
I. NECA 101 – Standard for Installing Steel Conduits (Rigid, IMC, EMT).
J. NFPA 70 – National Electrical Code.
K. SSPC-PA 1 – Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel.
L. ETL PVC-001 – PVC Coated Conduit

1.04 SUBMITTALS

A. Product Data: For the following:
   1. Steel slotted support systems.
   2. Nonmetallic slotted support systems.
   3. Raceway and cable supports.
   4. Support for conductors in vertical raceway.
   5. Structural steel for fabricated supports and restraints.
   6. Mounting, anchoring, and attachment components:
      a. Powder-actuated fasteners.
      b. Mechanical-expansion anchors.
      c. Concrete inserts.

d. Clamps for attachment to structural steel.
e. Through bolts.
f. Toggle bolts.
g. Hanger rods.

B. Shop Drawings: Include concrete anchors application, size, and placement. Include concrete inserts application, size, loading, and placement. Show fabrications and installation details and include calculations for the following:
1. Trapeze hangers. Include product data for components.
2. Steel slotted channel systems. Include product data for components.
3. Nonmetallic slotted channel systems. Include product data for components.
4. Fabricated metal equipment support assemblies.

C. Drawings showing specific locations of any suspended loads which exceed 100 lbs within joist chord panel, to be attached to open web steel joist structural members. Include weight supported by such attachments. (Panel is length of chord between two adjacent diagonal web members at points of connection to chord.)

D. Welding certificates and drawings showing specific locations of any weld attachments to structure including weight supported by such attachments.
1. Any proposed weld attachments to building structure shall be reviewed by Structural Engineer prior to execution of work. This review may result in use of other welding codes or standards, which may apply to “structural work”. Execution of this work may be assigned to General Trades responsible for building structural steel. Cost of this work, however, will remain the responsibility of this Contractor.

E. Schedule of hangers and support devices with support spacing.

1.05 QUALITY ASSURANCE

A. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): “The articles listed in FAR 25.104(a) that are acquired as construction materials.”

B. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, “Structural Welding Code – Steel.”

C. Comply with NFPA 70.

D. Certification:
1. Installer of PVC-coated hangers and supports shall be certified by a PVC conduit manufacturer.

PART 2 - PRODUCTS

2.01 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of 5 times the applied force.

B. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
1. Finishes
a. Metallic Coatings:
1) Factory standard primed, galvanized of electroplated finish and applied according to MFMA-4, for indoor applications.
2) Hot-dip galvanized after fabrication and applied according to MFMA-4, for outdoor applications.
b. Nonmetallic Coatings: Manufacturer’s standard PVC, polyurethane, or polyester coating applied according to MFMA-4, for corrosive environments.

c. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.

2. Channel Dimensions: Selected for applicable load criteria.
3. Manufacturers:
   a. Allied Support Systems; Power-Strut Unit.
   b. Cooper B-Line, Inc.; A division of Cooper Industries.
   c. ERICO International Corporation.
   d. GS Metals Corporation.
   e. Thomas & Betts Corporation.
   f. Unistrut; Tyco International, Ltd.
   g. Wesanco, Inc.
   h. National Pipe Hanger Corporation.
   i. Michigan Hanger Co., Inc.; O-Strut Division.
   j. Approved equal.

C. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
D. Raceway and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
E. PVC Raceway Support Devices: ANSI C80.1, UL6, ETL PVC-001.
F. Support for 600V and under Conductors in Vertical Raceway: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
   1. Manufacturers:
      a. O-Z/Gedney
      b. Approved equal
G. Support for Conductors 601V and greater in Vertical Raceway: Heavy duty strain relief grip consisting of solder protector, galvanized steel mesh, endless multi-weave style.
   1. Manufacturers:
      a. Hubbell-Kellems
      b. Approved equal
H. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
I. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
   1. Concrete Anchors
      a. Anchors shall be selected, sized, and detailed by Contractor's structural engineer registered in project's jurisdiction, based on project conditions and in accordance with project building code. Calculations and drawings shall be submitted.
      b. Anchors shall meet ICC Acceptance Criteria, and ICC-ES Evaluation Reports (ESRs) shall specifically list the current applicable codes.
      c. Anchors installed in hardened concrete for purpose of transmitting structural loads from one connected element to another, or for safety related elements such as sprinkler pipes, heavy suspended pipes, and barrier rails shall have ICC-ES report demonstrating anchors have met requirements of AC 193 for mechanical anchors in concrete elements.
      d. Post-installed expansion anchors and undercut anchors installed in hardened concrete shall be qualified for strength design and tested according to ACI 355.2. Designs shall be per the requirements of ACI 318, Appendix D.
      e. Anchors shall be zinc plated in accordance with ASTM B633.

f. Select anchors with load ratings based on cracked concrete conditions.
g. 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.
    1) Manufacturers:
        a) Hilti Inc.
        b) ITW Ramset/Red Head; A division of Illinois Tool Works, Inc.
        c) MKT Fastening, LLC.
        d) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit
        e) Approved equal
h. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
    1) Manufacturers:
        a) Cooper B-Line, Inc.; A division of Cooper Industries
        b) Empire Tool and Manufacturing Co., Inc.
        c) Hilti Inc.
        d) ITW Ramset/Red Head; A division of Illinois Tool Works, Inc.
        e) MKT Fastening, LLC.
        f) Approved equal

2. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
3. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.

J. Beam Clamps: C-clamps are allowed 3/8" or smaller and only for static loading such conduits. Provide locknut for hanging rod at clamp. C-clamps are not allowed for open web steel joist applications.
K. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
L. Toggle Bolts: All-steel springhead type.
M. Hanger Rods:
1. MSS SP-58; threaded steel, with adjusting and lock nuts; electroplated zinc finish.
2. MSS SP-58; nonmetallic, with adjusting and lock nuts.

2.02 FABRICATED METAL FRAMING EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural steel shapes, shop or field fabricated to fit dimensions of supported equipment.
B. Materials: Comply with requirements in Division 05 Section “Metal Fabrications” for steel shapes and plates; not be lighter than 12 ga.
C. Finish: Epoxy paint
D. Manufacturers: Same as in paragraph 2.1.B.3 above.

2.03 CONTINUOUS INSERT CHANNELS

A. Length and support capabilities to be suitable for application.
B. Brackets, inserts and accessories suitable for channel insert selected.
C. Manufacturers:
1. Unistrut; Tyco International, Ltd.
2. Cooper B-Line, Inc.; A division of Cooper Industries
3. Michigan Hanger Co., O-Strut Division
4. Anvil International, Inc.
5. Approved equal

PART 3 - EXECUTION

3.01 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70.

1. Size steel hanger rods for individual hangers and trapeze supports as indicated in the following schedule. Total weight of equipment shall not exceed limits indicated.

Maximum Loads (lbs)	Rod Diameter (")	Maximum Pipe Size With Single Rod
730	3/8	2"
1130	1/2	3"
1818	5/8	5"

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25% in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with 2-bolt conduit clamps.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 3/4" and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

E. Install PVC-coated hangers and supports in areas with corrosive atmosphere.

3.02 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements, except as specified in paragraphs below.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT and RMC may be supported by openings through structure members, as permitted in NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor application size and placement shall be reviewed and approved by Structural Engineer prior to installation. Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4" thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4" thick.
6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.
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.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

F. Do not support raceway by other raceway.

G. Do not support equipment or raceway from metal roof decking or floor decking.
H. Do not impose weight of electrical equipment, raceways, or lighting fixtures on support provided for other trades or systems.
I. Top or bottom chords of open web steel joists may be used to support loads provided total load within panel does not exceed 100 lbs and load is placed concentric to joist (panel is length of chord between two adjacent diagonal web members at point of connection to chord).
   1. C-clamps are not permitted for use in open web steel joist applications.
J. Suspend hangers by means of hanger rods. Perforated band iron and flat wire (strap iron) are not allowed.
K. Use conduit-mounting pedestals for piping on roof. Install bottom of pedestal flat on roof deck and insulate exterior of pedestal, flashing and counter flashing.
L. Minimize use of concrete anchors and inserts after concrete pour.
M. Punching, drilling, welding of building structural steel or welding attachment to building structural steel is not allowed, unless approved by structural engineer.
N. Use tools approved for use with PVC-coated conduits and fittings.

3.03 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Division 05 Section “Metal Fabrications” for site-fabricated metal supports.
B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
C. Field Welding: Comply with AWS D1.1/D1.1M.

3.04 CONCRETE HOUSEKEEPING PADS

A. Construct concrete housekeeping pads for all floor-mounted electrical equipment.
B. Dimensions: 3.5” high and not less than 2” larger in both directions than supported equipment, so anchors will be a minimum of 10 bolt diameters from edge of the base.
C. Use 3000 psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section “Cast-in-Place Concrete.”
D. Anchor equipment to concrete housekeeping pad.
   1. Place and secure anchorage devices. Use supported equipment manufacturer’s setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   2. Install anchor bolts to elevations required for proper attachment to supported equipment.
   3. Install anchor bolts according to anchor-bolt manufacturer’s written instructions.
E. Coordinate with Architect installation of housekeeping pads on roof.

3.05 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
B. Touchup: Comply with requirements in Division 09 Sections “Interior Painting” and “Exterior Painting” for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 260533
RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables
B. Section 26 0526 – Grounding and Bonding for Electrical Systems
C. Section 26 0529 – Hangers and Supports for Electrical Systems
D. Section 26 0553 – Electrical Systems Identification
E. Section 26 2726 – Wiring Devices
F. Section 27 0553 – Communications Systems Identification
G. Section 27 1100 – Communications Equipment Room Fittings
H. Section 27 1300 – Communications Backbone Cabling
I. Section 27 1500 – Communications Horizontal Cabling

1.02 DESCRIPTION

A. Section includes raceways, fittings, wireways, outlet boxes, pull and junction boxes, floor boxes, and raceway seals.

1.03 REFERENCE STANDARDS

A. ANSI/NECA 1 – Standard Practices for Good Workmanship in Electrical Contracting
B. ANSI C80-1 – Rigid Steel Conduit-Zinc Coated (GRS)
C. ANSI C80-3 – Electrical Metallic Tubing-Zinc Coated (EMT)
D. ANSI C80-5 – Aluminum Rigid Conduit-Zinc Coated (ARC)
E. ANSI C80-6 – Intermediate Metal Conduit-Zinc Coated (IMC)
F. ASTM A 53/A 53M – Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
G. BICSI TDMM – Telecommunications Distribution Methods Manual, Latest Edition
H. ETL PVC-001 – PVC-Coated Conduit
I. NEMA 250 – Enclosures for Electrical Equipment (1000 V Maximum)
J. NEMA FB 1 – Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable
K. NEMA OS 1 – Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports
L. NEMA OS 2 – Nonmetallic Outlet Boxes, Device Boxes, Covers, and Box Supports
M. NEMA RN 1 – Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
N. NEMA TC 2 – Electrical Polyvinyl Chloride (PVC) Conduit
O. NEMA TC 3 – PVC Fittings for Use with Rigid PVC Conduit and Tubing
P. NFPA 70 – National Electrical Code
Q. TIA-569-B – Commercial Building Standard for Telecommunications Pathways and Spaces
R. UL 1 – Flexible Metal Conduit
S. UL 6 – Electrical Rigid Metallic Conduit-Steel
T. UL 6A – Electrical Rigid Metallic Conduit-Aluminum and Stainless Steel
U. UL 360 – Liquid-Tight Flexible Steel Conduit
V. UL 514A – Metallic Outlet Boxes
W. UL 514B – Conduit, Tubing, and Cable Fittings
X. UL 514C – Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
Y. UL 651 – Schedule 40 and 80 Rigid PVC Conduit and Fittings
Z. UL 797 – Electrical Metallic Tubing-Steel
AA. UL 870 – Wireways, Auxiliary Gutters, and Associated Fittings
BB. UL 1242 – Electrical Intermediate Metal Conduit-Steel
CC. UL 1660 – Liquid-Tight Flexible Nonmetallic Conduit

1.04 SUBMITTALS

A. Product Data:
   1. Raceways
   2. Fittings
   3. Wireways
   4. Outlet boxes
   5. Pull and junction boxes
   6. Floor boxes
   7. Raceway seals

B. Manufacturer's Installation Instructions:
   1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation and installation of product.

C. Closeout Submittals:
   1. Project Record Documents:
      a. Record actual routing of raceways larger than 2".
      b. Record actual location and mounting heights of wireways, wall ducts, indoor service poles, floor boxes, tap boxes, outlet, pull and junction boxes.
   2. Operation and Maintenance Data:
      a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
      b. Include spare parts data listing, source, and current prices of replacement parts and supplies.

1.05 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. Comply with NFPA 70.
   2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
   3. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): "The articles listed in FAR 25.104(a) that are acquired as construction materials."

B. Certification:
   1. Installer of PVC-coated conduits and fitting shall be certified by a PVC conduit manufacturer.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.
B. Protect PVC conduit from sunlight.
C. Comply with manufacturer's written instructions.

1.07 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.
B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.01 RIGID METAL CONDUIT (RMC)

A. Rigid Steel Conduit (RSC): ANSI C80.1, UL 6; heavy wall galvanized steel
B. Intermediate Metal Conduit (IMC): ANSI C80.6, UL 1242; thinner wall, galvanized steel
C. Rigid Aluminum Conduit (RAC): ANSI C80.5; heavy wall aluminum
D. PVC coated rigid steel conduit: NEMA RN 1, ANSI C80.1, UL 6, ETL PVC-001; plastic cap protector caps
E. Fittings (couplings, connectors and bushings): NEMA FB 1, UL 514B; steel (concrete-tight where applicable)**;** threaded; connectors with double locknuts and steel insulating bushings, thermoplastic insulating bushings for conduits 2" and smaller.
F. Fittings (conduit bodies): NEMA FB 1, UL 514B; aluminum die-cast; cover: stamped steel, with stainless steel screws and neoprene gaskets; PVC coated to match conduit.
G. Fittings Manufacturers: Cooper Crouse-Hinds; Carlon Electric Products/Prime Conduit Inc.; O-Z/Gedney; Appleton; Hubbell; Approved equal

2.02 ELECTRICAL METALLIC TUBING (EMT)

A. ANSI C80.3, UL 797; galvanized steel tubing
B. Fittings (couplings and connectors): NEMA FB I, UL 514B; steel, gland compression type connectors with double locknuts and insulated throat. Indentor, drive-on, zinc die-cast or pressure cast not permitted.
C. Fittings (conduit bodies): NEMA FB 1, UL 514B: aluminum die-cast; cover: stamped steel, with stainless steel screws and neoprene gaskets.
D. Fittings Manufacturers: Same as manufacturers listed in 2.1.G.

2.03 FLEXIBLE METAL CONDUIT (FMC)

A. UL 1; interlocked steel
B. Fittings: NEMA FB I, UL 514B; steel, die-cast fittings not permitted

2.04 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)

A. UL 360; interlocked steel with PVC jacket
B. Fittings: NEMA FB 1, UL 514B; steel

2.05 RIGID NONMETALLIC CONDUIT (RNC)

A. NEMA TC 2, UL 651; Schedule 40 PVC
B. Fittings: NEMA TC 3, UL 651

2.06 LIQUIDTIGHT FLEXIBLE NONMETALLIC CONDUIT (LFNC)

A. UL 1660; flexible conduit with a plastic sheath
B. Fittings: UL 514B

2.07 STAINLESS STEEL CONDUIT

A. UL 6A
B. Type 304
C. Fittings: Threaded

2.08 METAL WIREWAYS

A. NEMA 250, UL 870; sheet metal troughs with hinged or removable cover, Type 1, unless otherwise indicated.
B. Size: Minimum 4" x 4", length as indicated on drawings.
C. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mated with wireways as required for complete system.
D. Wireways Covers: Screw-cover type
E. Knockouts: Manufacturer's standard
F. Finish: Manufacturer's standard enamel finish
G. Manufacturers: Hoffman; Square D Co.; Approved equal

2.09 OUTLET BOXES

A. Sheet Metal Outlet Boxes: NEMA OS 1, UL 514A; galvanized steel with stamped knockouts.
   1. Luminaire and Equipment Supporting Boxes: Rated for weight of equipment supported; 1/2” male fixture studs, where required.
   2. Concrete Ceiling Boxes: Concrete type
B. Cast-Metal Outlet Boxes: NEMA FB 1, ferrous alloy, Type FD, with gasketed cover and threaded hubs
   1. For applications requiring more than 2 gang boxes, provide stainless steel custom fabricated welded boxes with threaded hubs and coverplate. For applications including terminations and splicing of power conductors, a standard UL Listed box shall be used inside of the custom fabricated box.
C. Nonmetallic Outlet Boxes: NEMA OS 2
D. Gangable type boxes are not allowed.
E. Manufacturers: O-Z/Gedney; Raco; Cooper Crouse-Hinds; Approved equal

2.010 OUTLET BOXES FOR COMMUNICATIONS

A. Minimum outlet box size: 4-11/16” square by 2-1/8” deep minimum, with single-gang trim ring, unless otherwise noted on drawings.
   1. Total depth of the assembly including the trim ring shall not be less than 2-1/2”.

2.011 PULL AND JUNCTION BOXES

A. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1; galvanized steel
B. Cast-Metal, Pull, and Junction Boxes: NEMA FB 1; cast aluminum with ground flange, gasketed cover and stainless steel cover screws
C. Minimum size: 4” square by 2-1/8” deep for use with 1” conduit and smaller; 4-11/16” square by 2-1/8” deep for use with 1-1/4” conduit and larger
D. Sheet Metal Boxes Larger Than 12” in any direction: Hinged cover or a chain installed between box and cover
E. Field-fabricated boxes not allowed without prior approval of local authority having jurisdiction.
F. Manufacturers: O-Z/Gedney; Raco; Cooper Crouse-Hinds; Approved equal

2.012 PULL AND JUNCTION BOXES FOR COMMUNICATIONS

A. Size: Per TIA-569-B, unless otherwise noted on drawings.
B. Minimum pull box size: 4-11/16” square by 2-1/8” deep, where pull box is used with raceway(s) smaller than 1-1/4” trade size, unless otherwise noted on drawings.
C. Minimum pull box size, where pull box is used with raceway(s) 1-1/4” trade size or larger:
   1. For straight pull through: Length of at least 8 times trade-size diameter of largest raceway.
   2. For angle and U pulls:
      a. Have distance between each raceway entry inside box and opposite wall of box of at least 6 times trade-size diameter of largest raceway, this distance being increased by sum of trade-size diameters of other raceways on same wall of box; and
      b. Have distance between nearest edges of each raceway entry enclosing same conductor of at least:
         1) Six times trade-size diameter of raceway; or
         2) Six times trade-size diameter of larger raceway if raceways are of different sizes.
      c. For raceway entering wall of pull box opposite to removable cover, have distance from wall to cover of not less than trade-size diameter of largest raceway plus 6 times diameter of largest conductor.

2.013 POKE-THROUGH FITTINGS

A. Poke-Through Fittings: Assembly comprising service fitting, poke-through component, fire stops and smoke barriers, and junction box for conduit termination.
   1. Fire Rating: 3h
   2. Service Fitting Type: Flush

3. Housing: Satin aluminum
4. Configuration: One receptacle and provisions for communication outlets
5. Manufacturers: Hubbell, Legrand/Wiremold, FSR; Approved equal

2.014 MULTISERVICE FLOOR BOXES

A. Above Grade: Stamped steel, watertight design approved for use on above-grade concrete floor applications, with four independent wiring compartments and capacity for up to four duplex receptacles and/or communication services. The box: fully adjustable providing pre-pour and after-pour adjustment, tunnel compartment, and two receptacle brackets. Conduit knockouts per drawing requirements. Comply with UL 514A and UL 514C scrub water exclusion test for tile, terrazzo, carpet and wood floors.

B. On Grade: Cast iron or steel pour box, watertight design approved for use in on-grade and above-grade concrete floor applications, with four independent wiring compartments and capacity for up to four duplex receptacles and/or communication devices. The box: fully adjustable providing pre-pour and after-pour adjustment, tunnel compartment, and two receptacle brackets. Conduit knockouts per drawing requirements. Comply with UL 514A and UL 514C scrub water exclusion test for tile, terrazzo, carpet and wood floors.

C. Covers: Activation Covers – Die-cast aluminum with textured aluminum finish, and black or brass powder-coated paint finishes as selected by the Architect. Cover: flanged or flangeless, as required, with options for tile or carpet inserts, blank covers, or covers with one or two 1” liquid tight conduit openings for furniture feed applications.

D. Communication Modules Mounting Accessories: Complete line of faceplates and bezels provided by floor box manufacturer to facilitate mounting of fiber optic, coaxial, high-performance twisted-pair cabling, and communication devices. Cabling type and faceplate configurations per requirements in Section 27 1500 – Communications Horizontal Cabling. The box shall accommodate workstation connectivity outlets and modular inserts and other system devices.

E. Manufacturers:
   1. Hubbell - HBLCFB Series
   2. Spider - AFB/CFB Series
   3. Legrand/Wiremold - Evolution Series

2.015 RACEWAY PENETRATION SEALS

A. Thruwall and Floor Seals.

B. Manufacturers: New construction – OZ/Gedney FSK Series; existing construction – OZ/Gedney CSM Series; or equivalent by manufacturer listed in 2.1.F.

2.016 RACEWAY SEALING FITTINGS

A. For one through four conductors: Manufacturers: OZ/Gedney CSB Series; Approved equal

B. For greater than four conductors: Manufacturers: OZ/Gedney EYA Series with sealing compound; Approved equal

C. Low-temperature or hazardous locations: Manufacturers: OZ/Gedney EYA Series with sealing compound; Approved equal

2.017 CABLE SUPPORTS

A. Manufacturers: OZ/Gedney Type S; or equivalent by manufacturer listed in 2.1.F.

2.018 SLEEVES FOR RACEWAYS

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends, with integral water stop.

B. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052” or 0.138” thickness and of length to suit application.

C. Integral Water Stop: Manufacturer: Thunderline Corporation; Approved equal
   1. High density polyethylene (HDPE). Type Century-Line engineered sleeve with end caps.

2. Steel. Type WS engineered sleeve.

2.019 SLEEVE SEALS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
   1. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
   2. Pressure Plates: Carbon steel. Include two for each sealing element.
   3. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

PART 3 - EXECUTION

3.01 COORDINATION

A. Coordinate with Architect/Engineer size and location of required built-in openings in building structure, including those sleeved, formed or core drilled.
B. Coordinate with Architect/Engineer cutting, removing, or piercing general or mechanical insulation, fire-rated walls, ceilings or steelwork.
C. Verify with Architect/Engineer all surface raceway installations except in mechanical, electrical, and communications rooms.
D. Coordinate with Architect/Engineer exact locations of floor boxes, where shown on drawings, prior to rough-in.
E. Coordinate routing of through-roof conduits.
F. Coordinate sleeve selection and application with selection and application of firestopping specified in Section 26 0593 – Electrical Systems Firestopping.
G. Verify that exterior wall or wet location boxes are gasketed type cast boxes with matching cover.
H. Verify with manufacturer that “touch-up” paint kit and PVC-coating kit are available for use.

3.02 EXAMINATION

A. Examine surfaces to receive raceways and boxes for compliance with installation tolerances and other conditions affecting performance of raceway’s installation. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.03 INSTALLATION

A. Raceways:
   1. Comply with ANSI/NECA 1 and NFPA 70 for installation requirements applicable to products specified in Part 2 except where requirements on drawings or in this Section are stricter.
   2. Arrange raceways to maintain headroom and present neat appearance.
   3. Raceway routing is shown in approximate locations, unless dimensioned. Route to complete raceway installation before starting conductor installation.
   4. Keep raceways at least 6” away from parallel runs of flues, steam, hot-water pipes or ductwork. Install horizontal raceway runs above water and steam piping. Install raceways level and square and at proper elevations: 6’-6” minimum headroom, except in exit pathways 7’-0” minimum headroom. Do not block access to junction boxes, mechanical equipment or prevent removal of ceiling panels, etc.
   5. Run raceways concealed in construction to avoid adverse conditions such as heat and moisture, to permit drainage, and to avoid materials and equipment of other trades, except where noted otherwise.
   6. Avoid exposed raceway runs. Run raceways exposed where impractical or impossible to conceal or where specific approval is obtained. Run exposed raceways grouped and parallel or perpendicular to construction. Do not route exposed raceways over boilers or

other high-temperature machinery or in contact with such equipment. Offset exposed raceways at boxes.

7. Route raceways installed above accessible ceilings parallel or perpendicular to construction.
8. Do not install raceways in structural or topping floor slabs, except where noted on the plans. Install raceway in structural or topping floor slabs, where noted on plans, as follows:
    a. Center raceways in structural slabs clear of reinforcing steel, except where crossing same, and spaced on centers equal or exceeding 3 times the raceway diameter. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement. Space raceways laterally to prevent voids in concrete.
    b. Outside diameter of raceway shall not exceed 1/3 the structural slab thickness.
    c. Obtain approval from Engineer for each run of raceway 1" or larger.
    d. Do not install raceways in topping slabs of 2" or less.
    e. Locate raceways to avoid conflict with equipment, door bucks, partitions and other equipment bolted to floor.
    f. Arrange stub-ups so curved portions of bends are not visible above finished slab. Install with an adjustable top or coupling threaded inside for plugs set flush with finished floor. Extend conductors to equipment with rigid steel conduit; use flexible metal conduit 6" above the floor. Install threaded plugs flush with floor for future equipment connections.
    g. Change from nonmetallic raceway to RMC or IMC before rising above floor.
9. Cut raceways square using saw or pipecutter.
10. Use hydraulic one-shot raceway bender or factory elbows for bends in raceway larger than 2", unless sweep elbows required. Bend raceways according to manufacturer's recommendations. Do not use torches or open flame to aid in bend of PVC conduit.
11. Use raceway fittings compatible with raceways and suitable for use and environment.
12. Provide bushings on all raceways 1-1/2" and larger.
13. Raceways minimum sizes:
    a. Minimum raceway size 3/4", except as noted on drawings.
    b. Minimum home run size: 3/4", except as noted on drawings.
    c. Minimum size for flexible metal conduit is 1/2" except 3/8" for luminaires.
    d. Minimum size for liquidtight flexible metal conduit is 1/2"
14. Install empty raceways 2-1/2" and larger with 10 ga galvanized fishwire; install 200 lb nylon pull cord in raceways smaller than 2-1/2"; leave at least 12" of slack at each end of pull wire. Cap raceways at both ends.
15. Feed devices on same wall vertically from above or junction box in suspended ceiling.
    a. Do not install horizontal bends in conduit around corners.
    b. Feed devices in exterior or load-bearing walls by horizontal conduit runs.
    c. Where horizontal conduit runs are required or allowed, install conduits from device to device on same wall.
16. Raceways Supports:
    a. Independently support or attach raceway system to structural parts of construction. Suspended ceiling systems shall not be considered as structural parts of construction for raceway support. Do not attach raceways to piping system.
    b. Raceway supports for horizontal or vertical single runs:
        1) Hot dipped galvanized heavy-duty sheet steel straps, mineralac clamps or steel slotted support channel system with appropriate components.
        2) Spring steel type pressure clamps for raceways 3/4" and smaller.
    c. Raceway supports for horizontal and vertical multiple runs:

1) Trapeze-type supports fabricated with steel slotted channel systems with appropriate components.
2) Support horizontal runs with appropriately sized rods.
3) Anchor vertical runs to structure.
4) Spring-steel type pressure clamps for raceways 3/4” and smaller.

d. Vertical raceway runs 1-1/4” and larger passing through floors: Support at each floor with pipe riser clamps.
e. Do not support raceways with wire, perforated pipe straps or plastic tie-wrap. Remove wires used for temporary support.
f. Secure raceways in metal stud walls to prevent rattling.
g. Arrange raceway supports to prevent misalignment during wiring installation.
h. Do not fasten raceways to corrugated metal roof deck.
i. For fasteners and supports, including steel slotted support systems, support devices, support spacing, support of conductors in vertical raceways, and hanger rod size, refer to Section 26 0529 – Hangers and Supports for Electrical Systems and NFPA 70.

17. Identify raceways per requirements in Section 26 0553 – Electrical Systems Identification.
18. Ground raceways per requirements in Section 26 0526 – Grounding and Bonding for Electrical Systems.
19. Flexible Conduit Connections: Use maximum of 72” of flexible conduit for recessed and semi-recessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for motors.
    a. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.
20. Install PVC-coated raceways in areas with corrosive atmosphere.
21. Use tools approved for use with PVC coated conduits and fittings.
22. Install stainless steel raceway clamps, mounting hardware, supports, hangers, etc., when located in “wet” or “wash-down” areas.
23. Communications Raceways:
    a. Minimum communications raceway size: 1”, unless otherwise noted on drawings.
    b. Install one raceway from each communications outlet box. Horizontal raceway runs between wall outlet boxes are not allowed.
    c. Terminate raceway on cable tray.
    d. Install insulated bushings on end of each raceway.
    e. Use UL listed metallic grounding clamps, when terminating raceway on cable tray.
    f. Install flush two-gang box with single-gang trim ring for each communications outlet or as noted on drawings.
    g. Install with no more than 180 degrees of bends between pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
    h. Conduit bend radii (minimum) shall be:
        1) Six (6) times internal conduit diameter for conduit 2” or less internal diameter.
        2) Ten (10) times internal conduit diameter for conduit greater than 2” internal diameter.
    i. Conduit bends shall be smooth, even, and free of kinks or other discontinuities that may have detrimental effects on pulling tension or cable integrity during or after installation.
    j. Do not install 90-degree condulets. Install continuous radius sweeps of 45° minimum for 90-degree bends.
    k. Do not install continuous sections longer than 100 ft.
    l. Install nylon pull cord in empty raceways. Leave at least 12” of slack at each end of pull wire. Cap raceways at both ends.

B. Wireways:
   1. Install in accordance with manufacturer's instructions.
   2. Use screws, clips and straps to fasten raceway channel to surfaces.
   3. Mount plumb and level.
   4. Use suitable insulating bushings and inserts at connections to outlets and corner fittings.
   5. Supports: Per manufacturer's recommendations.
   6. Close ends of raceway channel and unused conduit openings.

C. Boxes:
   1. Install boxes to accommodate device indicated by symbol, in conformance with code requirements, number and size of conductors and splices and consistent with type of construction.
   2. Install the appropriate cover on surface-mounted boxes:
      a. Raised device covers on 4" square and 4-11/16" boxes and handy box covers on handy boxes, etc.
      b. Device covers that are square drawn or square cut on boxes in block.
      c. Tile covers on boxes in tile.
      d. Round drawn device covers on boxes in lath and plaster walls or dry wall only.
      e. Set front edge of device boxes flush with finished wall surfaces except on walls of non-combustible materials where boxes may have maximum set back of 1/4". Secure flush-mounted box to interior wall and partition studs. Accurately position to allow for surface finish thickness.
   3. Set outlet boxes parallel to construction and independently attached to same.
   4. Do not install back-to-back and through-the-wall boxes. Install with minimum 6" horizontal separation between closest edges of the boxes. Install with minimum 24" separation in acoustic-rated walls and fire-rated walls.
   5. Install multi-ganged boxes where 2 or more devices are in same location, unless otherwise noted.
   6. Box Support:
      a. Mount boxes straight.
      b. Install horizontal bracing at top or bottom of box for 3 or more gang device boxes in stud walls.
      c. Install stud support one side, with short piece of stud, for up to 2 gang device boxes.
      d. Do not support boxes with tie-wire.
      e. For one and two gang box support, manufactured bracket supports shall be accepted alternate.
      f. Support boxes independently of raceways.
      g. Install adjustable steel channel fasteners for hung ceiling outlet box.
      h. Install stamped steel bridges to fasten flush-mounted outlet box between studs.
      i. Do not install boxes to ceiling support wires or piping systems.
   7. Install partitions in multi-ganged boxes where different types of devices are installed, or devices installed operate at different voltages.
   8. Mount boxes in block walls at block joint nearest to indicated height.
   9. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.
   10. When boxes are installed in fire-resistive walls and partitions, provide 24" horizontal separation between boxes on opposite sides of a wall. In addition, limit penetrations to 16 sq in per penetration and not to exceed a total of 100 sq in per 100 sq ft of wall area. Apply fire stop putty pads acceptable to the fire marshal.

11. Pull and junction boxes: Install as shown, or as necessary to facilitate pulling of wire and to limit number of bends within code requirements. Install above accessible ceilings and in unfinished areas.
12. Install boxes to be permanently accessible.
13. Do not intermix conductors from more than one system in same junction box or pull box, unless shown or specifically authorized otherwise.
14. Adjust box location up to 10' prior to rough-in to accommodate intended purpose.
15. Orient boxes to accommodate wiring devices oriented as specified in Section 26 2726 – Wiring Devices.
16. Inaccessible Ceiling Areas: Install outlet and junction boxes no more than 6" from ceiling access panel or from removable recessed luminaire.
17. The drawings do not necessarily show every outlet, pull or junction box required. Add all required boxes as necessary.

D. Outlet Boxes for Communications:
   1. Install communications outlet boxes for each communications outlet, or as noted on drawings.
   2. Coordinate with other trades to maintain 8" clear space (minimum, measured from box centerline) on all sides of wall-mounted telephone outlet box.

E. Pull and Junction Boxes for Communications:
   1. Position Communications Pull and Junction Boxes:
      a. In any section of conduit longer than 100 ft
      b. Where there are bends totaling more than 180 degrees between pull points or pull boxes
      c. Wherever there is a reverse bend in run
   2. Do not use pull boxes in place of bends on straight section of raceway, unless otherwise shown on drawings.

F. Floor Boxes:
   1. Set metal floor boxes level and flush with finished floor surface.
   2. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.
   3. Use cast floor boxes for installations in slab on grade.
   4. Install floor boxes and fittings to preserve fire-resistant rating of slabs and other elements.
   5. Identify communication outlets per requirements in Section 27 0553 – Communications Systems Identification.
   6. Power and IT or AV conduits require a minimum 12" separation where routed parallel including entry into floor boxes.

G. Expansion Fittings:
   1. Install raceway expansion and deflection fittings in all raceway runs embedded in or penetrating concrete where movement perpendicular to axis of the raceway may be encountered.
   2. Install raceway expansion fittings complete with bonding jumpers in raceway runs that cross expansion joints in structure and raceway runs mechanically attached to 2 separate structures.
   3. Use couplings and flexible connection made up of 24" length of flexible metal conduit, where EMT runs across expansion joints in ceiling spaces.
   4. Install fitting(s) that provide expansion and contraction for at least 0.0004" per ft of length of straight run per °F of temperature change.
   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.

H. Raceway Penetration Seals:
   1. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.
   2. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint. Refer to Division 07 Section “Maintenance of Joint Protection” for materials and installation.
   3. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials.
   4. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.
   5. Aboveground, Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1” annual clear space between pipe and sleeve for installing mechanical sleeve seals.
   6. Underground, Exterior-Wall Penetrations: Install cast-iron “wall pipes” for sleeves. Size sleeves to allow for 1” annual clear space between raceway and sleeve for installing mechanical sleeve seals.
   7. Sleeve-Seal Installation: Use type and number of sealing elements recommended by manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
   8. Provide chrome- or nickel-plated escutcheons where raceways pass through walls, floors or ceilings and are exposed in finished areas. Size escutcheons to fit raceways for finished appearance. Finished areas shall not include mechanical/electrical rooms, janitor’s closets, storage rooms, etc., unless suspended ceilings are specified.
   9. Remove temporary sleeves, if used for form wall openings, prior to installation of permanent materials.

I. Raceway Sealing Fittings:
   1. Install listed watertight seals to prevent the passage of moisture and water vapor through raceway, where raceway passes from interior to exterior of the building, where raceway passes between areas of different temperatures such as into or out of cold rooms or freezers, where raceway enters room which at any time is subject to low or high temperatures and where raceway enters a room which at any time is subject to internal air pressures above or below normal.
   2. Install watertight seals in interior of all raceways passing through building roof, ground floor slab (when the raceway does not extend beyond building footprint), or through outside walls of building above or below grade. Seal on the end inside building, using raceway sealing fittings manufactured for the purpose. Locate fittings at suitable accessible locations. For concealed raceways install each fitting in flush steel box with blank coverplate to match finish of adjacent plates or surfaces.
   3. Seal raceways entering or passing through “hazardous (classified) areas” as defined in NFPA 70.

J. Sleeve Installation for Electrical Penetrations:
   1. Coordinate sleeve selection and application with selection and application of firestopping specified in Section 07 8400 – Firestopping.
   2. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
   3. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
   4. Rectangular Sleeve Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50” and no side greater than 16”, thickness shall be 0.052”.
b. For sleeve cross-section rectangle perimeter equal to, or greater than, 50” and 1 or more sides equal to, or greater than, 16”, thickness shall be 0.138”.

5. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies, unless openings compatible with firestop system used are fabricated during construction of floor or wall.
6. Cut sleeves to length for mounting flush with both surfaces of walls.
7. Extend sleeves installed in floors 2” above finished floor level.
8. Size pipe sleeves to provide 1/4” annular clear space between sleeve and raceway, unless sleeve seal is to be installed.

3.04 APPLICATION

A. Provide raceways and boxes in accordance with the following table:

Application	Approved Raceways	Approved Boxes	Application Notes
Underground More than 5 ft outside Foundation Wall	Rigid Steel Conduit, plastic-coated or Schedule 40 PVC	Cast Metal Boxes or Nonmetallic Handholes	
Underground Within 5 ft from Foundation Wall	Rigid steel conduit	Cast Metal Boxes or Nonmetallic Handholes	
In or Under Slab on Grade	Rigid Steel Conduit or Schedule 40 PVC	Cast or Nonmetallic boxes	Use steel elbows with RNC when encased in concrete
Outdoor Locations, Above Grade	Rigid Steel Conduit	Cast Metal or Nonmetallic	
In Slab Above Grade	Rigid Steel Conduit	Cast Metal	
Wet and Damp Locations	Rigid Steel Conduit	Cast Metal or Nonmetallic. Install flush mounting outlet boxes in finished areas	
Concealed Dry Locations	Electrical Metallic Tubing	Sheet Metal Boxes; Install flush mounting outlet boxes in finished areas; Install hinged enclosure for large pull boxes.	
Exposed Dry Locations	Rigid Steel conduit or Intermediate Metal Conduit	Sheet Metal boxes; Install flush mounting outlet boxes in finished areas; Install hinged	

Application	Approved Raceways	Approved Boxes	Application Notes
		enclosure for large pull boxes.	
Exposed Subject to Damage	Rigid Steel Conduit	Cast Metal	
Locations requiring Mechanical Protection	Rigid Steel Conduit, Intermediate Metallic Conduit		
Corrosive Atmospheres	PVC Coated Conduit		Use PVC Coated Elbows with PVC Conduits
Vibrating equipment (including transformers & hydraulic, pneumatic, electric solenoid or motor-driven equipment)	Flexible Metal Conduits (FMC) – Dry Locations Only Liquid Tight Flexible Metal Conduits (LFMC) – Wet Locations		Lengths for FMC & LFMC may range between 2 ft to 4 ft

B. Special Conditions
   1. One-half inch raceway permitted:
      a. Between controller and its control or pilot device
      b. Between lighting switch and nearest outlet for luminaire
      c. Control wiring where mounted on equipment where conduit must follow contour of equipment
      d. Protective and signal systems where noted
      e. Where shown on plans

3.05 FIELD QUALITY CONTROL

A. Inspect raceway, boxes, and wireways for physical damage and proper alignment.
B. Replace any damaged component of the raceway system or install new raceway system.
C. Inspect components, wiring, connections and grounding.

3.06 REPAINTING

A. Repair damage to galvanized finishes with manufacturer-supplied zinc-rich paint kit. Leave remaining paint with Owner.
B. Repair damage to PVC or paint finishes with manufacturer-supplied touch-up coating. Leave remaining coating with Owner.
C. Wireways, indoor service poles: Remove paint splatters and other marks from surface; touch-up chips, scratches, or marred finished to match original finish using manufacturer-supplied paint kit. Leave remaining paint with Owner.

3.07 ADJUSTING

A. Adjust flush-mounted boxes pre-pour and after-pour to be flush with finished materials.
B. Install knockout closures in unused openings in boxes.
C. Align adjacent wall-mounted outlet boxes for switches and similar devices.
D. Adjust outlet boxes to allow luminaires to be positioned as indicated on reflected ceiling plan.

3.08 CLEANING

A. Clean interior and exterior of boxes, wireways, and indoor poles to remove dust, debris and other material.

END OF SECTION

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SECTION 260533.13
SURFACE RACEWAY SYSTEM

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables
B. Section 26 0526 – Grounding and Bonding for Electrical Systems
C. Section 26 0553 – Electrical Systems Identification
D. Section 26 2726 – Wiring Devices
E. Section 27 0553 – Communications Systems Identification
F. Section 27 1500 – Communications Horizontal Cabling

1.02 DESCRIPTION

A. Section includes surface metallic raceway system for branch circuits, data network, and other low-voltage wiring.
B. Surface raceway system shall consist of raceway bases, appropriate fittings, and device mounting plates necessary for a complete installation.
C. The lengths of the raceways shown on drawings are illustrative and diagrammatic only and should not be used for material takeoff. Raceways shall be provided completely installed to match lengths of cabinets and shelving as indicated on (laboratory) casework shop drawings. Receptacle circuits shall be pre-wired.

1.03 REFERENCE STANDARDS

A. ANSI/NECA 1 – Standard Practices for Good Workmanship in Electrical Contracting
B. NFPA 70 – National Electrical Code
C. UL 5 - Surface Metal Raceways and Fittings
D. UL 5A - Nonmetallic Surface Raceways and Fittings
E. UL 94 – Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

1.04 SUBMITTALS

A. Product Data: Catalog cuts of components.
B. Shop Drawings:
    1. Complete layout, with locations of raceway components.
    2. Grounding, branch circuiting, and wiring including locations of service entrances.
    3. Receptacle types, manufacturers, and spacing.
    4. Receptacle labeling with proper voltage, phase, circuit and panelboard designations, as indicated on drawings.
    5. Communication faceplate types, manufacturers and labeling.
C. Manufacturer’s Installation Instructions:
    1. Indicate application conditions and limitations of use. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
D. Closeout Submittals:
    1. Project Record Documents
        a. Record actual locations of surface raceways with receptacle types, locations and circuits identified.
    2. Operation and Maintenance Data:
        a. Include manufacturer’s recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
        b. Include spare parts data listing, source, and current prices of replacement parts and supplies.

1.05 QUALITY ASSURANCE

A. Obtain surface raceways from one source and by single manufacturer.

B. Regulatory Requirements:
   1. Comply with NFPA 70 for components and installation.
   2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
   3. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): “The articles listed in FAR 25.104(a) that are acquired as construction materials.”

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory unopened packaging until ready for installation.
B. Comply with manufacturer’s written instructions.

1.07 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.
B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Metallic Raceways:
   1. Hubbell
   2. Legrand/Wiremold
   3. Mono-Systems

2.02 FABRICATION

A. UL 5, UL 5A, as applicable
B. Fabrication:
   1. Aluminum
   2. Suitable for use in dry interior locations only.
   3. Two-compartment raceway with separate cover for each compartment, same size as Wiremold Isoduct ALA4800 Series.
   4. Covers with cutouts for device plates as shown on drawings.
   5. 6” and 12” long device plates with flange to overlap joint of adjacent cover.
C. Prewired Raceways:
   1. Wiring devices factory installed, wired, and covers labeled with panel number and circuit number, voltage, phase, and amperes, as identified on drawings, per requirements in Sections 26 0519 – Low-Voltage Electrical Power Conductors and Cables and 26 2726 – Wiring Devices.
   2. Raceway sections with 12” pigtails at feed locations, in 2 ft minimum length and customized to match length shown on drawings.
   3. Equivalent distance between receptacles; number of receptacles per length of raceway as shown on drawings.
   4. Factory installed, NFPA 70 sized, grounding conductors, per requirements in Section 26 0526 – Grounding and Bonding for Electrical Systems.
   5. Raceway covers with hole-cut provisions for communication outlets.
   6. Wiring devices on top and communication outlets on bottom.
D. Material:
   1. Aluminum Raceways: Alloy 6063-T5 extruded aluminum, minimum thickness 0.060”
   2. Fittings: Same material and metal thickness as linear raceway components.

E. Finish:
   1. Aluminum Raceways:
      a. Satin, No. 204 clear anodized 0.004” thick, Class R1 Mil-Spec.
   2. Fittings: Color to match linear raceway components.
F. Accessories:
   1. Fittings: Available as standard accessories, including external corner units, internal corner units, flat units, blank end units, internal and external elbows, coupling for joining raceway sections, and device mounting brackets and plates.
   2. Wire Clips: One for every 2 linear ft of indicated raceway configuration.
   3. Corner elbows and tee fittings, to maintain 2” cable bend radius that meets requirements for communications pathways and specifications for fiber optic, coaxial, and high-performance twisted-pair cabling.
   4. Device Mounting Brackets and Plates: Plastic device mounting brackets and trim plates allowing installation of indicated wiring devices, and communications outlets horizontally in raceways; trim cover sized to overlap device cut-out in raceway, concealing seams; finished to match linear raceway components; plastic compatible with UL 94; brackets and plates, to match raceway width, and with device mounting holes.
G. Communications Outlets and Accessories:
   1. Cabling Type: Per requirements in Section 27 1000 – Structured Cabling and Section 27 1500 – Communications Horizontal Cabling.
   2. Mounting faceplates and bezels: Faceplates configuration per requirements in Section 27 1000 Structured Cabling and Section 27 1500 – Communications Horizontal Cabling.

PART 3 - EXECUTION

3.01 COORDINATION

A. Coordinate cover plate openings with the wiring devices contained within.
B. Coordinate cover plate openings with the communications outlets contained within, to provide for one opening for each communication symbol shown on drawings in Division 27. Coordinate device plate sizes (single-gang or two-gang) to accept communication faceplate types specified in Section 27 1000 – Structured Cabling and Section 27 1500 – Communications Horizontal Cabling.
C. Verify with manufacturer that ‘touch-up’ paint kit is available for repainting.
D. Coordinate surface raceways installation with (laboratory) casework shop drawings to match lengths of cabinets and shelving.
E. Verify location of raceways with architectural interior elevation drawings.

3.02 EXAMINATION

A. Do not begin installation until substrates have been properly prepared.
B. If substrate preparation is the responsibility of another installer, notify Architect/Engineer of unsatisfactory preparation before proceeding.

3.03 INSTALLATION

A. Install in accordance with ANSI/NECA 1 and manufacturer’s instructions.
B. Install flathead screws, clips and straps to fasten surface raceways to substrates, ensuring they are permanently and mechanically anchored. Double-sided adhesive is not acceptable. Mount plumb and level. Use suitable insulating bushings and inserts at connections to outlets and corner fittings.
C. Install wiring devices and communications outlets of type, quantity and spacing as indicated on drawings.
D. Mount raceways on wall parallel to or at right angles to structure and casework.
E. Feed raceways mounted on walls from a backbox through a wall box connector. Determine point of feed in field and complete wiring connections.

F. Maintain ground continuity throughout entire raceway length per requirements in Section 26 0526 – Grounding and Bonding for Electrical Systems.
G. Do not field cut prewired raceways.
H. Install appropriate backbox extension rings where raceway is mounted to steel slotted channel or by some other method, stood off from wall.
I. Raceway receptacle faceplates shall be labeled with adhesive labels with 1/4” high lettering, per requirements in Section 26 0553 – Electrical Systems Identification, indicating receptacle voltage, phase, and amperage (i.e., 120V, 1-phase, 20A) at top of receptacle, and panel and circuit designation (i.e., NLP-D2-2/12) at bottom of receptacle, in accordance with requirements in Section 26 0553 – Electrical Systems Identification, for 15A, 20A and 30A receptacles.
J. Reinforce each cover section for every 30A receptacle in raceway with two 4-40 Phillips counter-sunk steel screws attached to enclosure near top and bottom of receptacle.
K. Identify communication outlets per requirements in Section 27 0553 – Communications Systems Identification.
L. Raceway base shall be secured using screws. Securing with double-sided adhesive is not acceptable.

3.04 FIELD QUALITY CONTROL

A. Inspect surface raceways for physical damage and proper alignment.
B. Inspect components, wiring, connections, installation, and grounding.

3.05 REPAINTING

A. Remove paint splatters and other marks from surface of equipment.
B. Touch-up chips, scratches, or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Owner.

3.06 CLEANING

A. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.

END OF SECTION

SECTION 260553
ELECTRICAL SYSTEMS IDENTIFICATION

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 26 0516 – Owner Furnished Equipment
B. Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables
C. Section 26 0533 – Raceways and Boxes for Electrical Systems
D. Section 26 0573 – Power System Studies
E. Section 26 0923 – Lighting Control Devices
F. Section 26 2200 – Low-Voltage Transformers
G. Section 26 2416.13 – Lighting and Appliance Panelboards
H. Section 26 2416.16 – Distribution Panelboards
I. Section 26 2726 – Wiring Devices
J. Section 26 2816 – Enclosed Switches and Circuit Breakers
K. Section 26 2913 – Enclosed Controllers
L. Section 26 3213 – Engine Generators
M. Section 26 3623 – Automatic Transfer Switches
N. Section 26 4300 – Surge Protective Devices
O. Section 28 3116 – Multiplexed Fire Detection and Alarm Systems

1.02 DESCRIPTION

A. Section includes the following:
   1. Identification for raceway and metal-clad cable
   2. Identification for conductors and communication and control cable
   3. Underground-line warning tape
   4. Warning labels and signs
   5. Instruction signs and posted drawings
   6. Equipment identification nameplates
   7. Wiring devices identification
   8. Miscellaneous identification products
B. Refer to the respective Division 26 Sections, and Sections in other Divisions that specify electrical components, for additional electrical identification requirements.

1.03 REFERENCE STANDARDS

A. ANSI A13.1 – Scheme for the Identification of Piping Systems
B. ANSI C2 – National Electrical Safety Code
C. ANSI Z535.4 – National Standards for Product Safety Signs and Labels
D. 29 CFR – Labor, Part 1910 – Occupational Safety and Health Standards, Section 1910.145 – Specifications for Accident Prevention Signs and Tags
E. NFPA 70 – National Electrical Code

1.04 SUBMITTALS

A. Product Data: For each electrical identification product indicated.
B. Torque log for all terminations 100A and over. Log shall identify target torque values, as they are found via manufacturer documentation and individual locations.
C. Nameplate Schedule: Prior to making nameplates, submit a complete schedule to Architect for approval indicating nameplate size, lettering size, color and actual nameplate information.
D. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

1.05 QUALITY ASSURANCE

A. Comply with ANSI A13.1 and ANSI C2.

B. Comply with NFPA 70.
C. Comply with 29 CFR 1910.145.

1.06 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout project.
B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
C. Coordinate installation of identifying devices with location of access panels and doors.
D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.01 RACEWAY AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
B. Manufacturers: Brady USA, Ideal, Marking Services, Inc. (MSI), Seton, or approved equal.
C. Color for Printed Legend:
   1. Power Circuits: Black letters on an orange field.
   2. Legend: Indicate system or service and voltage, if applicable.
D. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
E. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action when placed in position.
F. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2" long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action when placed in position.
G. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2" wide; compounded for outdoor use.

2.02 CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend.
B. Manufacturers: Brady USA, Ideal, Marking Services, Inc. (MRI), Seton, or approved equal.
C. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1" to 2" wide.
D. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
E. Aluminum Wraparound Marker Labels: Cut from 0.014" thick aluminum sheet, with stamped, embossed, or scribed legend, and fitted with tabs and matching slots for permanently securing around wire or cable jacket or around groups of conductors.
F. Metal Tags: Brass or aluminum, 2" x 2" x 0.05", with stamped legend, punched for use with self-locking nylon tie fastener.
G. Write-On Tags: Polyester tag, 0.010" thick, with corrosion-resistant grommet and polyester or nylon tie for attachment to conductor or cable.
   1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
H. Plasticized Card-Stock Tags: Vinyl cloth with preprinted and field-printed legends. Orange background, unless otherwise indicated, with eyelet for fastener.

2.03 UNDERGROUND-LINE WARNING TAPE

A. Manufacturers: Ideal, Marking Services, Inc. (MRI), Seton, or approved equal.
B. Description: Permanent, bright-colored, continuous-printed, polyethylene tape.
   1. Not less than 6” wide by 4 mils thick.
   2. Compounded for permanent direct-burial service.
   3. Embedded continuous metallic strip.
   4. Printed legend shall indicate type of underground line.
   5. Red tape for electrical and orange tape for communications / controls installations.

2.04 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.
B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.
C. Self-Adhesive Arc Flash Warning Labels: Industrial grade, made of durable polyester with over-laminate to withstand harsh environments (UV rays, scratches and most chemicals).
   1. Manufacturer: Seton or approved equal
D. Engraved Plastic Signs: Engraving stock, melamine plastic laminate, minimum 1/16” thick for signs up to 20 sq in and 1/8” thick for larger sizes.
   1. Engraved legend with black letters on white face.
   2. Punched or drilled for mechanical fasteners.
E. Baked-Enamel Warning Signs for Interior Use: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 1/4” grommets in corners for mounting. Nominal size, 7” x 10”.
F. Metal-Backed, Butyrate Warning Signs for Exterior Use: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396” galvanized-steel backing; and with colors, legend, and size required for application. 1/4” grommets in corners for mounting. Nominal size, 10” x 14”.
G. Warning label and sign shall include, but are not limited to, the following legends:
   1. Multiple Power Source Warning: “DANGER – ELECTRICAL SHOCK HAZARD – EQUIPMENT HAS MULTIPLE POWER SOURCES.”
   2. Workspace Clearance Warning: “WARNING – OSHA REGULATION – AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES.”
   3. Arc Flash Labels: Per ANSI Z535.4, the signal word WARNING appearing in black letters on an orange background, with second line below (Arc Flash and Shock Hazard) in black letters on white background and third line below (Appropriate PPE Required) in black letters on white background. Include the following information on the label:
      a. Equipment name
      b. Available bolted current
      c. Flash protection boundary distance
      d. Incident energy level at 18” expressed in cal/cm^2
      e. Personnel protective equipment (PPE) class
      f. Voltage shock hazard
      g. Limited shock approach boundary
      h. Restricted shock approach boundary

2.05 TORQUE MARKING

A. Contractor shall keep a log of torque values used for project. This record shall incorporate name of installer for each specific location with date/time.

B. Torque marks shall be made on nut side and extend to a non-rotating surface. Torque marks shall be made at time of torqueing – placing torque marks after the fact is not permitted, but instead must be re-torqued and marked.
C. Permanent marker: Contractor shall confirm torque requirements with manufacturer and use tools calibrated within past 6 months. Terminations over 100A shall have black permanent marker utilized for visual confirmation.

2.06 INSTRUCTION SIGNS AND POSTED DRAWINGS

A. Instruction Signs: Engraved, laminated acrylic or melamine plastic, minimum 1/16” thick for signs up to 20 sq in and 1/8” thick for larger sizes.
   1. Engraved legend with black letters on white face
   2. Punched or drilled for mechanical fasteners.
   3. Mounting Frames: Extruded aluminum, 4-point screw mount with 1/8” clear plexiglass cover.
B. Posted Drawings: Print electrical riser diagrams on 20 lb bond paper. (Blueprint paper is not acceptable.) Reduce drawings to approximately 1/2 size using Xerox reduction process. Contact Engineer to obtain updated original plans for printing.

2.07 EQUIPMENT IDENTIFICATION NAMEPLATES

A. Engraved, Three-layer, Laminated Acrylic or Melamine Nameplate: Punched or drilled for screw mounting. White letters on a black background, except emergency power equipment nameplates are to have white letters on a red background. Minimum letter height shall be 3/8” unless noted otherwise.
B. Stenciled Legend: In non-fading, waterproof, black ink or oil-based, alkyd enamel paint. Minimum letter height shall be 1”.

2.08 WIRING DEVICES IDENTIFICATION

A. Refer to Section 26 2726 – Wiring Devices for requirements.

2.09 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, type 6/6 nylon cable ties.
   1. Minimum Width: 3/16”
   2. Tensile Strength: 50 lb minimum
   3. Temperature Range: -40°F to 185°F
   4. Color: Black, except where used for color-coding
B. Paint: Paint materials and application requirements are specified in Division 09 – Finishes painting Sections.
C. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.01 APPLICATION

A. Raceway and Ductbanks More Than 600 V Concealed within Buildings: 4” wide black stripes on 10” centers over orange background that extends full length of raceway or duct and is 12” wide. Stencil legend “DANGER CONCEALED HIGH-VOLTAGE WIRING” with 3” high black letters on 20” centers. Stop stripes at legends. Apply to the following finished surfaces:
   1. Floor surface directly above conduits running beneath and within 12” of a floor that is in contact with earth or is framed above unexcavated space.
   2. Wall surfaces directly external to raceways concealed within wall.
   3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.
B. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30A: Identify with orange self-adhesive vinyl labels.

1. Identify 4” round, 4” square and 4-11/16” junction boxes concealed above ceiling or exposed with neat lettering on cover with permanent black marking pen. Identify source, circuit number, phase, and control circuit number.

C. Accessible Raceways and Cables of Auxiliary Electrical Systems: Identify the following systems with color-coded, self-adhesive vinyl tape applied in bands:
   1. Fire Alarm System (including covers of pull and junction boxes): Red

D. Branch-Circuit Conductor Identification: Where there are conductors for more than three branch circuits in same junction or pull box, use color-coding conductor tape or write-on tags. Identify each ungrounded conductor according to source and circuit number.

E. Conductors to Be Extended in the Future and Spare Conductors: Attach write-on tags to conductors and list source and circuit number.

F. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.
   1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
   2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
   3. Coordinate identification with project drawings, manufacturer’s wiring diagrams, and Operation and Maintenance Manual.

G. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.

H. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply self-adhesive warning labels. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access to equipment.
   1. Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, but not limited to, the following:
      a. Power transfer switches
      b. Controls with external control power connections
   2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.
   3. Arc Flash Warning Labels: install per NFPA 70 for each switchgear, switchboard, panelboard, motor control center, industrial control panel (every enclosure that may contain energized conductors or components). Locate labels so they are visible to the personnel before examination, adjustment, servicing, or maintenance of the equipment.
   4. Available Fault Current Labels: install per NFPA 70 for each piece of service entrance equipment. Locate labels so they are visible to the personnel before examination, adjustment, servicing or maintenance of the equipment.

I. Instruction Signs and Posted Drawings:
   1. Operating Instructions: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend printed in all capital letters of 12 pt size minimum where instructions are needed for system or equipment operation.
   2. Emergency Operating Instructions: Install instruction signs with white legend on a red background with minimum 3/8” high letters for emergency instructions at equipment used for power transfer.

J. Emergency Electrical System Junction and Pull Boxes:
   1. Identify with spray-painted covers as follows:
      a. Emergency circuits: Green/Yellow

b. Standby circuits: Yellow

K. Equipment Identification Nameplates: On each unit of equipment, install unique designation nameplate that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply nameplates to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
   1. Nameplate Instructions:
      a. Indoor Equipment: Engraved, laminated acrylic or melamine nameplate. Unless otherwise indicated, provide a single line of text with 1/2” high letters (1/4” where space is limited) on 1-1/2” high nameplate; where 2 lines of text are required, use nameplates sized 2” high.
      b. Outdoor Equipment: Engraved, laminated acrylic or melamine nameplates sized similar to indoor equipment nameplates.
      c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
   2. Install nameplates for equipment including, but not limited to, the following:
      a. Panelboards, electrical cabinets, and enclosures
      b. Access doors and panels for concealed electrical items
      c. Electrical distribution panelboards including each feeder device within the equipment enclosures.
      d. Transformers
      e. Emergency system boxes and enclosures
      f. Disconnect switches
      g. Enclosed circuit breakers
      h. Motor controllers
      i. Pushbutton stations
      j. Power transfer equipment
      k. Contactors
      l. Remote-controlled switches, dimmer modules, and control devices
      m. Power-generating units
      n. Monitoring and control equipment
      o. Terminals, racks, and patch panels for voice and data communication and for signal and control functions
      p. Non-concealed junction box covers of auxiliary electrical systems
   3. Provide the following information on each nameplate:
      a. Equipment name/tag:
         1) Matching the designation from the contract documents, or identifying the load controlled or function of the equipment where no specific tag is shown on the contract documents.
         2) For disconnect switches, use the prefix “SW-” followed by the name of the equipment served, example: “SW-PMP-201.”
      b. Equipment operating voltage, phase, wiring configuration, and ampacity:
         1) Example: “208V/3PH/4W/225A”
      c. Source of power supply, including circuit number:
         1) Example: “FED FROM LP-2/45”

L. For distribution boards and panelboards, provide a nameplate identifying the color code of wiring within the panel, including the following information:
   1. Heading “<PANEL VOLTAGE> CONDUCTOR COLOR CODING”
   2. PHASE A: <COLOR OF INSTALLED CONDUCTORS>

3. PHASE B: <COLOR OF INSTALLED CONDUCTORS>
4. PHASE C: <COLOR OF INSTALLED CONDUCTORS>
5. NEUTRAL: <COLOR OF INSTALLED CONDUCTORS>
6. GROUND: GREEN>

M. For service entrance equipment, provide a nameplate identifying the maximum available fault current and “as of” effective date.
   1. Example: “MAXIMUM AVAILABLE FAULT CURRENT 33,500A AS OF 2021/06/15.”
N. Access Panel Identification: Furnish typewritten charts with identification and location of access panels serving equipment and incorporate in O&M Manuals.

3.02 INSTALLATION

A. Verify identity of each item before installing identification products.
B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
C. Apply identification devices to surfaces that require finish after completing finish work.
D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
E. Install non-adhesive signs and plastic nameplates parallel to equipment lines; attach with screws and auxiliary hardware appropriate to the location and substrate. Secure to inside surface of door or panelboard that is recessed in finished locations.
F. Posted Drawings and Operating Instructions: Mount drawings and operating procedures on the wall immediately adjacent to the piece of equipment for which the instructions apply. If sufficient wall space is available, mount directly to one of the sheet metal panels of the equipment.
G. Warning Signs: Install warning signs where there is hazardous exposure or danger associated with access to or operation of electrical facilities. Provide text of sufficient clarity and lettering of sufficient size to convey adequate information at each location; mount permanently in an appropriate and effective location. Comply with ANSI A13.1 standard color and design.
   1. Operational Tags: Where needed for proper and adequate information on operation and maintenance of electrical systems, provide tags of plasticized card stock, either preprinted or hand printed to convey the message; example: “DO NOT OPEN THIS SWITCH WHEN BREAKER IS CLOSED.”
H. System Identification Color Banding for Raceways and Cables: Each color band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50 ft maximum intervals in straight runs, and at 25 ft maximum intervals in congested areas.
I. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder, and branch-circuit conductors.
   1. Color shall be factory applied, or, for sizes larger than No. 10 AWG if authorities having jurisdiction permit, field applied.
   2. Colors for 208/120 V Circuits:
      a. Phase A (left bus in panelboard): Black
      b. Phase B (center bus in panelboard): Red
      c. Phase C (right bus in panelboard): Blue
      d. Neutral: White
         1) Dedicated neutral, Phase A; white with black tracer
         2) Dedicated neutral, Phase B: white with red tracer
         3) Dedicated neutral, Phase C: white with blue tracer
      e. Equipment Ground: Green
   3. Colors for 480/277 V Circuits:
      a. Phase A (left bus in panelboard): Brown

b. Phase B (center bus in panelboard): Orange
c. Phase C (right bus in panelboard): Yellow
d. Neutral: Gray
    1) Dedicated neutral, Phase A; gray with brown tracer
    2) Dedicated neutral, Phase B: gray with orange tracer
    3) Dedicated neutral, Phase C: gray with yellow tracer
e. Equipment Ground: Green

4. Field-applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6” from terminal points and in boxes where splices or taps are made. Apply last two runs of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

J. Aluminum Wraparound Marker Nameplates and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

K. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6” to 8” below finished grade. Use multiple tapes where width of multiple lines installed in a common trench exceeds 16” overall.

L. Painted Identification: Prepare surface and apply paint according to Division 09 – Finishes painting Sections.

END OF SECTION

SECTION 260573
POWER SYSTEM STUDIES

PART 1 - GENERAL

1.01 RELATED WORK
A. Section 26 0553 – Electrical Systems Identification
B. Section 26 2200 – Low-Voltage Transformers
C. Section 26 2416.13 – Lighting and Appliance Panelboards
D. Section 26 2416.16 – Distribution Panelboards
E. Section 26 2813 – Fuses
F. Section 26 2816 – Enclosed Switches and Circuit Breakers
G. Section 26 2913 – Enclosed Controllers
H. Section 26 3623 – Automatic Transfer Switches

1.02 DESCRIPTION
A. Section includes computer based, fault current, arc flash, and overcurrent protective device coordination studies for an electrical distribution system, based on actual equipment supplied. Set protective devices based on results of the protective device coordination study.
   1. Coordination of series-rated devices is permitted only where indicated on drawings.
B. Furnish field information and data needed for the studies.
C. Available fault current and electrical equipment interrupting capacity indicated on drawings are based on the short circuit study performed during design as part of the construction documents.

1.03 REFERENCE STANDARDS
A. ANSI C57.96 – Distribution and Power Transformers, Guide for Loading Dry-Type (Appendix to ANSI C57.12 Standards)
B. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings
C. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
D. IEEE 399 – Recommended Practice for Power System Analysis
E. IEEE 620 – Guide for the Presentation of Thermal Limit Curves for Squirrel Cage Induction Machines
F. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems
G. IEEE 1584 – Guide for Performing Arc-Flash Hazard Calculations
H. IEEE 37.46 – American National Standard Specifications for Power Fuses and Fuse-Disconnecting Switches
I. IEEE C57.96 – IEEE Guide for Loading Dry-Type Distribution and Power Transformers
J. ICEA P-32-382 – Short-Circuit Characteristics of Insulated Cable
K. ICEA P-45-482 – Short-Circuit Performance of Metallic Shielding and Sheaths of Insulated Cable
L. NEMA MG 1 – Motors and Generators
M. NFPA 70 – National Electrical Code (NEC)
N. NFPA 70B – Recommended Practice for Electrical Equipment Maintenance
O. NFPA 70E – Standard for Electrical Safety in Workplace

1.04 SUBMITTALS
A. Product Data: Computer software program to be used for studies. Include specific software version for owner record.
B. Product Certificates:
   1. Coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399.
   2. Arc flash calculations computer software programs, certifying compliance with IEEE 1584.

C. Qualification Data: For coordination study specialist.
   1. Submit qualifications of the organization proposed for performing the study. Include description of the equipment and computer-based computation methods or programs used and the names and experience histories of the personnel who will perform the study.
D. Other Action Submittals: Subsequent to having approval for system protective devices submit the following in digital format:
   1. Electrical one-line drawing drafted in computer software program with component names.
      a. Drawing minimum text height of 3/32". Maximum paper size 30"x42". Provide multiple drawing sheets as required.
   2. Fault current study report
   3. Equipment evaluation report
   4. Coordination study input data, including completed computer program input data sheets
   5. Coordination Study Report
   6. Arc Flash Study and Report
   7. Arc Flash labels
   8. Serving utility information with utility letterhead, including but not limited to:
      a. Protective device part numbers/settings
      b. Maximum available 1P and 3P fault
      c. Line conductor sizes/lengths
      d. Transformer impedance
      e. Serving voltage
   9. All software files, including report documents and system study native files (including relevant library files), to allow review and future use of files
   10. Sample energized work permit form

1.05 QUALITY ASSURANCE

A. Perform studies using computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.
B. Coordination Study Specialist Qualifications: An organization experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
   1. Perform study under the direct supervision and control of a Registered Professional Electrical Engineer licensed in the State of Florida, with a minimum of 5 yrs recent experience in performing protective device coordination studies, arc flash calculations, and electrical system analysis. Final report shall be signed and sealed by said engineer.
C. Comply with IEEE 242 for short circuit currents and coordination time intervals.
D. Comply with IEEE 399 for general study procedures.
E. Comply with IEEE 1584 for arc flash calculations.

PART 2 - PRODUCTS

2.01 COMPUTER SOFTWARE DEVELOPERS

A. Computer Software Developers: Subject to compliance with requirements, provide products by one of the following:
B. Basis of Design Product:
   1. CYME International, Inc.
   2. EDSA Micro Corporation

3. SKM Systems Analysis, Inc.
4. ETAP

2.02 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

A. Comply with IEEE 399 and IEEE 1584.
B. Analytical features of fault current study computer software program shall include “mandatory,” “very desirable,” and “desirable” features as listed in IEEE 399 Table 7-4.
C. Computer software program shall be capable of plotting and diagramming time-current characteristic curves as part of its output. Computer software program reports device settings and ratings of all overcurrent protective devices and demonstrates selective coordination by computer-generated, time-current coordination plots.
D. Arc Flash Calculations: Software program capable of calculating Arc Flash Incident Energy (AFIE) levels and flash protection boundary distances.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices for coordination are indicated on drawings.
B. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.
C. Provide the study based on the actual electrical equipment supplied for the project.

3.02 POWER SYSTEM DATA

A. Gather and tabulate the following input data to support coordination study:
    1. Product Data for overcurrent protective devices specified in other Division 26 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with power riser diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
    2. Impedance of utility service entrance(s).
    3. Power Riser Diagrams: In hard copy and electronic copy formats, showing the following:
        a. Circuit breaker and fuse-current ratings and types
        b. Relays and associated power and current transformer ratings and ratios
        c. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios
        d. Generator kilovolt amperes, size, voltage, and source impedance
        e. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length
            1). Prior to equipment purchase, utilize conservative lengths (up/down included) based on planned conduit routing to validate equipment ratings. Final study to utilize contractor provided as-built lengths to confirm equipment ratings.
        f. Busway ampacity and impedance
        g. Motor horsepower and code letter designation according to NEMA MG 1
        h. Load current that is the basis for sizing continuous ratings of circuits for cables and equipment
    4. Data sheets to supplement power riser diagrams, cross-referenced with tag numbers on diagrams, showing the following:

a. Special load considerations, including starting inrush currents and frequent starting and stopping
b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability
c. Motor full-load current, locked-rotor current, service factor, starting time, type of start, and thermal-damage curve
d. Generator thermal-damage curve
e. Ratings, types, and settings of utility company's overcurrent protective devices
f. Special overcurrent protective device settings or types stipulated by utility company
g. Time-current characteristic curves of devices indicated to be coordinated
h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers
i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays
j. Panelboards and automatic transfer switch ampacity, and interrupting rating in amperes rms symmetrical
    1). Automatic transfer switch withstand rating to comply with UL 1008. Equivalent trip curves are not accepted for specific breaker rated equipment – exact breaker and associated trip unit must be listed on UL certification.

3.03 FAULT CURRENT STUDY

A. Calculate maximum available short circuit current in amperes rms symmetrical at circuit breaker positions of electrical power distribution system. Provide calculation for a current immediately after initiation and for a three-phase bolted short circuit at the following:
    1. Distribution panelboard
    2. Branch circuit panelboard
    3. Disconnect switches
    4. Automatic transfer switch
    5. Equipment fed by Variable Frequency Drive (VFD)
    6. Industrial control panels including air handling equipment, elevator controllers, etc.
B. For standard non-bypass Pulse Width Modulation VFDs, a line short circuit condition may be ignored.
C. Verify mechanical equipment served meets or exceeds maximum short circuit available.
D. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for project. Include studies of system switching configurations and alternate operations that could result in maximum fault conditions.
    1. Model the entire electrical distribution system from utility company point of connection to circuit breakers in 208 V distribution panels at secondary side of distribution transformers. Include mechanical HVAC equipment, motor driven equipment feeder circuits, and elevator feeder circuits.
    2. Model shall include components of the distribution system which would be exposed to fault current levels of 10,000 A symmetrical on a calculated basis.
E. Calculate momentary and interrupting duties on basis of maximum available fault current.
F. Perform calculations to verify interrupting ratings of overcurrent protective devices in compliance with IEEE 241 and IEEE 242.
    1. Transformers:
        a. ANSI C57.12.10

b. ANSI C57.12.22
c. ANSI C57.12.40
d. IEEE C57.12.00
e. IEEE C57.96

2. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.20.1
3. Low-Voltage Fuses: IEEE C37.46

G. Study Report:
1. Show calculated X/R ratios and equipment interrupting rating (5-cycle) fault currents on power riser diagrams in report. List other output values from computer analyses, including momentary (1/2-cycle), interrupting (5-cycle), and 30-cycle fault current values for 3-phase, 2-phase, and phase-to-ground faults.

H. Equipment Evaluation Report:
1. Prepare report on adequacy of overcurrent protective devices and conductors by comparing fault current ratings of devices with calculated fault current momentary and interrupting duties.
2. For 600V overcurrent protective devices, ensure interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
3. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in standards to 1/2-cycle symmetrical fault current.
4. Verify adequacy of phase conductors at maximum 3-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure short circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
5. Notify Owner/Engineer promptly of discrepancies, problem areas, or inadequacies and provide recommendations for problem resolution.

3.04 COORDINATION STUDY

A. Perform coordination study using approved computer software program. Prepare a written report using results of fault current study. Comply with IEEE 399.
1. Calculate maximum and minimum 1/2-cycle short circuit currents.
2. Calculate maximum and minimum interrupting duty (5 cycles to 2 seconds) short circuit currents.
3. Calculate maximum and minimum ground-fault currents.

B. Comply with NFPA 70 for overcurrent protection of circuit elements and devices.
C. Comply with IEEE 242 recommendations for fault currents and time intervals.
D. Transformer Primary Overcurrent Protective Devices:
1. Devices non-operational in response to the following:
a. Inrush current when first energized
b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
2. Protect transformers according to IEEE C57.12.00, for fault currents by device settings.

E. Protect motors served by voltages more than 600 V according to IEEE 620.
F. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate equipment withstands the maximum short circuit current for a time equivalent to tripping time of primary relay protection or total clearing time of fuse. To determine temperatures that damage insulation, use

curves from cable manufacturers or from listed standards indicating conductor size and short circuit current. Verify adequacy of phase conductors at maximum three-phase bolted fault currents, equipment grounding conductors, and grounding electrode conductors at maximum ground-fault currents.

G. Include voltage classes of equipment from utility's incoming line protective device down to and including each panelboard. The phase and ground overcurrent protection shall be included as well as settings for other adjustable protective devices.

H. Selective Coordination: Overcurrent devices installed upstream and downstream of automatic transfer switches and/or associated with NEC Article 700 Emergency and 701 Legally Required loads shall be selectively coordinated from source of supply (both normal and emergency sources) through final device. Change specific circuit breakers (type, frame, trip-unit, etc.) and equipment bus rating as necessary to meet this requirement. Selective coordination of the system indicated on the one-line diagram is based on Schneider Electric/Square D equipment.

1. Additionally, provide selective coordination for ground fault through-out.

I. Coordination Study Report: Prepare a written report indicating results of coordination study:

1. Tabular Format of Settings Selected for Overcurrent Protective Devices:
    a. Device tag
    b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values
    c. Circuit breaker sensor rating; and long-time, short-time, and instantaneous settings
    d. Fuse-current rating and type
    e. Ground-fault relay-pickup and time-delay settings
    f. Manufacturer and type of device
    g. Range of adjustments and recommended settings
2. Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate adequate time separation exists between devices installed in series, drawn to show the boundaries of device operation on log-log scale graphs, including power utility company's upstream devices. Where time current curves do not explicitly illustrate selective coordination but breakers have been tested and documented as being selectively coordinated, submit manufacturer's literature to substantiate device coordination. Include on curve sheet a title and legend identifying portion of the system covered. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
    a. Device tag
    b. Voltage and current ratio for curves
    c. Three-phase and single-phase damage points for each transformer
    d. No damage, melting, and clearing curves for fuses
    e. Cable damage curves
    f. Transformer inrush points, full-load amps, and damage curves
    g. Maximum fault current cutoff point
    h. Generator decrement curve and full-load amps
3. Plot characteristics where applicable:
    a. Low-voltage fuses including minimum melt, total clearing and damage bands
    b. Low-voltage circuit breaker trip devices
    c. Transformer full-load current, magnetizing inrush current, and ANSI transformer withstand parameters
    d. Ground-fault protective devices
    e. Motor starting characteristics and motor damage points
    f. Generator short circuit decrement curve and generator damage point

g. Conductor damage curves
h. Electric utility's protective devices

4. Energy-reducing maintenance switch: Where a circuit breaker is equipped with an energy reducing maintenance switch, provide both normal and "maintenance mode" settings for the breaker. Include both settings in tabular format and in coordination curves.
5. Notify Owner/Engineer promptly of discrepancies, problem areas, or inadequacies and provide recommendations for problem resolution. Propose approaches to effectively protect the underrated equipment. Present technical evaluation with discussion of logical compromises for best coordination.

J. Completed data sheets for setting of overcurrent protective devices.

3.05 ARC FLASH STUDY

A. Perform arc flash calculations for Arc Flash Incident Energy (AFIE) levels and flash protection boundary distances. Utilize short circuit rating of equipment identified in fault current study – note infinite bus fault current alone is not acceptable.
B. Model worst-case arc flash conditions.
1. Equipment with PPE rating greater than 2 shall be investigated. Investigation shall include adjustment of upstream overcurrent device settings to determine if PPE rating can be reduced with minimal compromise to coordination with other overcurrent devices.
C. Arc Flash Study Report: Provide study results in tabular form and include:
1. Device or bus name
2. Bolted fault and arcing fault current levels
3. Arc Flash Incident Energy (AFIE) level at 455 mm expressed in cal/cm^2
4. Flash protection boundary distances including:
a. Limited shock approach boundary
b. Restricted shock approach boundary
5. Trip/Delay time
6. Breaker opening time
7. Working distance
8. Equipment class and bus gap
9. Personal protective equipment class (PPE)
D. Provide recommendation for reducing AFIE levels and enhancing worker safety.

3.06 FIELD QUALITY CONTROL

A. Inspect, set, test, and calibrate the circuit breakers, fuses, and other applicable devices.
B. Upon final approval of study, provide weatherproof vinyl or polyester arc flash label for all electrical equipment defined above. Label shall include calculated flash protection boundary, incident energy in cal/cm^2 at working distance (mm working distance based on equipment class, per IEEE 1584), required PPE level, limited approach, restricted approach, equipment name, company name/logo who performed the study, available fault current, overcurrent device settings if applicable, and date label was produced.
1. Label to comply with ANSI Z535. Use "WARNING" (ANSI safety orange background with an orange exclamation point safety symbol) for all arc flash levels.
2. Per NFPA 70E 130.5(C), due to use of incident energy analysis method, PPE categories shall not be provided on labels unless site specific standard PPE categories differ from incident energy levels noted in NFPA 70E Table 130.7(C)(16).
3. Include verbiage on label noting study should be re-examined once every (5) years or upon modifications to electrical system.

3.07 ADJUSTING

A. Make modifications to equipment, as required, to accomplish conformance with equipment evaluation study.
B. Adjust relay and overcurrent protective device settings according to recommended settings table provided by overcurrent protective device coordination study.
C. Verify maintenance mode indicators illuminate upon being engaged.
D. Notify Owner/Engineer in writing of any required major modifications.

3.08 INSTALLATION

A. Install PPE labels on each piece of equipment prior to energizing equipment.
B. PPE labels shall be protected by clear plastic cover, weatherproof type material, or laminated and mounted on front of equipment. Taping of PPE label to front of equipment is unacceptable.
C. PPE label shall be clearly visible upon approach to equipment.
D. For large pieces of equipment, label shall be placed near main overcurrent device or incoming feeder to equipment. For equipment such as switchboards, UPS, or switchgear, with multiple vertical sections, provide (1) label per vertical section.
E. Contractor to provide one-line diagrams (meet IEEE/ANSI standard 141), mounted on 24”x36” (minimum) Styrofoam backboard. These one-line diagrams shall be mounted in each electrical room.
F. Label shall be mounted at a minimum of 42” to bottom and maximum 66” to top above finished floor.

END OF SECTION

SECTION 260923
LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.01 RELATED WORK
A. Section 26 0000 - General Electrical Requirements
B. Section 26 5000 - Lighting

1.02 DESCRIPTION OF SYSTEM
A. Provide devices such as wall box dimmers, wall and ceiling mounted occupancy sensors, ambient light sensors, sensor power packs, etc., as shown on drawings.
B. Openings shall be covered with devices and matching plates.
C. Devices of same type shall be from same manufacturer.

1.03 REFERENCE STANDARDS
A. UL20 - General Use Snap Switches.
B. UL773A - Non-Industrial Photoelectric Switches for Lighting Control.
C. UL924 - Emergency Lighting and Power Equipment
D. NEMA WD 7 - Occupancy Motion Sensors.

1.04 SUBMITTALS
A. Product Data: For each type of product indicated.
B. Shop Drawings shall include:
   1. Bill of material
   2. Schematic diagrams
   3. Suggested manufacturer layouts of all devices including overlays of product range.
C. Samples: One for each type of device and wall plate specified, in each color specified upon request.
D. Manufacturer’s Installation Instructions:
   1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
E. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
F. Closeout Submittals:
   1. Project Record Documents:
      a. Record actual locations and type of devices.
   2. Operation and Maintenance Data:
      a. Include in manufacturers’ packing label warnings and instruction manuals with labeling conditions.
      b. Include source and current prices of replacement parts and supplies.

1.05 QUALITY ASSURANCE
A. Obtain devices from one source and by single manufacturer.
B. Regulatory Requirements:
   1. Comply with NFPA 70 for components and installation.
   2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
   3. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): “The articles listed in FAR 25.104(a) that are acquired as construction materials.”

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory unopened packaging until ready for installation.

1.07 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.
B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers:
   1. Wall Box Dimmers: Acuity Brands Controls, Cooper Controls, Hubbell, Leviton, Lutron, Philips (Sunrise Series), Wattstopper
   2. Low Voltage Switches: Acuity Brands Controls, Cooper Controls, Hubbell, Leviton, Lutron, Philips, Wattstopper
   3. Sensors and Power Packs: Acuity Brands Controls, Cooper Controls, Hubbell, Leviton, Lutron, Philips, Wattstopper
   4. Exterior Occupancy Sensors: Acuity Brands Controls, Leviton, Wattstopper
   5. UL 924 Emergency Bypass/Control Device: Acuity Brands Controls, Hubbell, Leviton, Wattstopper, LVS
   6. Exterior Photocells: Cooper Controls, Hubbell, Intermatic, Leviton, Paragon, Tork
   7. Timeclocks: Intermatic, Paragon, Tork
   8. Self-Contained Automatic Timer Switches: Acuity Brands Controls, Cooper Controls, Hubbell, Leviton, Philips, Wattstopper
B. It is the responsibility of Electrical Contractor to ensure devices submitted meet or exceed functional intent and design quality standards.

2.02 FABRICATION AND MANUFACTURE

A. Devices shall be UL listed for loads and voltages as indicated in contract drawings and specifications.

2.03 WALL BOX DIMMERS

A. Dimmers shall:
   1. Operate in ambient temperature range of 32°F to 104°F.
   2. Be linear slide or pushbutton preset or programmable dimmers with power-failure memory.
   3. Incorporate separate control of intensity and ON/OFF.
   4. Include voltage compensation circuitry that adjusts firing angle of dimmer to compensate light output for variations in AC line voltage. Dimmers in which firing angle is held constant with varying AC line voltage shall not be acceptable.
   5. Provide smooth and continuous IESNA Square Law Dimming Curve throughout entire dimming range.
   6. Incorporate filter network to minimize interference (RFI) with radio, audio, and video equipment.
   7. Incorporate air-gap switch to meet requirements of UL 20 for air-gap switches in incandescent dimmers.
B. LED dimmers shall:
   1. Be approved for use with luminaire and driver.
   2. Provide smooth non-flicker dimming of controlled luminaires.
   3. Be 0-10V type, unless noted otherwise on drawings.
   4. Provide at least 10 steps for continuously dimmed luminaires.
   5. Refer to Section 26 5000 –Lighting for solid state dimming ballast/driver specification.

2.04 LOW-VOLTAGE SWITCHES

A. Low voltage switches shall:
   1. Mount in a single or double gang box.
   2. Be capable of multi-way switching.

2.05 OCCUPANCY AND VACANCY SENSORS

A. Sensors shall:
   1. Operate with all lamp and ballast combinations; including magnetic, hybrid, and solid-state ballasts/drivers.
   2. Operate with ultrasonic, microphonic, passive infrared or presence technologies as indicated on drawings.
   3. Have visible LED to indicate occupant detection.
   4. Have adjustable time delay with a maximum setting of 30 minutes and adjustable sensitivity.
   5. Contain isolated relay with normally open, normally closed, and common outputs for use with HVAC system, data logging, controlled receptacles or other system control options where indicated in contract documents.
   6. Be provided with ceiling, wall or wall switch style mounting as indicated on drawings.
   7. Have daylight filter to ensure PIR sensor is insensitive to short-wavelength waves emitted by the sun.
   8. Incorporate by-pass switch to enable lighting to be turned on if sensor fails.

B. Occupancy Sensor shall:
   1. Provide automatic ON, automatic OFF operation where indicated on drawings.

C. Vacancy Sensor shall:
   1. Provide manual ON, automatic OFF operation where indicated on drawings.

2.06 AMBIENT LIGHT SENSORS

A. Ambient light sensors shall:
   1. Incorporate photoconductive cell to measure light levels between 1 and 1,000 footcandles.
   2. Be adjustable with deadband feature to prevent cycling of lighting from minor changes in cloud cover.
   3. Have adjustable time delay range from 3 to 5 minutes.
   4. Not permit lighting systems to be turned on if enough daylight is present.
   5. Incorporate by-pass switch to enable lighting to be turned on if sensor fails.

2.07 POWER PACKS

A. Sensor power packs shall:
   1. Be self-contained transformer relay modules.
   2. Have universal rated voltage inputs 120-277 VAC, 60 Hz.
   3. Have normally closed dry contacts rated for switching 120-277 volts, 60 Hz. 20 amp loads. Provide 24VDC output capable of controlling low-voltage occupancy sensors.

2.08 EXTERIOR OCCUPANCY SENSORS

A. Exterior occupancy sensors shall:
   1. Be a completely self-contained device capable of detecting presence in the controlled range by detecting changes between infrared energy in motion and the background space.
   2. Utilize passive infrared detection technology and a three level Fresnel lens to increase detection density and accuracy of motion detection.
   3. Be capable of mounting vertically or horizontally onto a standard outdoor junction box or integral to exterior luminaires.
   4. Cover up to 35 ft with a field of view of 180 degrees or 52.5 ft with a field of view of 270 degrees.
   5. Have an operating temperature range of -40°F to 130°F.

6. Be IP66 rated for outdoor applications.
7. Include a built-in light level sensor, adjustable by the user that will keep lights from turning on during daylight hours.
8. Have user-adjustable time delay settings, including an override ON option that enables controlled lights to be turned on remotely for the length of the time delay.
9. Be compatible with all electronic ballasts and LED drivers with no minimum load requirements.
10. Provide continuous dimming or bi-level control to reduce electric light levels from a minimum of 40% to a maximum of 80% based on area occupancy.

2.09 UL 924 EMERGENCY BYPASS/CONTROL DEVICES

A. UL 924 listed bypass relays shall:
   1. Be UL924 listed and labeled for connection to both normal and emergency lighting power sources.
   2. Have universal rated voltage inputs 120-277 VAC, 60 Hz.
   3. Have normally closed dry contacts rated for switching 120-277 volts, 60 Hz. 20 amp loads.
   4. Have integral manual test switch.
   5. Have auxiliary isolated normally closed contact for connection to remote test switch, fire alarm system, or other external system capable of providing a normally closed dry contact closure.
   6. Have status indication for presence of normal and emergency power sources and current operational mode (normal or emergency).
   7. Utilize zero crossing circuitry to protect relay contacts from the damaging effects of inrush current generated by switching electronic ballast loads.
   8. Be forced into the emergency mode upon loss of normal power sense and turn ON the emergency lighting.
   9. Automatically switch emergency lighting ON/OFF as normal lighting is switched. When normal power is not available, the unit shall force and hold emergency lighting ON regardless of the state of any external control device until normal power is restored.
B. Operational temperature range shall be -40°F to 140°F.
C. Device shall have universal mounting; surface, above suspended ceiling or recessed.

2.010 EXTERIOR PHOTOCELLS

A. Photocells shall:
   1. Have universal rated voltage inputs 120-277 VAC, 60 Hz.
   2. Be rated for up to 2,000 watts.
   3. Have cadmium sulfide, 1” diameter cell.
   4. Have SPST normally closed contacts.
   5. Have a minimum delay of 3 minutes to prevent false switching.
B. ON/OFF adjustment shall be done by moving light selector with range from 2 to 50 footcandles.
C. Operational temperature range shall be -40°F to 140°F.
D. Enclosure shall be die cast zinc, gasketed for maximum weatherproofing.
E. Enclosure shall include positioning lug on top.
F. Mounting shall be for 1/2” conduit nipple.

2.011 TIMECLOCKS

A. Timeclocks shall:
   1. Be multi-purpose, 7-day, 365-day advance single and skip a day, combination 2-channel electronic astronomical time clock with SPDT switching configuration.
   2. Have universal rated voltage inputs 120-277 VAC, 60 Hz.
   3. Be capable of programming in AM/PM or 24-hour format by jumper selection or digital setting, in one-minute resolution, using 2 buttons for basic settings.

4. Have 365-day and/or holiday selection capabilities, with 16 single date and 5 holiday selection options and user selectable daylight savings/standard time functions.
5. Have 72-hour memory backup with rechargeable battery and charger.
6. Have manual override, ON/OFF to the next scheduled event, using one button for each channel.
7. Have operational temperature range of -40°F to 150°F.
8. Have a maximum allowed over-ride period no greater than 2 hours.

B. Contacts shall be rated 10 amp resistive at 120/250 VAC, 7.5 amps inductive at 120/250 VAC, 5 amps inductive at 30 VDC and up to 1/2 hp at 250 VAC.
C. Display shall be LCD type.
D. Enclosure shall be rated for installation location.

2.012 SELF-CONTAINED AUTOMATIC TIMER SWITCHES

A. Timer switches shall:
1. Have universal rated voltage inputs 120-277 VAC, 60 Hz.
2. Be programmable to turn lights OFF after a preset time.
3. Have a ground wire and ground strap for safety with a latching air gap relay switching mechanism.
4. Use Zero Crossing Circuitry to increase the relay life, protect from the effects of inrush current.
5. Be compatible with all electronic ballasts, motor loads, LEDs and LED drivers, compact fluorescent and inductive loads. Triac and other harmonic generating devices shall not be allowed.
6. Have no minimum load requirement and shall be capable of controlling 0 to 800 watt incandescent, fluorescent @ 100/120 VAC, 50/60 Hz; 0 to 1200 watts fluorescent @ 230/277 VAC, 50/60 Hz; 1/6 hp @ 125 VAC. LED with internal or external driver@ 100/120VAC.
7. Have the option for light flash warning at five minutes before the timer runs out and again when the countdown reaches one minute.
8. Have the option for a beep warning that shall sound every five seconds once the time switch countdown reaches one minute.
9. Have manual feature for timer reset where pressing the ON/OFF switch for more than 2 seconds resets the timer to the programmed time-out period.
10. Have a feature that shows the timer's countdown.
11. Have the calibration switch for setting time-out, time scroll, one second light flash, and beep warning shall be concealed to prevent tampering of adjustments and hardware.
12. Have a maximum allowed over-ride period no greater than 2 hours.
13. Be capable of operating as an ON/OFF switch.
14. Utilize terminal style wiring.
15. Have a 100% OFF override switch with no leakage current to the load.

2.013 FINISHES

A. Color:
1. Wall box dimmers, low-voltage switches, occupancy sensors, ambient light sensors and device cover plates: white.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install devices at heights scheduled, and as indicated on drawings.
B. Install wall devices vertically on latch side of door within 6" of frame edge, unless otherwise noted.
C. Install ceiling devices as shown on drawings and as recommended by device manufacturer.

D. Ceiling mounted occupancy sensors shall be located minimum of 6 ft from supply air diffusers.
E. Install devices plumb, level with finished surfaces and free from blemishes.
F. Verify device locations prior to rough in.
G. Control wiring shall be low voltage, Class II wiring, electrically isolated from power wiring by a Class II transformer.
H. Provide separate neutral conductor for each dimmer.
I. Wiring shall be in conduit.
J. Electrical Contractor shall be responsible for final adjustment and testing of all devices.

3.02 TESTING

A. Verify proper location and operation of all devices.
B. Verify dimmers function without:
   1. Producing lamp flicker or audible noise.
   2. Interference of audio and visual equipment.
C. Adjust occupancy sensors for a 20 minute time delay.
D. Adjust occupancy sensor sensitivity such that movement outside range of coverage shall not trigger sensor.
E. Adjust ambient light sensor to maintain illuminance level equal to light level from controlled lighting in the space when no daylight is present or as indicated per drawings. Demonstrate ambient light sensor(s) control lighting as specified.
F. Functionality of all installed lighting controls shall be verified by Commissioning Agent as required in Florida Energy Conservation Code.

END OF SECTION

SECTION 262200
LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables
B. Section 26 0526 – Grounding and Bonding for Electrical Systems
C. Section 26 0529 – Hangers and Supports for Electrical Systems
D. Section 26 0533 – Raceway and Boxes for Electrical Systems
E. Section 26 0553 – Electrical Systems Identification

1.02 DESCRIPTION

A. Section includes dry type distribution and buck-boost transformers rated 600V and less, with capacities up to 300 kVA.

1.03 REFERENCE STANDARDS

A. ANSI/NECA 1 – Standard Practices for Good Workmanship in Electrical Contracting
B. IEE C57.12.91 – Test Code for Dry Type Distribution and Power Transformers
C. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum)
D. NEMA ST 1 – Specialty Transformers (except General Purpose Type)
E. NEMA ST 20 – Dry-Type Transformers for General Applications
F. NFPA 70 – National Electrical Code
G. UL 506 – Specialty Transformers
H. UL 1561 – Dry-Type General Purpose and Power Transformers
I. 10 CFR 431.196 (a) (2) – Energy Conservation Standards and Their Effective Dates

1.04 SUBMITTALS

A. Product Data:
    1. Include rated nameplate data, capacities, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.
B. Shop Drawings:
    1. For each transformer size and type:
        a. Physical dimensions, including bolting templates, weight, and center of gravity
        b. Loads, method of field assembly, components, and location and size of each field connection
        c. Wiring Diagrams: Power, signal, and control wiring
        d. kVA rating
        e. Primary taps
        f. Insulation class and temperature rise
        g. Efficiency values measured at 0, 25, 50, 75, and 100% load
        h. Impedance value – X/R and %Z
        i. Sound level
        j. “K” factor listing, where applicable
C. Manufacturer’s Installation Instructions:
    1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
D. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
E. Output Settings Report: Record output voltages and tap settings.
F. Closeout Submittals:
    1. Project Record Documents:

a. Record actual locations of transformers.
2. Operation and Maintenance Data:
a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.

1.05 QUALITY ASSURANCE

A. Obtain transformers from one source and by single manufacturer.
B. Regulatory Requirements:
1. Comply with NFPA 70 for components and installation.
2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
3. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): "The articles listed in FAR 25.104(a) that are acquired as construction materials."

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.
B. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.07 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.
B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Schneider Square D
B. ABB-GE Industrial Solutions
C. Eaton Cutler-Hammer
D. Siemens

2.02 DISTRIBUTION TRANSFORMERS

A. Fabrication:
1. NEMA ST 20, UL 1561
2. Factory assembled and tested
3. Air-cooled, for 60 Hz service
4. Two winding dry type
5. Coils:
a. Continuous wound construction and impregnated with non-hydroscopic, thermosetting varnish.
b. Conductors: Continuous windings without splices, except for taps, and encapsulated wire resin compound to seal out moisture and air.
c. Materials: Aluminum
d. Separate primary and secondary
e. Internal Connections: Braised or pressure type

6. Cores: High-grade silicon steel, non-aging, with high magnetic permeability, low eddy current losses and low hysteresis. Magnetic flux densities below saturation point. Core laminations clamped with steel members, one leg per phase.
7. Rubber vibration absorbing mounts to isolate base of enclosure from core and coil assembly.
8. Transformer neutral visibly grounded to enclosures with flexible grounding conductor.

B. Enclosure:
1. NEMA 250
2. Type 2, unless otherwise indicated to comply with environmental conditions at installed location.
3. Code-gauge steel panel over core and coil.
4. Ventilated (air-cooled): Louvered openings for convection cooling.
5. Cooling and terminal chamber access with both sides and rear obstructed.
6. Manufacturer's lifting eyes or brackets.
7. Finish: Manufacturer's standard gray enamel over prime coat after being degreased, cleaned, and phosphatized.

C. Ratings:
1. KVA Rating: 300 kVA maximum
2. Primary Voltage: 480V, 3-phase, 3 wires.
3. Secondary Voltage: 208Y/120V, 3-phase, 4 wires unless indicated otherwise on drawings.
4. Insulation Class and Winding Temperature Rise:
   a. All Transformers: Class 220°C, continuous operation at full load with temperature rise of not over 150°C above 40°C ambient temperature, with a maximum hot spot temperature of 220°C.
5. Top of Enclosure Temperature: Maximum 35°C above 40°C ambient temperature at warmest point at full load.
6. K-Factor Rating: UL 1561, as indicated.

D. Primary Taps:
1. Transformers rated 3kVA - 15kVA: One 5% above and one 5% below normal full capacity.
2. Transformers rated 15kVA and larger: Two 2.5% above and two 2.5% below normal full capacity, minimum of four taps.

E. Energy Efficiency:
1. Transformers rated 15kVA and larger, except K-rated, quiet type and ultra quiet type:
   a. 10 CFR 431.196 (a) (2) compliant

F. Sound Levels:
1. NEMA ST 20, maximum average sound levels as follows:
   a. 45 dB for general-purpose transformer sizes less than 51kVA.
   b. 50 dB for general-purpose transformer sizes 51-150kVA.
   c. 55 dB for general-purpose transformer sizes 151-300kVA.
2. Minimum of 3 dB less than NEMA ST 20. Maximum average sound levels as follows:
   a. 42 dB for quiet type transformer sizes less than 51kVA.
   b. 47 dB for quiet type transformer sizes 51-150kVA.
   c. 52 dB for quiet type transformer sizes 151-300kVA.
3. Maximum average sound levels, when factory tested according to IEEE C57.12.91, as follows:
   a. 35 dB for ultra quiet transformers, for all sizes through 300kVA.

G. Electrostatic Shielding, where indicated: Each winding with an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.
1. Coil leads and terminal strips arranged to minimize capacitive coupling between input and output terminals.

2. Special terminal included for grounding the shield.
3. Shield Effectiveness:
    a. Capacitance between Primary and Secondary Windings: Not to exceed 33 picofarads over a frequency range of 20 Hz to 1 MHz.
    b. Common-Mode Noise Attenuation: Minimum of minus 120 dBA at 0.5 to 1.5 kHz; minimum of minus 65 dBA at 1.5 to 100 kHz.
    c. Normal-Mode Noise Attenuation: Minimum of minus 52 dBA at 1.5 to 10 kHz.

2.03 BUCK-BOOST TRANSFORMERS

A. Description: NEMA ST 1, UL 506, UL 1561, same as distribution transformers, except rated for continuous duty and with wiring terminals suitable for connection as autotransformer.
B. Enclosure: Ventilated, NEMA 250, Type 2.
    1. Finish Color: Gray enamel over prime coat.

2.04 LUGS

A. Manufacturer's primary and secondary bolted lugs: labeled for 75°C copper and aluminum conductors for ventilated enclosures.
B. Connections at sides near bottom, accessible from front of cabinet.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine conditions for compliance with enclosure and ambient temperature requirements for each transformer.
B. Examine areas and surface to receive transformers for compliance with requirements, installation tolerances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.
C. Verify space indicated for transformers' mounting meets code-required working clearances.
D. Notify Architect/Engineer of any discrepancies prior to submittal of product data and shop drawings.
E. Verify that ground connections are in place and requirements in Section 26 0526 – Grounding and Bonding for Electrical Systems have been met.
F. Verify with manufacturer that "touch-up" paint kit is available for repainting.

3.02 INSTALLATION

A. Install transformers in accordance with ANSI/NECA 1.
B. Install level and plumb within 1/2 degree, and at least 6" from the adjacent wall or structure to insure proper ventilation, in accordance with manufacturer's written instruction, and in compliance with recognized industry practices.
C. Transformer mounting and vibration control:
    1. Mount transformers on floor.
    2. Floor mounting:
        a. Secure to floor via isolation pads between floor brackets (per manufacturer recommendations) and transformer.
        b. Mount on spring isolator.
    3. Wall mounting:
        a. Secure to concrete-and-block wall via isolation pads between wall brackets (fabricated by manufacturer) and transformer.
        b. Secure to gypsum walls with independent steel slotted channel supports, secured to floor via isolation pads between wall brackets (fabricated by manufacturer) and transformer.
        c. Mount on spring isolator.
    4. Suspended mounting:

a. Suspend transformer enclosures designed for floor mounting, where suspended from structural ceiling, via trapeze constructed of steel slotted channel support system hung via 3/8” minimum steel threaded hanger rods attached to structural members or inserts in structural slab. Each rod to contain spring isolator ceiling hanger. Use locking type nuts in assembly.
b. Install restraint cables sway bracing sized to resist a horizontal force of 162% of the operating weight acting in any direction for normal power transformers and 212% of the operating weight for emergency/standby power transformers.
c. Anchor and fasten transformers and their supports to building structural elements by the methods described in Section 26 0529 – Hangers and Supports for Electrical Systems.

D. Install engraved plastic nameplates under provisions of Section 26 0553 – Electrical Systems Identification. Attach nameplate to transformer using small, corrosion-resistant metal screws or rivets. Do not use contact adhesive.
1. Indicate kVA rating, voltage/phase rating, taps, insulation class and temperature rise, impedance value, sound level, and K-factor listing.

E. Install conduit per requirements in Section 26 0533 – Raceway and Boxes for Electrical Systems.
F. Install transformer in dedicated electrical space per NFPA 70 and as shown on drawings. Coordinate with miscellaneous trades for equipment foreign to the electrical installation to be outside of dedicated electrical space.

3.03 CONNECTIONS

A. Ground transformers according to Section 26 0526 – Grounding and Bonding for Electrical Systems.
B. Connect wiring according to Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables.

3.04 FIELD QUALITY CONTROL

A. Inspect transformers for physical damage, proper alignment, anchorage, grounding, connections, and installation.
B. Output Settings Report: Prepare a written report recording output voltages and tap settings and submit to Engineer.

3.05 REPAINTING

A. Remove paint splatters and other marks from surface of equipment.
B. Touch-up chips, scratches, or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Owner.

3.06 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 h of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10% and not being lower than nameplate voltage minus 3% at maximum load conditions.
B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5%, at secondary terminals.

3.07 CLEANING

A. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.

END OF SECTION

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SECTION 262416.13
LIGHTING AND APPLIANCE PANELBOARDS

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables
B. Section 26 0526 – Grounding and Bonding for Electrical Systems
C. Section 26 0529 – Hangers and Supports for Electrical Systems
D. Section 26 0533 – Raceway and Boxes for Electrical Systems
E. Section 26 0553 – Electrical Systems Identification
F. Section 26 0573 – Power System Studies

1.02 DESCRIPTION

A. Section includes circuit breaker type lighting and appliance branch circuit panelboards as shown on drawings and as scheduled.

1.03 REFERENCE STANDARDS

A. NECA 407 - Recommended Practice for Installing and Maintaining Panelboards
B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
C. NEMA AB 1 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
D. NEMA PB 1 - Panelboards
E. NEMA PB 1.1 - General Instructions for Proper Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or Less
F. NFPA 70 - National Electrical Code
G. UL 50 - Enclosures for Electrical Equipment
H. UL 67 - Panelboards
I. UL 486A-486B - Wire Connectors
J. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
K. UL 869A - Reference Standard for Service Equipment

1.04 SUBMITTALS

A. Product Data:
   1. Submit catalog data showing specified features of standard products. Eliminate extraneous catalog data.
B. Shop Drawings:
   1. Submit for review prior to manufacture. Include complete description, front view, dimensions, voltage, main bus ampacity, circuit breaker arrangement and sizes, short circuit current rating, and factory settings of individual protective devices.
   2. Submit 1/4” scale electrical room floor plans with panelboard locations.
C. Partial Submittals:
   1. Panelboards shall be submitted for review together. Partial submittals of panelboards are not acceptable and will be rejected.
D. Manufacturer’s Installation Instructions:
   1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
E. Test Reports:
   1. Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
F. Closeout Submittals:

1. Project Record Documents:
   a. Record actual locations of panelboards and record actual circuiting arrangements.
2. Operation and Maintenance Data:
   a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
   b. Include manufacturer's written instructions for testing and adjusting overcurrent protective devices.
   c. Include time-current curves and selectable ranges for each type of overcurrent protective device.
   d. Include spare parts data listing, source, and current prices of replacement parts and supplies.

1.05 QUALITY ASSURANCE

A. Obtain panelboards, overcurrent protective devices, components, and accessories from one source and by single manufacturer.
B. Regulatory Requirements:
   1. Comply with NFPA 70.
   2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
   3. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): "The articles listed in FAR 25.104(a) that are acquired as construction materials."

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.
B. Comply with NEMA PB 1.1 and manufacturer's written instructions.

1.07 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.
B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

1.08 MAINTENANCE

A. Extra Materials:
   1. Furnish Owner with two keys per panelboard.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Schneider Square D
B. ABB-GE Industrial Solutions
C. Eaton Cutler Hammer
D. Siemens

2.02 LIGHTING AND APPLIANCE BRANCH CIRCUIT PANELBOARDS

A. NEMA PB 1, UL 67
B. Fabrication:
   1. Factory assembled.
   2. With door
   3. Incoming feeder lugs: copper conductors.
   4. Multiple lugs to match number of conductors per phase.

5. Sub-feed (double) lugs, or feed-through lugs where indicated.
6. Filler plates.
7. Wiring terminals for field installed conductors: Pressure wire connectors, except wire-binding screws for #10 AWG or smaller conductors.

C. Panelboard Buses:
1. Copper
2. Ampere rating as scheduled
3. Ground bus: uninsulated, bonded to panelboard cabinet
4. Insulated neutral bus: 100% of phase bus rating

D. Molded-Case Circuit Breakers:
1. NEMA AB 1, UL 489
2. Bolt-on type, labeled for 75°C copper and aluminum conductors
3. Quick-make, quick-break, with thermal-magnetic trip.
4. Common internal trip on multi-pole breakers. Handle-ties are not permitted.
5. Ampere rating as scheduled
6. Listed as Type SWD for lighting circuits
7. Listed as Type HACR for air conditioning equipment circuits
8. Bussing, device mounting hardware, and steel knockouts in dead front where “space” is indicated
9. Tandem circuit breakers are not acceptable
10. Locks on trip handles where indicated
11. Ground fault equipment protection (GFEP), rated 30 mA trip, to provide equipment protection for branch circuits feeding electrical heat tracing, where indicated
12. Ground fault circuit interrupter (GFCI), rated at 4-6 mA trip for protection of personnel, where indicated

E. Cabinet
1. NEMA 250, UL 50
2. NEMA Type 1, Type 3R (outdoor locations) enclosure.
3. Front (trim) flush or surface mounted with door in front with concealed self-adjusting trim clamps, and complete with cylinder-type lock and catch.
4. Same height matching trim, where two cabinets are mounted adjacent to one another in finished areas.
5. All sections of panelboards have the same size, where oversize cabinets are required for one section of multi-section panelboard.
6. Boxes and fronts made of code-gauge galvanized steel.
7. Manufacturer’s standard gray enamel finish over prime coat.

2.03 SERVICE ENTRANCE

A. UL 869A
B. Panelboards labeled as suitable for use as service entrance equipment where applicable and must include connection for bonding and grounding of neutral conductor.
C. Barriers shall be placed such that no uninsulated, ungrounded service busbar or service terminal is exposed to inadvertent contact by persons or maintenance equipment while servicing load terminations.

2.04 SHORT CIRCUIT CURRENT RATING

A. Each panelboard with minimum short circuit current rating as indicated on drawings.
B. Panelboards marked with their maximum short circuit current rating at supply voltage.
C. Panelboards: Fully rated. Series-rated panelboards are not acceptable.

2.05 SURGE PROTECTIVE DEVICES (SPD)

A. By panelboard manufacturer.

B. Per requirements in Section 26 4300 – Surge Protective Devices.

2.06 SPARE CONDUITS

A. Spare conduits per requirements in Section 26 0533 – Raceway and Boxes for Electrical Systems.

PART 3 - EXECUTION

3.01 COORDINATION WITH MANUFACTURER

A. Instruct manufacturer about the location of additional wiring gutter space when required (i.e., top, bottom, right, left, or combination).
B. Instruct manufacturer about the location of main lugs or main circuit breaker (i.e., top or bottom feed based on incoming feeder entrance location).
C. Instruct manufacturer to provide multiple lugs where conductors in parallel or sub-feed (double) lugs or feed-through lugs are indicated.
D. Instruct manufacturer on the size of cross-connection cables for panelboards fed via sub-feed (double) lugs or feed-through lugs. Make cable size with ampacity equal to incoming feeder.
E. Verify that “touch-up” paint kit is available for repainting.

3.02 EXAMINATION

A. Verify that space indicated for panelboard mounting meets code-required working clearances and dedicated equipment space.
B. Notify Architect/Engineer of any discrepancies prior to submittal of product data and shop drawings.

3.03 INSTALLATION

A. Install panelboards in accordance with NECA 407 and NEMA PB 1.1.
B. Install panelboards plumb and rigid without distortion of box, in accordance with manufacturer's written instructions, and in compliance with recognized industry practices.
C. Panelboard mounting:
    1. Fasten panelboards firmly to walls and structural surfaces, ensuring they are permanently and mechanically anchored.
    2. Anchor and fasten panelboards and their supports to building structural elements (wood, concrete, masonry, hollow walls and nonstructural building surfaces) by the methods described in Section 26 0529 – Hangers and Supports for Electrical Systems.
    3. Install two rows of steel slotted channel, with a minimum of 4 attachment points, for each panelboard section.
    4. When not located directly on wall, provide support frame of steel slotted channel anchored to floor and ceiling structure.
D. Install top breaker handle a maximum of 6’-7” above finished floor or working platform with handle in its highest position.
E. Tighten electrical connectors and terminals according to equipment manufacturer's published torque-tightening values. Where manufacturer’s torque values are not indicated, use those specified in UL 486A – 486B.
F. Install as-built typewritten circuit directory in directory frame (to indicate installed circuit loads) mounted inside each panelboard door. Include description of connected loads, room number, room name, area, or item served for each branch circuit. Indicate motor names and horsepower as applicable. Cover circuit directory with colorless plastic. Coordinate with Owner and Architect to ensure that room numbers used in panel directory are final numbers assigned by Owner.
G. Install engraved plastic nameplates under provisions of Section 26 0553 – Electrical Systems Identification. Attach nameplate to exterior of each panelboard using small metal screws, rivets, or contact adhesive.
    1. Include panelboard name, amperage, voltage, phase, and number of wires.

H. Label spare circuits as SPARE. Leave spare breakers in OFF position.
I. Room numbers used shall be those used by Owner except as otherwise directed by Architect.
J. Install panelboard in dedicated electrical space per NFPA 70 and as shown on drawings. Coordinate with miscellaneous trades for equipment foreign to the electrical installation to be outside of dedicated electrical space.
K. Install filler plates in unused spaces.
L. Install three 3/4" spare conduits stubbed into accessible ceiling space or space designated to be ceiling space in the future for all flush-mounted panelboards. Install conduits in accordance with requirements in Section 26 0533 – Raceway and Boxes for Electrical Systems.
M. Install three 3/4" spare conduits stubbed into ceiling space above and below for panelboards that serve loads on levels other than that where the panelboard is located. Install conduits in accordance with requirements in Section 26 0533 – Raceway and Boxes for Electrical Systems.

3.04 CONNECTIONS

A. Ground panelboards according to Section 26 0526 – Grounding and Bonding for Electrical Systems.
B. Connect wiring according to Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables.

3.05 FIELD QUALITY CONTROL

A. Inspect for physical damage, proper alignment, anchorage, and grounding.
B. Maintain proper phasing for multi-wire circuits.
C. Check phase-to-phase and phase-to-ground insulation resistance levels prior to energization of panelboards.
D. Check panelboards for electrical continuity of circuits and for short-circuits prior to energization.

3.06 REPAINTING

A. Remove paint splatters or other marks from surface of panelboards.
B. Touch-up chips, scratches, or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Owner.

3.07 ADJUSTING

A. Adjust fronts, covers, hinges, and locks.

3.08 CLEANING

A. Clean panelboard interiors and exteriors prior to final inspection. Remove paint splatters and other spots, dirt and debris.

END OF SECTION

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SECTION 262416.16
DISTRIBUTION PANELBOARDS

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables
B. Section 26 0526 – Grounding and Bonding for Electrical Systems
C. Section 26 0529 – Hangers and Supports for Electrical Systems
D. Section 26 0553 – Electrical Systems Identification
E. Section 26 0573 – Power System Studies
F. Section 26 4300 – Surge Protective Devices

1.02 DESCRIPTION

A. Section includes circuit breaker type power distribution panelboards as shown on drawings and as scheduled.

1.03 REFERENCE STANDARDS

A. NECA 407 - Recommended Practice for Installing and Maintaining Panelboards
B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
C. NEMA AB 1 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
D. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
E. NEMA PB 1 - Panelboards
F. NEMA PB 1.1 - General Instructions for Proper Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or Less
G. NFPA 70 - National Electrical Code
H. UL 50 - Enclosures for Electrical Equipment
I. UL 67 - Panelboards
J. UL 486A – 486B - Wire Connectors
K. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
L. UL 869A - Reference Standard for Service Equipment

1.04 SUBMITTALS

A. Product Data:
   1. Submit catalog data showing specified features of standard products. Eliminate extraneous catalog data.
B. Shop Drawings:
   1. Submit for review prior to manufacture. Include complete description, front view, dimensions, voltage, main bus ampacity, circuit breaker arrangement and sizes, short circuit current rating, and factory settings of individual protective devices.
   2. Submit 1/4” scale electrical room floor plans with panelboard locations.
C. Partial Submittals:
   1. Panelboards shall be submitted for review together. Partial submittals of panelboards are not acceptable and will be rejected.
D. Manufacturer’s Installation Instructions:
   1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
E. Test Report:

1. Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.

F. Closeout Submittals:
   1. Project Record Documents:
      a. Record actual locations of panelboards and record actual circuiting arrangements.
   2. Operation and Maintenance Data:
      a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
      b. Include manufacturer's written instructions for testing and adjusting overcurrent protective devices.
      c. Include time-current curves and selectable ranges for each type of overcurrent protective device.
      d. Include spare parts data listing, source, and current prices of replacement parts and supplies.

1.05 QUALITY ASSURANCE

A. Obtain panelboards, overcurrent protective devices, components, and accessories from one source and by a single manufacturer.
B. Regulatory Requirements:
   1. Comply with NFPA 70.
   2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
   3. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): "The articles listed in FAR 25.104(a) that are acquired as construction materials."

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.
B. Comply with NEMA PB 1.1 and manufacturer's written instructions.

1.07 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.
B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

1.08 MAINTENANCE

A. Extra Materials:
   1. Furnish Owner with two keys per panelboard.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Schneider Square D
B. ABB-GE Industrial Solutions
C. Eaton Cutler Hammer
D. Siemens

2.02 POWER DISTRIBUTION PANELBOARDS

A. NEMA PB 1, UL 67.
B. Fabrication:
   1. Factory assembled

2. Individualized breaker dead-front cover without door
3. Incoming feeder lugs: copper conductors
4. Multiple lugs to match number of conductors per phase
5. Sub-feed (double) lugs, or feed-through lugs where indicated
6. Filler plates
7. Wiring terminals for field installed conductors: Pressure wire connectors, except wire-binding screws for #10 AWG or smaller conductors.
8. Barriers shall be placed such that no uninsulated, ungrounded service busbar or service terminal is exposed to inadvertent contact by persons or maintenance equipment while servicing load terminations.

C. Panelboard Buses:
1. Copper
2. Ampere rating as scheduled
3. Ground bus: uninsulated, bonded to panelboard cabinet
4. Insulated neutral bus where applicable: 100% of phase bus rating

D. Molded-Case Circuit Breakers:
1. NEMA AB 1, UL 489
2. Bolt-on or I-line type, labeled for 75°C copper and aluminum conductors
3. Quick-make, quick-break, with thermal-magnetic trip and electronic (solid-state microprocessor-based) trip.
4. Equipped with individually insulated, braced, and protected connectors
5. Common internal trip on multi-pole breakers. Handle-ties are not permitted.
6. Ampere rating as scheduled
7. Front face flush with each other
8. Large, permanent, individual circuit numbers affixed to each breaker in uniform position
9. Tripped indication clearly shown by breaker handle taking position between “ON” and “OFF.”
10. Listed as Type HACR for air conditioning equipment circuits
11. Bussing, device mounting hardware, and steel knockouts in dead front where “space” is indicated
12. For 225A frame size and below: thermal-magnetic trip
13. For 250A frame size and above: electronic trip units interchangeable in the field within the frame size and field-adjustable long time pick-up, long time delay, short time pick-up, short time delay, and instantaneous current settings. Each adjustment shall have discrete settings and shall be independent of all other adjustments.

E. Cabinet
1. NEMA 250, UL 50
2. NEMA Type 1, Type 3R (outdoor locations) enclosure.
3. Four-piece front (trim) surface mounted without door with breakers exposed.
4. Same height matching trim, where two cabinets are mounted adjacent to one another in finished areas.
5. All sections of panelboards have the same size, where oversize cabinets are required for one section of multi-section panelboard.
6. Boxes and fronts made of code-gauge galvanized steel
7. Manufacturer’s standard gray enamel finish over prime coat.

2.03 SERVICE ENTRANCE

A. UL 869A
B. Panelboards labeled as suitable for use as service entrance equipment where applicable and must include connection for bonding and grounding of neutral conductor.

2.04 SHORT CIRCUIT CURRENT RATING

A. Each panelboard with minimum short circuit current rating as indicated on drawings.
B. Panelboards marked with their maximum short circuit current rating at supply voltage.
C. Panelboards: Fully rated. Series-rated panelboards are not acceptable.

2.05 SURGE PROTECTIVE DEVICES (SPD)

A. By panelboard manufacturer.
B. Per requirements in Section 26 4300 – Surge Protective Devices.

PART 3 - EXECUTION

3.01 COORDINATION WITH MANUFACTURER

A. Instruct manufacturer about the location of additional wiring gutter space when required, i.e. top, bottom, right, left, or combination.
B. Instruct manufacturer about the location of main lugs or main circuit breaker (i.e., top or bottom feed based on incoming feeder entrance location).
C. Instruct manufacturer to provide multiple lugs where conductors in parallel or sub-feed (double) lugs or feed-through lugs are indicated.
D. Instruct manufacturer on the size of cross-connection cables for panelboards fed via sub-feed (double) lugs or feed-through lugs. Make cable size with ampacity equal to incoming feeder.
E. Verify that “touch-up” paint kit is available for repainting.

3.02 EXAMINATION

A. Verify that space indicated for panelboard mounting meets code-required working clearances and dedicated equipment space.
B. Notify Architect/Engineer of any discrepancies prior to submittal of product data and shop drawings.

3.03 INSTALLATION

A. Install panelboards in accordance with NECA 407 and NEMA PB 1.1.
B. Install panelboards plumb and rigid without distortion of box, in accordance with manufacturer's written instructions, and in compliance with recognized industry practices.
C. Panelboard mounting:
    1. Fasten panelboards firmly to walls and structural surfaces, ensuring they are permanently and mechanically anchored.
    2. Anchor and fasten panelboards and their supports to building structural elements (wood, concrete, masonry, hollow walls and nonstructural building surfaces) by the methods described in Section 26 0529 – Hangers and Supports for Electrical Systems.
    3. Install two rows of steel slotted channel, with a minimum of four attachment points, for each panelboard section.
    4. When not located directly on wall, provide support frame of steel slotted channel anchored to floor and ceiling structure.
D. Install top breaker handle a maximum of 6’-7” above finished floor or working platform, with handle in its highest position.
E. Tighten electrical connectors and terminals according to equipment manufacturer's published torque tightening values. Where manufacturer’s torque values are not indicated, use those specified in UL 486A –486B.
F. Install as-built typewritten circuit directory in directory frame (to indicate installed circuit loads before completing load balancing) affixed to outside cover of each panelboard**.** Include description of connected loads, room number, room name, area, or item served for each branch circuit. Indicate motor names and horsepower as applicable. Cover circuit directory with colorless plastic.
G. Install engraved plastic nameplates under provisions of Section 26 0553 – Electrical Systems Identification. Attach nameplate to exterior of each panelboard using small, corrosion-resistant metal screws or rivets. Do not use contact adhesive.

1. Indicate panelboard name, amperage, voltage, phase, and number of wires.

H. Label spare circuits as SPARE. Leave spare breakers in OFF position.
I. Room numbers used shall be those used by Owner except as otherwise directed by Architect.
J. Install panelboard in dedicated electrical space per NFPA 70 and as shown on drawings. Coordinate with miscellaneous trades for equipment foreign to the electrical installation to be outside of dedicated electrical space.
K. Install filler plates in unused spaces.

3.04 CONNECTIONS

A. Ground panelboards according to Section 26 0526 – Grounding and Bonding for Electrical Systems.
B. Connect wiring according to Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables.

3.05 FIELD QUALITY CONTROL

A. Inspect for physical damage, proper alignment, anchorage, and grounding.

3.06 REPAINTING

A. Remove paint splatters or other marks from surface of panelboards.
B. Touch-up chips, scratches, or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint to Owner.

3.07 ADJUSTING

A. Adjust fronts, covers, hinges, and locks.
B. Circuit Breakers: Set field-adjustable trip settings or change the trip settings recommended by the overcurrent protective device coordination study per Section 26 0573 – Power System Studies.

3.08 CLEANING

A. Clean panelboard interiors and exteriors prior to final inspection. Remove paint splatters and other spots, dirt and debris.

END OF SECTION

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SECTION 262726
WIRING DEVICES

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 26 0526 - Grounding and Bonding for Electrical Systems
B. Section 26 0553 - Electrical Systems Identification

1.02 DESCRIPTION

A. Section includes general-use snap switches, receptacles, pendant cord-connector devices, cord and plug sets and device cover plates.

1.03 REFERENCE STANDARDS

A. IEEE C62.41.2 – Characterization of Surges in Low-Voltage (1000V and less) AC Power Circuits
B. IEEE C62.45 – Surge Testing for Equipment Connected to Low-Voltage (1000V and less) AC Power Circuits
C. NECA 1 – Good Workmanship in Electrical Contracting
D. NFPA 70 – National Electrical Code
E. NEMA WD-1 – General Color Requirements for Wiring Devices
F. NEMA WD-6 – Wiring Devices - Dimensional Requirements
G. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum)
H. UL 20 – General-Use Snap Switches
I. UL 498 – Attachment Plugs and Receptacles
J. UL 943 – Ground-Fault Circuit-Interrupters
K. UL 1203 – Safety Explosion-Proof and Dust-Ignition Proof Electrical Equipment for Use in
L. UL 1436 – Outlet Circuit Testers and Similar Indicating Devices
M. UL 1449 – Transient Voltage Surge Suppressors

1.04 SUBMITTALS

A. Product Data: For each type of product indicated.
B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
C. Samples: One for each type of device and wall plate specified, in each color specified.
D. Manufacturer’s Installation Instructions:
    1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
E. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
F. Closeout Submittals:
    1. Project Record Documents:
        a. Record actual locations and ratings of wiring devices.
    2. Operation and Maintenance Data:
        a. Include in manufacturers’ packing label warnings and instruction manuals with labeling conditions.
        b. Include source and current prices of replacement parts and supplies.

1.05 QUALITY ASSURANCE

A. Obtain wiring devices from one source and by single manufacturer.
B. Regulatory Requirements:
    1. Comply with NFPA 70 for components and installation.
    2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

3. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): “The articles listed in FAR 25.104(a) that are acquired as construction materials.”

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory unopened packaging until ready for installation.

1.07 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.
B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Cooper Wiring Devices; a division of Cooper Industries, Inc.
B. Hubbell Incorporated; Wiring Device-Kellems
C. Leviton Manufacturing Company, Inc.
D. Pass & Seymour/Legrand; Wiring Devices & Accessories

2.02 GENERAL-USE SNAP SWITCHES

A. Comply with NEMA WD 1 and UL 20.
B. Switches: Heavy-duty (specification grade); back and side wired; flush or surface mounting; Body and Handle: thermoplastic with toggle handle; for connection to copper or copper-clad conductors:
    1. Ratings:
        a. Voltage: 120-277V, AC
        b. Current: 20 A
    2. Single pole
    3. Pendant and Through-cord: For field installation on flexible cord and provided with one “ON’ and one “OFF” position.
    4. Switches for Connections to Aluminum Conductors: Comply with UL 1567.
    5. Weatherproof: Toggle switch

2.03 RECEPTACLES

A. Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
B. Receptacles: 125 V, 20A, heavy-duty (specification grade); back and side wired; flush or surface mounted; straight blade; 2 pole, 3 wire grounding; thermoplastic body; duplex and single as indicated on drawings.
    1. Ground Fault Circuit Interrupter (GFCI):
        a. Additional compliance with UL 943 Class A.
        b. Leakage current trip level: 4 to 6 mA.
        c. Trip time: .025 seconds nominal.
        d. Non-feed through type
        e. Reverse line-load function to prevent GFCI from functioning if wired incorrectly.
        f. Indicator Light: Lighted when device is tripped.
    2. Transient Voltage Surge Suppression (TVSS):
        a. Additional compliance with UL 1449, with integral TVSS in line to ground, line to neutral, and neutral to ground.
        b. TVSS Components: Multiple metal-oxide varistors; with a nominal clamp-level rating of 400 volts and minimum single transient pulse energy dissipation of 240 J, according to IEEE C62.41.2 and IEEE C62.45.

c. Active TVSS Indication: Visual and audible, with light visible in face of device to indicate devise is “active” or “no longer in service.”

3. Tamper Resistant (TR):
   a. Requires insertion of object in both left and right contacts to energize.
   b. 2- or 3-prong plug.
4. Twist-locking:
   a. NEMA WD 6 configuration L5-20R unless indicated otherwise on drawings.
5. Switched: Upper half switched and lower half not switched.
6. Dedicated: Labeled “Dedicated.”
7. Special Purpose Receptacles: Specification grade, rated for voltage, amperage and NEMA configuration as noted on drawings.

2.04 PENDANT CORD-CONNECTOR DEVICES

A. Description: Matching, locking-type plug and receptacle body connector; NEMA WD 6 configuration L5-20P and L5-20R, heavy-duty grade.
   1. Body: Nylon with screw-open cable-gripping jaws and provision for attaching external cable grip.
   2. External Cable Grip: Woven wire-mesh type made of high-strength galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.05 CORD AND PLUG SETS

A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.
   1. Cord: Thermoset-insulated, stranded-copper conductors, with Type SOOW jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30%.
   2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.06 DEVICE COVER PLATES

A. Single and combination types to match corresponding wiring devices:
   1. Attachment: Metal screws with head color to match plate finish.
   2. Material for Finished Spaces: 0.035” thick, satin-finished stainless steel.
   3. Material for Unfinished Spaces: Galvanized steel.
   4. Material for Damp Locations: Thermoplastic with while-in-use hinged cover, and listed and labeled for use in “wet locations”.

B. Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant, thermoplastic with weatherproof while-in-use hinged cover.

C. Lockable Cover:
   1. Hinged steel cover with cylinder lock.
   2. Keyed all the same.

D. Tamper Resistant (TR):
   1. Slide cover over receptacle.

2.07 FINISHES

A. Color:
   1. Switch handles and receptacles: ~~White~~Gray, except as follows:
      a. Switch handles and ~~receptacle faceplates~~receptacles connected to Emergency or Standby Power System: Red; labeled “Emergency.”

PART 3 - EXECUTION

3.01 COORDINATION

A. Special Purpose Receptacles: Coordinate final selections of NEMA configuration (locking, straight, blade, etc.) with configuration of plug on utilization equipment.
B. Receptacles for Owner-furnished equipment and equipment furnished under other divisions of specifications: Match plug configurations.
C. Cord and Plug Sets: Match equipment requirements.
D. Coordination with Other Trades:
    1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers guided by riding against outside of the boxes.
    2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
    3. Install device boxes in brick or block walls so that the device cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
    4. Install wiring devices after all wall preparation, excluding painting, is complete. Install device cover plates after painting is complete.

3.02 EXAMINATION

A. Verify location of wiring devices with architectural interior elevation drawings, prior to rough-in.
B. Verify outlet boxes are installed at proper height.
C. Verify wall openings are neatly cut and completely covered by wall plates.
D. Verify branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.

3.03 PREPARATION

A. Clean debris from outlet boxes.

3.04 INSTALLATION

A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise scheduled or indicated on drawings. Indicated dimensions are to center of device.
B. Conductors:
    1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
    2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
    3. Length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
    4. Do not place bare stranded conductors directly under device screws. Use crimp on fork terminals for device terminations.
C. Device Installation:
    1. Replace all devices that have been in temporary use during construction or show signs of installation prior to completion of building finishing operations.
    2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
    3. Do not remove surface protection, such as plastic film and smudge covers, until last possible moment.
    4. Connect devices to branch circuits using pigtails that are not less than 6” in length.
    5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
    6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
    7. When conductors larger than #12 AWG are installed on 15A or 20A circuits, splice #12 AWG pigtails for device connections.
    8. Tighten unused terminal screws on the device.

9. When mounting into metal boxes, remove fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.
10. Install devices plumb, level with finished surfaces and free from blemishes.
11. Install lighting switches vertically on latch side of door within 6" of frame edge.
12. Install devices above counters, 2" to the bottom of device above countertop or backsplash. Install all devices at same height above any one counter or fixed cabinet.
13. Install special purpose receptacles and switches according to shop and rough-in drawings furnished by trade(s) producing such equipment. Verify locations prior to rough-in.
14. Install weatherproof GFCI receptacles:
    a. Within 25'-0" of mechanical equipment
    b. Outdoors
    c. As indicated on drawings
15. Group adjacent switches under single, multigang wall plates.
16. Connect wiring device grounding terminal to outlet box with bonding jumper and branch circuit equipment grounding conductor. Ground per requirements in Section 26 0526 – Grounding and Bonding for Electrical Systems.

D. Installation Orientations:
   1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.
   2. Install switches with handle operating vertically, with "ON" position up.
   3. Unless otherwise indicated or where space problem occurs, mount devices flush, with long dimension vertical.

E. Device Cover Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

F. Wall-Box Dimmers:
   1. Install dimmers within terms of their listing.
   2. Verify that dimmers used for fan speed control are listed for that application.
   3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

G. Arrangement of Devices:
   1. Unless otherwise indicated or where space problem occurs, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

3.05 IDENTIFICATION

A. Comply with Section 26 0553 – Electrical Systems Identification.
   1. Switches and Receptacles: Use hot, stamped or engraved machine printing with black-filled lettering on face of cover plate, and durable wire markers or tags inside outlet boxes.
      a. Receptacles: Label shall indicate receptacle voltage, phase, and amperage for receptacles other than 20A, 120 V, at top of cover plate, and panel and circuit number at bottom of cover plate.
      b. Switches: Label shall indicate switch voltage, phase, and amperage at top of cover plate, and panel, circuit number and switch designation at bottom of cover plate.

3.06 FIELD QUALITY CONTROL

A. Inspect wiring devices for defects.
B. Operate wall switches with circuits energized and verify proper operation.
C. Verify receptacle device is energized.
D. Perform tests and prepare test reports:
   1. Test receptacle devices for proper polarity:

a. Test every receptacle with receptacle circuit tester. Tester shall test for open ground, reverse polarity, open hot, open neutral, hot and ground reversed, hot or neutral and hot open. Rewire receptacles with faults and retest.

2. Test each GFCI receptacle device for proper operation:
   a. Perform testing using an instrument specifically designed and manufactured for testing ground-fault circuit interrupters. Apply the test to the receptacle. “TEST” button operation will not be acceptable as a substitute for this test. Replace receptacles that do not shut off power with 5/1000 A within 1/40 second and retest.
3. Test Instruments: Use instruments that comply with UL 1436.
4. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

E. Tests for Convenience Receptacles:
1. Line Voltage: Acceptable range is 105 V to 132 V.
2. Percent Voltage Drop under 15A Load: A value of 5% or higher is not acceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

F. Operational Tests: Demonstrate the operation of each switch with the systems fully energized and operating. Each switch shall be demonstrated three times.

3.07 ADJUSTING

A. Adjust devices and wall plates to be flush and level.

3.08 CLEANING

A. Remove excess plaster from interior of outlet boxes.
B. Clean devices and cover plates after painting is complete. Replace stained or improperly painted devices and cover plates.

END OF SECTION

SECTION 262813
FUSES

PART 1 - GENERAL

1.01 RELATED WORK
A. Section 26 0573 - Power System Studies
B. Section 26 2816 - Enclosed Switches and Circuit Breakers
C. Section 26 2913 - Enclosed Controllers

1.02 DESCRIPTION
A. Section includes nonrenewable cartridge fuses, rated 600V and less, for use in low-voltage power distribution system and spare fuse cabinet.

1.03 REFERENCE STANDARDS
A. NEMA FU 1 - Low Voltage Cartridge Fuses
B. UL 248-1 - Low Voltage Fuses - Part 1: General Requirements
C. UL 248-12 - Low-Voltage Fuses - Part 12: Class R Fuses
D. UL 512 - Fuseholders

1.04 SUBMITTALS
A. Product Data:
   1. Submit the following for each fuse type and size indicated:
      a. Manufacturer's technical data on features, performance, electrical characteristics, ratings, and dimensions.
      b. Time-current curves, coordination charts and tables, and related data.
      c. Let-through current curves for fuses with current-limiting characteristics.
      d. Fuse size for each elevator disconnect switch.
B. Closeout Submittals:
   1. Project Record Documents:
      a. Record actual class, size, and location of fuses.

1.05 QUALITY ASSURANCE
A. Obtain fuses from one source and by single manufacturer.
B. Comply with NFPA 70 for components and installation.
C. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): “The articles listed in FAR 25.104(a) that are acquired as construction materials.”

1.06 MAINTENANCE
A. Extra Materials:
   1. Furnish to the Owner a quantity of spare fuses equal to 10% of the total quantity of each fuse class and size installed, minimum of 3 of each fuse class and size.
   2. Furnish 2 fuse pullers for each size fuse.

PART 2 - PRODUCTS

2.01 MANUFACTURERS
A. Cooper Bussmann
B. Mersen
C. Littelfuse
D. Edison Fusegear

2.02 CARTRIDGE FUSES
A. NEMA FU 1, UL 248-1.

B. Characteristics: nonrenewable current-limiting cartridge fuse; current rating and class, as specified or indicated, and voltage rating consistent with circuit voltage.
C. Miscellaneous data:

UL Standard	Class	Volts	Amperage	Interrupting Rating (Amp RMS Sym.)
248-12	RK5	250 or 600	0-600	200,000

2.03 FUSEBLOCKS

A. UL 512
B. Thermoplastic base with UL flammability 94VO
C. Clip reinforcing springs – 100A and above
D. 200,000 A RMS Sym withstand rating
E. Copper or aluminum connections

2.04 TOUCH SAFE FUSEHOLDERS

A. UL 512
B. Thermoplastic base with UL flammability 94VO
C. Cover over fuses
D. Neon indicator lamp: "ON" when fuse opens

2.05 SPARE FUSE CABINET

A. Wall-mounted sheet metal cabinet with shelves, suitably sized to store spare fuses and fuse pullers specified with 10% capacity minimum.
B. Doors shall be hinged, with hasp for Owner’s padlock.
C. Finish shall be gray enamel.
D. Cabinet shall have nameplate engraved “Spare Fuses” in 1/2” letters on door.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

3.02 INSTALLATION

A. Verify proper fuse locations, sizes, and characteristics.
B. Install fuses in fusible devices 26 2816 – Enclosed Switches and Circuit Breakers and 26 2913 – Enclosed Controllers at job site.
C. Arrange fuses so manufacturer, class, and size are readable without removing fuse.
D. Install typewritten labels on inside door of each fused device, indicating fuse replacement information.
E. Install spare fuse cabinet**.**

3.03 APPLICATION

A. Motor Branch Circuits: Class RK5.
B. Other Branch Circuits: Class RK5.

3.04 CLEANING

A. Clean fuses and tighten connections prior to energizing of equipment.

END OF SECTION

SECTION 262816
ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables
B. Section 26 0526 – Grounding and Bonding for Electrical Systems
C. Section 26 0529 – Hangers and Supports for Electrical Systems
D. Section 26 0553 – Electrical Systems Identification
E. Section 26 0573 – Power System Studies
F. Section 26 2813 – Fuses

1.02 DESCRIPTION

A. Section includes fusible and non-fusible disconnect switches and circuit breakers in individual enclosures.

1.03 REFERENCE STANDARDS

A. ANSI//NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting
B. NEMA AB 1 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breakers Enclosures
C. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
D. NFPA 70 - National Electrical Code
E. UL 98 - Enclosed and Dead Front Switches
F. UL 486A - 468B - Wire Connectors
G. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
H. UL 869A - Reference Standard for Service Equipment

1.04 SUBMITTALS

A. Product Data:
    1. Submit catalog cut sheet indicating voltage, amperage, HP ratings, enclosure type, and dimension, fuse clip features, terminal lugs and all accessories including interlock devices, short circuit current ampere rating and factory settings of individual protective devices.
B. Manufacturer’s Installation Instructions:
    1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
C. Test Reports:
    1. Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
D. Closeout Submittals:
    1. Project Record Documents:
        a. Record actual locations of disconnect switches and ratings of installed fuses.
        b. Record actual locations and continuous current ratings of enclosed circuit breakers.
    2. Operation and Maintenance Data:
        a. Include manufacturer’s recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
        b. Include spare parts data listing, source, and current prices of replacement parts and supplies.

1.05 QUALITY ASSURANCE

A. Obtain disconnect switches and enclosed circuit breakers from one source and by single manufacturer.
B. Regulatory Requirements:
   1. Comply with NFPA 70 for components and installation.
   2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
   3. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): “The articles listed in FAR 25.104(a) that are acquired as construction materials.”

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.
B. Comply with manufacturer’s written instructions.

1.07 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.
B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Schneider Square D
B. ABB-GE Industrial Solutions
C. Eaton Cutler-Hammer
D. Siemens

2.02 DISCONNECT SWITCHES

A. NEMA KS 1, UL 98
B. Load interrupter enclosed knife switch, heavy-duty type.
C. Fusible or non-fusible type as indicated.
D. Switch Interiors:
   1. Switch blades that are visible in "OFF" position when switch door is open.
   2. Plated current carrying parts.
   3. Removable arc suppressors to permit easy access to line side lugs.
E. Switch Mechanism:
   1. Quick-make, quick-break, with visible blades and externally operable handle.
   2. Lockable only in “OFF” position and accept three industrial type, heavy-duty padlocks.
   3. Dual cover interlock to prevent unauthorized opening of switch door when handle is in "ON" position, and to prevent closing of switch mechanism with door open.
   4. Defeater mechanism to bypass interlock.
   5. Operating handle integral part of enclosure.
   6. Handle to physically indicate "ON" and "OFF" position.
F. Ratings:
   1. Ampacity as indicated on drawings.
   2. Horsepower rated.
G. Fusible Switches:
   1. Rejection clips for Class R fuses specified.
   2. Fuses: Per requirements in Section 26 2813 – Fuses.

2.03 ENCLOSED CIRCUIT BREAKERS

A. NEMA AB 1, UL 489.
B. Enclosed molded-case circuit breakers:
   1. Tripped indication clearly shown on breaker handle taking position between “ON” and “OFF”.
   2. 225A frame size and below: thermal-magnetic trip.
   3. 250A frame size and above: electronic (solid-state microprocessor-based) trip units interchangeable in the field within the frame size and field-adjustable long time pick-up, long time delay, short time pick-up, short time delay, and instantaneous current settings. Each adjustment shall have discrete settings and shall be independent of other adjustments.
   4. Locks on trip handles where indicated.
   5. Shunt trip, where indicated.
C. Breaker Mechanism:
   1. Quick-make, quick-break.
D. Ratings:
   1. Ampacity as indicated on drawings.
   2. Listed as Type HACR for air conditioning equipment circuits.
   3. Listed as Type SWD for lighting circuits.

2.04 LUGS

A. Front removable lugs.
B. Labeled for 75°C copper and aluminum conductors.
C. Multiple lugs to match number of conductors per phase.
D. Termination of field installed conductors: Pressure wire connectors, except wire-binding screws for #10 AWG or smaller conductors.

2.05 ACCESSORIES:

A. Solid neutral assembly, where required.
B. Equipment ground kit.
C. One set of normally open (NO) auxiliary contacts, where disconnect switch is installed at a remote motor served by variable frequency drive (VFD).

2.06 ENCLOSURES

A. NEMA KS 1, NEMA AB 1, UL 98, UL 489, as applicable.
B. NEMA Type 1, Type 3R (outdoor locations) enclosure.
C. Code-gauge galvanized steel.
D. Manufacturer’s standard gray enamel finish over prime coat.
E. Surface-mounted.

2.07 SERVICE ENTRANCE

A. UL 869A
B. Switches and circuit breakers identified for use as service entrance equipment are to be labeled for this application, provided with solid neutral assembly and equipment ground bar, and must include connection for bonding and grounding of neutral conductor.

2.08 SHORT CIRCUIT CURRENT RATING

A. Each circuit breaker shall have minimum short circuit current rating as indicated on drawings.

PART 3 - EXECUTION

3.01 COORDINATION WITH MANUFACTURER

A. Instruct manufacturer about the location of incoming lugs, i.e., top or bottom feed based on incoming feeder entrance location.
B. Verify that “touch-up” paint kit is available for repainting.

3.02 EXAMINATION

A. Examine areas and surface to receive disconnect switches and enclosed circuit breakers for compliance with requirements, installation tolerances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.
B. Verify that space indicated for disconnect switches and enclosed circuit breakers mounting meets code-required working clearances.
C. Notify Architect/Engineer of any discrepancies prior to submittal of product data and shop drawings.

3.03 INSTALLATION

A. Install disconnect switches and/or enclosed circuit breakers in accordance with ANSI/NECA 1.
B. Install disconnect switches and/or enclosed circuit breakers level and plumb, in accordance with manufacturer's written instruction.
C. Disconnect switches and enclosed circuit breakers mounting:
    1. Fasten disconnect switches and enclosed circuit breakers firmly to walls and structural surfaces, ensuring they are permanently and mechanically anchored.
    2. Anchor and fasten disconnect switches and enclosed circuit breakers and their supports to building structural elements (wood, concrete, masonry, hollow walls and nonstructural building surfaces) by the methods described in Section 26 0529 – Hangers and Supports for Electrical Systems.
    3. Install two rows of steel slotted channel, with a minimum of four attachment points, for each disconnect switch and enclosed circuit breaker.
    4. When not located directly on wall, install support frame of steel slotted channel anchored to floor and ceiling structure.
D. Do not support disconnect switches and/or enclosed circuit breakers by raceway.
E. Install top disconnect switch and/or enclosed circuit breaker handle a minimum of 3'-6" and maximum of 6'-6" above finished floor.
F. Tighten electrical connectors and terminals according to equipment manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A - 486B.
G. Install engraved plastic nameplates under provisions of Section 26 0553 – Electrical Systems Identification. Attach nameplate to exterior of each switch and/or enclosed circuit breaker using small corrosion-resistant metal screws or rivets. Do not use contact adhesive.
    1. Include switch and/or enclosed circuit breaker name, amperage, voltage, phase, and number of wires.
H. Install fuses in fusible switches at job site per requirements in Section 26 2813 – Fuses.

3.04 CONNECTIONS

A. Ground equipment according to Section 26 0526 – Grounding and Bonding for Electrical Systems.
B. Connect wiring according to Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables.

3.05 FIELD QUALITY CONTROL

A. Inspect for physical damage, proper alignment connections, anchorage, and grounding.
B. Verify that circuit breakers or fuse sizes and types are in accordance with the drawings, short-circuit, and overcurrent protective device coordination studies.
C. Operate circuit breakers to ensure smooth operation. For switches, verify correct blade alignment, blade penetration, travel stops, and mechanical operation.
D. Correct malfunctioning units on-site and retest to demonstrate compliance. Remove and replace with new units and retest.

3.06 REPAINTING

A. Remove paint splatters and other marks from surface of equipment.
B. Touch-up chips, scratches, or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Owner.

3.07 ADJUSTING

A. Circuit Breakers: Set field-adjustable trip settings or change the trip settings recommended by the overcurrent protective device coordination study per Section 26 0573 – Power System Studies.

3.08 CLEANING

A. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.

END OF SECTION

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SECTION 262913
ENCLOSED CONTROLLERS

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables
B. Section 26 0526 – Grounding and Bonding for Electrical Systems
C. Section 26 0529 – Hangers and Supports for Electrical Systems
D. Section 26 0533 – Raceway and Boxes for Electrical Systems
E. Section 26 0553 – Electrical Systems Identification
F. Section 26 2813 – Fuses

1.02 DESCRIPTION

A. Section includes enclosed manual and magnetic motor controllers and enclosed contactors.
B. Motors shown on the drawings or specified in other Divisions of these specifications shall be provided with motorized equipment and connected under this section. Provide motor controllers and power circuit disconnect devices for all motors, unless shown or specified to be furnished with motorized equipment under other Divisions of these specifications, and/or by others, for installation by this contract.
C. Variable-frequency controllers furnished by Division 20 for installation by Division 26.
D. Motor Voltage Information:
    1. Voltages available are: 208 and 480 V, 3-phase and 120, 208 and 277V single phase. Circuits are designed for motors with voltage ratings as follows:
        a. Smaller than 1/2 hp motors: 115 V, single phase.
        b. 1/2 hp motors and larger: 200 and 460 V, 3-phase.

1.03 REFERENCE STANDARDS

A. ANSI/NECA 1 – Standard Practices for Good Workmanship in Electrical Contracting
B. NEMA AB 1 – Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breakers Enclosures
C. NEMA 250 – Enclosures for Electrical Equipment (1000 V Maximum)
D. NEMA ICS 2 – Industrial Control and Systems: Controllers, Contactors and Overload Relays, Rated Not More Than 2000 VAC or 750 VDC
E. NEMA ICS 4 – Industrial Control and Systems: Terminal Blocks
F. NEMA ICS 5 – Industrial Control and Systems: Control Circuit and Pilot Devices
G. NEMA ICS 6 – Industrial Control and Systems: Enclosures
H. NEMA KS 1 – Enclosed and Miscellaneous Distribution Equipment Switches (600 V Maximum)
I. NEMA MG 1 – Motors and Generators
J. NFPA 70 – National Electrical Code
K. UL 98 – Enclosed and Dead Front Switches
L. UL 486A-486B – Wire Connectors
M. UL 489 – Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breakers Enclosures
N. UL 508 – Industrial Control Equipment

1.04 SUBMITTALS

A. Product Data:
    1. Motor controllers: Submit catalog cut sheets showing voltage, size, rating and size of switching and overcurrent protective devices, dimensions, and enclosure details.
    2. Contactors: Submit catalog cut sheets showing voltage, size, current rating, dimensions, and enclosure details.
    3. Factory settings and time-current curves of individual protective devices.

4. Confirm motor sizes and voltages with submittals of other Divisions of specifications, and/or by others, prior to Section submittals.

B. Manufacturer's Installation Instructions:
   1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and/or starting of product.

C. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.

D. Closeout Submittals:
   1. Project Record Documents:
      a. Record actual locations and ratings of enclosed motor controllers and enclosed contactors.
   2. Operation and Maintenance Data:
      a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
      b. Include spare parts data listing, source, and current prices of replacement parts and supplies.

1.05 QUALITY ASSURANCE

A. Obtain motor controllers, and contactors from one source and by single manufacturer.

B. Regulatory Requirements:
   1. Comply with NFPA 70 for components and installation.
   2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
   3. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): "The articles listed in FAR 25.104(a) that are acquired as construction materials."

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, water, construction debris, and traffic.

1.07 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

1.08 MAINTENANCE

A. Extra Materials: Furnish extra materials described below that match product installed, are packaged with protective covering for storage, and are identified with labels describing contents.
   1. Spare pilot lights: Furnish 1 spare lamp for every 5 installed units, but not less than 1 set of 3 of each kind.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Schneider Square D
B. ABB-GE Industrial Solutions
C. Eaton Cutler-Hammer
D. Siemens

E. Allen Bradley

2.02 MANUAL MOTOR CONTROLLERS

A. Description: NEMA ICS 2, AC general-purpose, Class A, manually operated, full-voltage controller for small motors, with bimetal type overload relay, and toggle operator.

2.03 FRACTIONAL-HORSEPOWER MANUAL CONTROLLERS

A. Description: NEMA ICS 2, AC general-purpose, Class A, manually operated, full-voltage controller for fractional horsepower induction motors, with bimetal type overload relay, and toggle operator.

2.04 MOTOR STARTING SWITCHES

A. Description: NEMA ICS 2, AC general-purpose Class A manually operated, full-voltage controller for fractional horsepower induction motors, without thermal overload unit, with toggle operator.

2.05 FULL-VOLTAGE NON-REVERSING MAGNETIC MOTOR CONTROLLERS

A. Description: NEMA ICS 2, AC general-purpose, Class A, magnetic controller for induction motors rated in horsepower, three-phase and single-phase, as scheduled, except where single-phase motors scheduled to be provided with built-in overload elements:
   1. Size 1 minimum
   2. Control Voltage: 120 V, 60 Hz
   3. Overload Relays: NEMA ICS 2, solid-state bimetal, 1 overload relay per phase:
      a. Solid-state type:
         1) Class 10, 20, 30 inverse-time tripping characteristics.
         2) Non-volatile operating memory.
         3) 3:1 current adjustment range.
         4) Phase loss/phase unbalance protection.
         5) Ambient temperature insensitive.
         6) Self-powered.
         7) Manual reset. Automatic recent not acceptable.
         8) Manual trip.
         9) Visible trip indication.
         10) One normally open and 1 normally closed isolated auxiliary contract.
      b. Bimetallic type:
         1) Class 10, 20, 30 inverse-time tripping characteristics.
         2) Manual reset.
         3) Ambient temperature compensated bimetallic
         4) One normally open and one normally closed isolated auxiliary contract.
   4. Features:
      a. Auxiliary Contacts: NEMA ICS 2, 2 each normally open and normally closed contacts in addition to seal-in contact.
      b. Pushbuttons: Recessed type.
      c. Pilot Lights NEMA ICS 5: push-to-test LED type.
      d. Hand-Off-Auto (H-O-A) Selector Switches: Rotary type.
      e. Control Power Transformers: 120V secondary, adequate capacity to operate connected pilot, indicating and control devices, plus 100% spare capacity in each motor controller, but not less than 100VA. Fused primary and secondary, and unfused leg of secondary bonded to enclosure.
      f. Terminals: NEMA ICS 4.
      g. Other accessories detailed or required by drawings.

2.06 MOTOR CONTROLLER ACCESSORIES

A. Factory installed devices in controller enclosure, unless otherwise indicated, as follows:
   1. “On-Off” and “Start-Stop” pushbutton stations, pilot lights, selector switches: NEMA ICS 2, heavy duty type.
   2. 120 V control circuits and pilot light, unless noted otherwise.
   3. Red pilot light to indicate motor operation.
   4. Green pilot light to indicate motor stopped.
   5. Minimum wire size for control circuits: #14 AWG.
   6. Stop and Lockout Pushbutton Station: Momentary-break pushbutton station with a factory-applied hasp arranged so a padlock can be used to lock pushbutton in depressed position with control circuit open, where indicated.

B. Control services: As scheduled on motor schedule or indicated.

2.07 GENERAL PURPOSE MAGNETIC CONTACTORS

A. Description: NEMA ICS 2, same as magnetic controllers, except without overload protection.
B. Poles: To match circuit configuration and control function.
C. Configuration: Electrically held
D. Contact Rating: Match branch circuit overcurrent protection.

2.08 LIGHTING MAGNETIC CONTACTORS

A. Description: NEMA ICS 2, same as magnetic controller, except without overload protection.
B. Poles: To match circuit configuration and control function.
C. Configuration: Electrically held
D. Contact Rating: Match branch circuit overcurrent protection.

2.09 LUGS

A. Labeled for 75°C copper and aluminum conductors.
B. Multiple lugs to match number of conductors per phase.
C. Termination of field installed conductors: Pressure wire connectors, except wire-binding screws for #10 AWG or smaller conductors.
D. For equipment specified in this section and for equipment furnished under other Divisions of this specification and/or by others.

2.010 MOTOR CONTROLLERS AND CONTACTOR ENCLOSURES

A. NEMA 250, NEMA 1CS 6.
B. NEMA Type 1, Type 3R (outdoor locations) enclosure.
C. Code-gauge galvanized steel.
D. Manufacturer’s standard gray enamel finish over prime coat.
E. Surface-mounted.

PART 3 - EXECUTION

3.01 COORDINATION

A. Coordinate motor control wiring with Division 23 of these specifications.
B. Coordinate motor sizes and voltages with submittals of other Divisions of these specifications and/or by others.
C. Verify with manufacturer that “touch-up” paint kit is available for repainting.

3.02 EXAMINATION

A. Examine areas and surface to receive motor controllers and contactors for compliance with requirements, installation tolerances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.
B. Verify that space indicated for motor controllers and contactors mounting meets code-required working clearances.
C. Notify Architect/Engineer of any discrepancies prior to submittal of product data.

3.03 INSTALLATION

A. Install motor controllers and contactors in accordance with ANSI/NECA 1.
B. Install level and plumb, in accordance with manufacturer's written instruction.
C. Motor controllers and contactors mounting:
    1. Fasten motor controllers and contractors firmly to walls and structural surfaces, ensuring they are permanently and mechanically anchored.
    2. Anchor and fasten motor controllers and contactors and their supports to building structural elements (wood, concrete, masonry, hollow walls and nonstructural building surfaces) by the methods described in Section 26 0529 – Hangers and Supports for Electrical Systems.
    3. Install two rows of steel slotted channel, with minimum of four attachment points, for each motor controller and contactor.
    4. When not located directly on wall, install support frame of steel slotted channel anchored to floor and ceiling structure.
    5. Do not support motor controllers and contactors only by raceway.
D. Tighten electrical connectors and terminals according to equipment manufacturer's published torque-tightening valves. Where manufacturer's torque valves are not indicated, use those specified in UL 486A-486B.
E. Install engraved plastic nameplates under provisions of Section 26 0553 – Electrical Systems Identification. Attach nameplate to exterior of each motor controller and contactor, using small corrosion resistant metal screws or rivets. Do not use contact adhesive:
    1. Indicate motor served, nameplate horsepower, full load amperes, code letter, service factor, voltage/phase rating, and fuse size and type, when applicable.
F. Connect each motor terminal box to rigid conduit system with maximum 18" of flexible liquid-tight metal conduit. Install conduit per requirements in Section 26 0533 – Raceway and Boxes for Electrical Systems.
G. Check for proper rotation and phase relationship of each motor.
H. Install fuses in fusible switch at job site pre requirements in Section 26 2813 – Fuses.
I. Control Wiring Installation:
    1. Install wiring between motor control devices according to Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables.
    2. Install motor control wiring in accordance with control wiring diagrams and in raceways where indicated or required by contract drawings.
    3. Bundle, train, and support wiring in enclosures.
    4. Connect hand-off-automatic switch and other automatic-control devices where applicable.
        a. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
        b. Connect selector switches with motor-control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.04 APPLICATION

A. Select features of each motor controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, and configuration of pilot device and control circuit affecting controller functions.

3.05 CONNECTIONS

A. Provide green wire ground through flexible conduit to interconnect motor frame and rigid conduit system.
B. Ground and bond motor controller and contactor enclosures according to Section 26 0526 – Grounding and Bonding for Electrical Systems.
C. Connect power and control wiring according to Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables.

D. Connect control wiring for operation, control and supervision of motorized equipment as shown on drawings and/or specified in this and other Divisions of these specifications.

3.06 FIELD QUALITY CONTROL

A. Inspect motor controllers and contactors for physical damage, proper alignment, connections, anchorage, and grounding.
B. Compare equipment nameplate data with drawings and specifications.
C. Perform operational tests by initiating control devices.
D. Correct malfunctioning motor controllers and contactors on-site and retest to demonstrate compliance. Remove and replace with new units and retest.

3.07 REPAINTING

A. Remove paint splatters and other marks from surface of equipment.
B. Touch-up chips, scratches or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Owner.

3.08 ADJUSTING

A. Set field-adjustable circuit breakers trip settings or change the trip settings as indicated on drawings.
B. Adjust motor circuit protectors.

3.09 CLEANING

A. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.

END OF SECTION

SECTION 263213
ENGINE GENERATORS

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 26 0000 – General Electrical Requirements
B. Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables
C. Section 26 0526 – Grounding and Bonding for Electrical Systems
D. Section 26 3623 – Automatic Transfer Switches

1.02 DESCRIPTION OF SYSTEM

A. Section describes complete package generator set, unit-mounted radiator cooling system, microprocessor based control and monitoring panel, battery and charger, Building Management System (BMS) communications module, remote annunciator, drop over weatherproof enclosure.
B. Package generator set rated for emergency use.
C. Engine fuel system: natural gas

1.03 REFERENCE STANDARDS

A. NEMA MG-1 – Motors and Generators
B. IEEE446 – Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
C. NFPA 37 - Standard for Installation and Use of Stationary Combustion Engines and Gas Turbines
D. NFPA 110 – Standard for Emergency and Standby Power Systems
E. UL 2200 – Stationary Engine Generator Assemblies
F. IEC8528 Part 4 – Control Systems for Generator Sets

1.04 SUBMITTALS

A. Shop Drawings
    1. Submit for engineering review and approval prior to production release. Include the following for engine-generator:
        a. Outline drawings of equipment showing weights
        b. Overall dimensions including bolting template and earthquake restraints
        c. Right hand, left hand, end, and top views of proposed assembly
        d. Battery, battery rack, battery charger, and wiring diagrams
        e. Vibration isolation bases, mounts, and hangers
        f. Exhaust silencer and flexible fittings
        g. Stub ups for fuel
        h. Power and control wiring entrance locations
        i. Main circuit breaker size, location, and required clearance
        j. Lug sizes and locations
        k. Engine-generator control panel drawings showing devices to be provided, with each device referenced to material list with complete description for device.
        l. Weather protective enclosure installation drawings, structural calculations, lighting fixture catalog cut, conduit, and wiring.
        m. Enclosure sound performance data
        n. Muffler characteristics
        o. Calculations for starting based on step loads outlined in Paragraph 2.2, B.5.
        p. Factory certified prototype test report indicating fuel efficiency and emission levels
    2. Information on engine characteristics:
        a. Make, type, and number of cylinders
        b. Brake horsepower (bhp) available

c. Jacket water heat rejection
d. Cooling pump characteristics
e. Exhaust flow rate and temperature at 25, 50, 75, and 100% rated load
f. Ventilation requirements
g. Combustion air requirements
h. Fuel consumption rates at 25, 50, 75, and 100% rated load
i. Liquid refill capacities
j. Exhaust backpressure limitation
k. Type and manufacturer of governor
l. Alternator size to limit voltage dip to 10%

3. Information on generator characteristics:
   a. Make and type
   b. Type of construction and overspeed capabilities
   c. Temperature rise
   d. Regulation characteristics
   e. Ventilation requirements
   f. Type of winding insulation
   g. KW power factor
   h. Type of exciter and voltage regulator

B. Interconnection detail drawing showing control and power connections in complete standby system. Control connections between components are to be labeled with identical nomenclature. Coordinate with generator manufacturer.
C. Accessories including fuel lines, flexible exhaust couplings, exhaust flange, and other exhaust system components.
D. Complete review of this specification, noting for each paragraph whether or not proposed equipment complies with project specifications, or deviates in some fashion. Justification must be provided for each deviation.
E. Complete test specification detailing testing procedure to be used to verify performance of equipment provided.
F. Recommended spare parts lists.
G. Test Reports:
   1. Submit certified factory tests report on engine-generator delivery. Alarms, sensors, and meters must be tested and certified.
   2. Submit, upon completion of installation and testing of engine-generator sets, certified test reports from load tests for each engine-generator.

1.05 QUALITY ASSURANCE

A. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): “The articles listed in FAR 25.104(a) that are acquired as construction materials.”

1.06 DELIVERY, STORAGE, AND HANDLING

A. Handle equipment in accordance with manufacturer’s written instructions. One copy of instructions is to be included with equipment at time of shipment. Maintain factory bracing, packaging, and wrapping.

1.07 OPERATION AND MAINTENANCE MANUALS

A. Refer to Section 01 7700 - Closeout Procedures and herein below.
B. Submit Operation and Maintenance (O&M) manuals to Engineer for review 60 days prior to acceptance of unit.

C. Installation, maintenance, and operating instruction manuals shall include, but not limited to, the following:
   1. 100% accurate system “as-installed” drawings, interconnect diagrams, schematic diagrams, wiring diagrams, individual sub-system component manuals, operation procedures, system description with theory of operation, maintenance schedules and procedures, original programmed settings and parameters, and other information necessary for the Owner to maintain, operate, test, and troubleshoot system.
   2. The O&M manual shall contain step-by-step instructions for startup and shutdown. The first page shall contain name, address, and phone number of local representative to be called for service or parts. Follow with complete parts lists by actual ordering catalog numbers. O&M manual also shall contain four copies each of test record forms and service record forms for Owner use. Forms shall show proper interval for testing, servicing, and replacing of components, lubrication, filters, antifreeze, etc., including recommended specifications and fluid levels for lubricants.
   3. Recommended spare parts list (with pricing) for 2 yrs of operation.

D. O&M manuals shall not solely rely on sub-component manuals. Thorough consolidation of operating and maintenance information shall be available in system overview guide. Include major components of system in overview.

E. Turn final reviewed manuals over to Owner prior to conducting training of Owner personnel.

F. Seal single copy of service record forms, recommended operation and service practices for unit in plastic and wall mount in weather-protective enclosure.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Acceptable Manufacturers:
   1. Engine Generator Set - Caterpillar, Cummins, MTU Onsite Energy, Kohler
   2. Exhaust Silencer – Maxim, Nelson, or approved equal
   3. Isolation equipment
   4. Battery charger – Sens, La Marche, Charles Industries

2.02 RATINGS AND PERFORMANCE

A. Engine Generator Set
   1. Generator kW Output: As shown on drawings
   2. Altitude 250 ft above sea level in ambient temperature of 104°F
   3. Stable frequency regulation

B. Alternator
   1. As shown on drawings kVA, .8 Power Factor
   2. 480V, 3 Ph, 60 Hz, 4 Wire Y
   3. Stable voltage regulation 0-full load less than or equal to ± .5%.

C. Transient Performance
   1. Engine
      a. Start and load in 10 seconds per NFPA 110
      b. Accept 100% block load per NFPA 110
   2. Frequency regulation ± .25% no load to full load. ± .25% steady state.
   3. Alternator
      a. 20% Voltage dip
      b. Step Load Requirements
      c. AC waveform output contains <5% total harmonic distortion (THD) at full linear load when measured from line to neutral with <3% in any single harmonic, and no third-order harmonics or their multiples.
      d. Telephone influence factor < 40

e. Telephone harmonic factor < 3

D. Factory Prototype Test Certified
1. Harmonic Distortion Levels
a. Demonstrate
2. Airflow Restriction tests
a. Demonstrate controlled shutdown after overheating
3. Unit tested with enclosure
a. UL 2200 listed
4. Air Filter Test
a. Demonstrate engine contains engine backfire explosion

E. Factory Production Test Certified
1. Alternator Impedance to Ground
2. Dielectric Testing
a. At 1000 V and 2 times rated voltage
3. Maximum kW Rating
4. Engine Response Time
5. Alternator Construction Testing
a. Impedance Balance Tested
6. Alternator Insulation Testing
a. Surge Tested

2.03 FABRICATION AND MANUFACTURER

A. Engine:
1. Type: Inline or vee
2. Rated speed 1800 RPM consistent with engine durability.
3. Aspiration: Turbo Charged and After Cooled
4. Displacement: Six or eight cylinders with maximum cubic inch displacement of 860 and a maximum BMEP consistent with engine durability.
5. Liquid cooled
6. Fuel Type: Natural gas.
7. Engine accessories:
a. Fuel filter
b. Lube oil filter
c. Intake air filter
d. Lube oil cooler
1) Suitable for operation of generator set at full rated load in ambient temperature specified.
e. Fuel transfer pump
f. Fuel priming pump
1) Engine driven positive displacement, mechanical, full pressure
g. Gear driven water pump
h. Electronic direct fuel injection or have suitable emission control equipment
i. Electric speed sensing governor capable of isochronous regulation.
j. Safety-shut-offs for:
1) High water temperature
2) Low oil pressure
3) Overspeed
4) Overcranking
8. EPA Certified Tier 2

B. Cooling System:

1. Engine skid mounted, engine-driven radiator with blower type fan, sized to maintain safe operation at 122°F ambient temperature.
2. Provide radiator with:
   a. Motor-driven fan with voltage same as generator
   b. Motor Starter
   c. Initiating contacts to actuate on generator startup
   d. Connect to generator distribution system
   e. Core guard
   f. Fan guard
   g. Mounting hardware
   h. Direct adapter flange. Ductwork with flexible connection between radiator and exhaust plenum to be provided by Division 23. Coordinate with Division 23.
   i. Flexible pipe connections at engine and radiator.
   j. Supply power for fans and pumps on remote radiators from a tap at generator output terminals or ahead of first load circuit overcurrent protective device.
   k. Heat exchangers
3. Block Heater
   a. Water Jacket Heater: Circulating
   b. Maintain engine jacket water to 110°F in ambient temperature of 30°F
   c. Heater to be equipped with thermostatic switch.
   d. Single phase 208V
   e. Provide two heaters, 4500 W each minimum.
4. Fill engine cooling system with solution of 50/50 mix ethylene glycol at initial fill.

C. Exhaust System:
1. Furnish critical type exhaust silencer:
   a. Sized according to manufacturer's recommendations
   b. Mount so weight is not supported by engine
   c. Flexible exhaust fitting
   d. Installation inside drop over enclosure.
2. Condensate Traps
   a. Drain plug at low point of muffler
3. Thermal Expansion
   a. Stainless steel exhaust flex to accommodate thermal growth and vibration isolation
4. Exhaust Blankets
   a. 1” high temperature fiberglass cloth wrap
   b. Coordinate with weather protective enclosure.
5. Thimble
   a. Pipe and wall of compatible construction
6. Acceptable Back Pressure
   a. Size silencer and exhaust pipe so exhaust back pressure does not exceed maximum limitations specified by generator set manufacturer.
7. Exhaust clearing area

D. Starting System
1. Provide DC electric starting system with positive engagement drive. Provide DC voltage recommended by manufacturer.
2. Provide fully automatic start-stop controls.
3. Provide cycle cranking to open and lock out start circuit after 3 attempts to start failed engine start.
4. Batteries
   a. Provide sealed lead-acid storage battery set:

1) Heavy duty diesel starting type
2) Voltage compatible with starting system voltage
3) Capacity to provide for 1-1/2 minutes total cranking time at -17°C(0°F) without recharging. In accordance with NFPA Level 1.

b. Provide vinyl coated steel battery rack.
c. Provide starting battery heater:
1) Heater plate under battery
2) Heater type blanket around battery case
3) Thermal switch - heater control relay
4) 120 VAC input
d. Battery cables and clamps

5. Battery Charger
a. Dual Rate Battery Charger
1) Constant current, and float equalized
b. Charger Accessories:
1) Overload protection
2) ±1% line and load regulation
3) Electronic current limit output 105%
4) DC ammeter and voltmeter.
5) UL 1236 listed and meets NFPA 110 requirements
6) Output protection
7) Temperature compensation
8) Enclosed in NEMA 1 aluminum or stainless-steel enclosure
9) Form C contacts for the following alarms
a) AC fail
b) Low battery volts
c) High battery volts
d) Charger fail
e) Battery fault

6. AC input voltage: 208V
7. When installed on the engine generator set, mount on vibration isolators.

E. Speed Control
1. Electronic: Isochronous

F. Alternator:
1. Maximum temperature rise 135°C at 40°C ambient
2. Synchronous type
3. Self-ventilated
4. Drip-proof construction
5. Directly connected to engine flywheel housing with a flex coupling
6. Capable of sustaining 300% overcurrent for 10 seconds under a 3 Ph symmetrical short circuit
7. 120 V Anti-Condensation heater
8. Subtransient Reactance limited to 12%
9. Insulation
a. Complies with NEMA (MG1-33.4)
b. Class H Insulation Systems
1) UL 1449 recognized
2) Vacuum impregnated with epoxy varnish
3) Fungus resistant
10. Permanent magnet brushless excitation (PMG)

a. PMG shall derive excitation current from pilot exciter mounted on the rotor shaft. It is to be able to sustain 300% of rated current for ten seconds during a fault condition.

11. Rotor
    a. 4 pole
    b. Winding
        1) Wet layer wound
    c. Varnish process
        1) Epoxy based material applied to each layer of magnet wire
    d. Coil supports
        1) Driven through flexible coupling to ensure permanent alignment.
    e. End winding spacing
    f. Amortisseur windings
    g. Bearings
        1) Sealed
        2) Single
12. Stator
    a. 3 Ph winding
    b. Laminations
    c. Cooling air passages and fan
        1) Provide space heater to keep alternator free of moisture. Space heater to be 1500 W, 120 VAC, 1 Ph.
    d. Welded laminations to prevent cutting of wires
    e. Skewed stack to minimize slot ripple on output voltage and produce smooth voltage waveform.
    f. Pitch – Skewed design to optimize efficiency and minimize total harmonic distortion.
    g. Varnish process
        1) 2 dips and bakes using Class A impregnating varnish
13. Alternator Components
    a. Solid state design digital voltage regulator:
        1) Performance
            a) Microprocessor based.
            b) Programmable
            c) Regulation: ± .25% at any constant load for any load from 0% to 100% of pf rating.
            d) 3 Ph, true RMS sensing
            e) PMG input, engine unloading
            f) Design insensitive to severe, load induced wave shape distortion from SCR or thyrister circuits such as those used in battery charging, UPS, and motor speed control equipment loads.
            g) Controls to limit build-up of AC generator voltage to provide a linear rise and limit overshoot.
            h) Digital adjustments for out voltage adjustment gain, damping and frequency rate–off.
            i) System setup controls and fault alarms.
        2) Protection
            a) Over-excitation protection
            b) Electronic voltage buildup protection
            c) Loss of sensing protection
            d) Temperature compensation
            e) Limitation of voltage overshoot on startup

3) Features
   a) Parallel support
   b) VAR/PF control
4) Environmentally sealed
5) UL 508A listing

b. Output Circuit Breaker(s)
1) Two 100% thermal magnetic rated circuit breakers
2) Adjustable long time, long time delay, short time, and short time delay curve shaping elements
3) Shunt Trip for integration with load bank controls
4) Solid state trip fixed mounted insulated case generator mounted circuit breaker
5) NEC required access in front of breaker
6) Ground fault alarm only: Monitoring relay for breaker 1000A and above. Relay to be adjustable from 3.8 – 1200A and include an adjustable time delay of 0-10S.

G. Controls:
1. NFPA 110 listed
2. Micro-processor based solid state controls to automatically start, protect and monitor engine-generator set with panel illuminating lighting and digital display.
3. Control panel includes:
   a. Solid state trip main circuit breaker
   b. Motor starting switch
   c. Electrically operated fuel control
   d. Relay to disconnect battery charger during cranking
   e. Switching lamps and meters to be oil tight and dust tight. All active components to be installed within a NEMA 3R enclosure. There shall be no exposed components with door open operating 750 V.
   f. Protective relays to open main circuit breaker and shut down and lockout engine on abnormal conditions including:
      1) NFPA 20-9.6.2.2 requires that certain safety devices associated with a generator be disabled when that generator serves a fire pump. Removal of some of the safety devices in the following section may put the emergency standby source at risk. Engineer should consider use of a dedicated standby generator or service for the fire pump.
      2) Overspeed
      3) Operation of Remote Stop
      4) Overcrank
      5) Low lube oil pressure
      6) High Engine Temp
      7) Low coolant level
      8) Fail to crank
      9) Dead battery
   g. Monitoring items shall include but is not limited to the following items and control:
      1) Coolant temperature
      2) Oil pressure
      3) Battery voltage
      4) RPM
      5) Voltmeter, 3-1/2” dual type, 0.5% accuracy with selector switch
      6) Ammeter, 3-1/2” dual type, .05% accuracy with selector switch
      7) Frequency meter, 55-65 Hz ±0.125 Hz.
      8) Running Time Meter (hours and 1/10 hours)

9) AC power metering to be 0.5% accuracy and include frequency, phase, selector switch with real time power metering including, kW, kVA, kVAR, kWh, PF, % of rated load.

h. Control Items:
1) Voltage level adjustment rheostat
2) Overspeed level adjustment
3) Overvoltage level adjustment
4) Undervoltage level adjustment
5) Overfrequency level adjustment
6) Underfrequency level adjustment
7) Position function switch(es) marked AUTO, MANUAL RUN, OFF/RESET and STOP
8) 4 NO and 4 NC dry contacts for local and remote alarms, wired to terminal strips.
9) Emergency off mushroom button
10) Automatic remote start capability. Engine cranking system to permit minimum 4 cranking attempts of 10 seconds (adjustable) duration with rest of periods of 10 seconds (adjustable).
a) Overcrack lockout shall occur after 4 cranking attempts.

i. In accordance with NFPA 110, Level 1, control panel shall furnish battery-powered individual visual alarm indicator functions at battery voltage and visual and audible pre-alarm:
1) Overcrank
2) Low water temperature
3) High engine temperature pre-alarm
4) High engine temperature
5) Low lube oil pressure pre-alarm
6) Low lube oil pressure
7) Overspeed
8) Low fuel main tank
9) Low coolant level
10) EPS supplying load
11) Control switch not in automatic position
12) High battery voltage
13) Low cranking voltage
14) Low voltage in battery
15) Battery charger ac failure
16) Lamp test
17) Contacts for local and remote common alarm
18) Low starting air pressure
19) Low starting hydraulic pressure

j. Engine shut down, with audible alarm:
1) Low oil pressure
2) High engine temperature
3) Overcrank
4) Overspeed
5) Remote Emergency Stop
6) Reverse power
7) Low-coolant level

k. Status report:
1) Engine running

2) Circuit breaker open
3) Circuit breaker closed

4. Visual alarm resettable only after fault condition has been corrected.
5. Audible alarm shall include silencing circuit, which, after activation, will permit annunciation of subsequent failures.
6. Control Panel mounting:
   a. Mounted on engine generator set in NEMA 1 enclosure on shock isolators
   b. Wall mounted in NEMA 1 enclosure
   c. Free standing in NEMA 1 enclosure
7. Provide remote annunciator panel
   a. Compliant with NFPA Level 1 requirements.

H. Isolate engine generator set from building structure and from connecting services.
   1. Separately derived grounding system. Connect generator ground as shown on drawings to grounding electrode system.

I. Termination Bars and Connections:
   1. Silver- or tin-plated copper bus bars for terminating cables.
   2. Standard NEMA standard bolt hole spacing, for 3 Ph and neutral, within generator connection box with gasketed bolt on cover.
   3. Engine-generator set control interfaces to other system components to be made on a permanently labeled terminal block assembly. Provide labels describing connection points.
   1. Connections to engine-generator set: Flexible or isolation type connections. Include electrical, fuel, exhaust, and ventilation connections.

J. Equipment Bases:
   1. Mount complete unit on a structural steel sub-base, rectangular in shape, with sufficient rigidity to maintain alignment of generator set. Provide perimeter beams with minimum depth equal to 1/10 of longest dimension of base, except beam depth need not exceed 14” provided that deflection and misalignment are kept within acceptable limits as determined by manufacturer. Engine-generator set to be statically and dynamically balanced at factory. Peak-to-peak amplitude of vibration velocity in horizontal, vertical, and axial direction shall not exceed 0.65” per second at main structural components.
   2. Engine-generator set weight distribution is to be considered to provide uniform deflections.
   2. Bases shall provide equipment alignment and assure uniform weight distribution. Provide side brackets on bases to contain isolating mounts and reduce total installed heights of equipment.

K. Vibration Isolators:
   1. Prevent equipment vibrations from being transmitted to enclosure.
   2. Required between the structural steel sub-base and concrete housekeeping pad.
   3. Steel or cast iron top and bottom housings incorporating 1 or more steel springs with built-in leveling bolts and built-in resilient chocks to control oscillation and withstand lateral forces in all directions.

L. Outdoor Weather Protective Drop-Over Enclosure:
   1. Rated NEMA 3R
   2. Attenuation:
      a. Provide engine-generator set with weatherproof enclosure. Enclosure will reduce sound level of engine-generator set while operating at full rated load and ventilation running to maximum of 107 dBA at 1 meter or 87 dBA at 7 meters from engine-generator set in free-field environment.
   3. Overall Size:
      a. Drawings show generator footprint, which is maximum allowed for available space.

b. Air intake requirements are to be taken into consideration and shall not prevent enclosure from operating within space limitations indicated above.

4. Construction:
   a. Construction to be welded, 14 ga galvanized steel to ASTM A-446.
   b. Package listed to UL 2200
   c. Lockable doors
   d. Minimum 100A accessory distribution panel to power items listed in Paragraph 2.3.L.a.
   e. Interior lights
   f. Remote mounted emergency stop button
   g. Lifting lugs
   h. Refer to Paragraph 2.3.N for fuel system.
5. Ventilation:
   a. Intake: Complete with gravity damper, hood with silencer, flex connections, and 1/2” x 1/2”, 16 ga galvanized bird screen to protect against ice and snow.
   b. Discharge: Complete with gravity-type damper with discharge duct, hood with silencer, flex connector, and 1/2” x 1/2”, 16 ga galvanized bird screen.
6. Paint:
   a. Clean surfaces to SSPC-SP1, seal seams, prime with industrial phenolic primer to 1.5 mils D.F.T. Top coat exterior with Clovacoat epoxy enamel to 2.0 mils D.F.T.
7. Power Coat Paint. Selections to include white, beige, ASA61 gray, and manufacturer factory standard. Architect to select.

M. Fuel System
1. Natural gas
2. System shall comply with local codes and permitting requirements.

2.04 INTERFACE WITH BUILDING MANAGEMENT SYSTEM (BMS)

A. Interface shall be as follows:
1. Control panel shall incorporate communication module with digital communication port connection to building control system (BMS) via Ethernet communication.
2. Communications shall be for the following:

TYPE	CONDITION/DESCRIPTION	RANGE/UNITS
LDI 1	Low lube oil pressure prealarm	
LDI 2	Low water temperature	
LDI 3	High engine temperature prealarm	
LDI 4	Battery charger AC failure	
LDI 5	Spare	
LDI 6	Control switch not in automatic position	
LDI 7	High battery voltage	
LDI 8	Low coolant level	
LDI 9	Low cranking voltage	
LDI 10	Low voltage in battery	
LDI 11	EPS supplying loads	
LDI 12	Generator circuit breaker ground fault	
LDI 13	Low lube oil pressure	
LDI 14	High engine temperature	
LDI 15	Overcrank	
LDI 16	Overspeed	

TYPE	CONDITION/DESCRIPTION	RANGE/UNITS
LDI 17	Remote emergency manual stop switch	
LDI 18	Overcurrent (circuit breaker trip and lockout)	
LDI 19	Reverse power relay trip	
LDI 20	Spare	
LDI 21	Engine running	
LDI 22	Generator running	
LDI 23	Generator circuit breaker open	
LDI 24	Generator circuit breaker closed	
LDI 25	Generator circuit breaker failed to close	
LDI 26	Spare	
LDI 27	Control voltage failure	
LDI 28	Auto start	
LDI 29	Battery charger failure	
LDI 30	Spare	
LDI 31	Spare	
LDI 32	Spare	
LDI 33	Spare	
LDI 34	Spare	
LDI 35	Spare	
LDI 36	Spare	
LDI 37	Spare	
LDI 38	Spare	
LDI 39	Spare	
LDI 40	Spare	
LDI 41	Spare	
LDI 42	Spare	
LDI 43	Spare	
LDI 44	Spare	
LDI 45	Spare	
LDI 46	Spare	
LDI 47	Spare	
LDI 48	Spare	
LDI 49	Spare	
LDI 50	Spare	
LDI 51	Spare	
LDI 52	Spare	
LDI 53	Spare	
LDI 54	Spare	
LDI 55	Spare	
LDI 56	Air damper closed	

TYPE	CONDITION/DESCRIPTION	RANGE/UNITS
LDI 57	System test mode (lamp test)	
LDI 58	Spare	
LDI 59	Spare	
LDI 60	Spare	
LDI 61	Spare	
LAI 1	Generator phase A-B voltage	Volts
LAI 2	Generator phase B-C voltage	Volts
LAI 3	Generator phase C-A voltage	Volts
LAI 4	Generator phase A current	Amperes
LAI 5	Generator phase B current	Amperes
LAI 6	Generator phase C current	Amperes
LAI 7	Total real power	KW
LAI 8	Total apparent power	KVA
LAI 9	Total reactive power	KVAR
LAI 10	Generator power factor	
LAI 11	Generator phase A frequency	Hertz
LAI 12	Generator phase B frequency	Hertz
LAI 13	Generator phase C frequency	Hertz
LAI 14	Battery voltage	Volts
LAI 15	Engine oil pressure	KPA
LAI 16	Engine speed	RPM
LAI 17	Engine water temperature	Degrees Centigrade
LAI 18	Engine running time	Hours
LAI 19	Spare	
LAI 20	Spare	
LAI 21	Spare	
LDO 1	Remote fault reset	
LDO 2	Remote start initiative	
LDO 3	Cool down override control	
LDO 4	Phase select	
LDO 5	Load adding and load shedding	

Notes:

LDI - LAN: Digital Input from control panel communication module to BMS via Ethernet communication.

LAI - LAN: Analog Input from control panel communication module to BMS via Ethernet communication.

LDO - LAN: Digital Output from BMS to communication module via Ethernet communication.

LAN – Local Area Network

3. Provide all additional information as required for a complete and operable system.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install engine-generator set and associated equipment as indicated. Coordinate final location of equipment with General Contractor. Final location of equipment to be reviewed with Engineer prior to installation.

B. Install equipment in accordance with manufacturer's recommendations. Provide equipment protection during and subsequent to installation.

3.02 ACCEPTANCE TESTS

A. Testing by Electrical Contractor

3.03 LOAD TEST

A. Conduct load testing of engine-generator set, under direct supervision of factory-authorized representatives of manufacturers of engine-generator set and auto-transfer switch.

B. Provide external load bank control power for the load bank to avoid control drop-out during 100% block load.

C. Generator start-up and load bank testing to be coordinated with project commissioning to advance project schedule and save costs.

D. Installation is NFPA 110, Level 1 – Authority Having Jurisdiction must be given notice prior to testing as required in NFPA 110.

E. Testing to include cold start, 25, 50, 75, and 100% step loads (slow addition of load to confirm operation), 50% and 100% block loads (instantaneous load percentages), and 4-hour testing at rated nameplate.

1. Loading shall be by use of contractor rented portable load banks.

F. Provide certified results of testing, including frequency and voltage regulation at 25, 50, 75, and 100% of rated load, fuel consumption, exhaust temperature, and exhaust emissions at the above load ratings, actual measured values for pickup and drop out relays for ATS, measured values for time delay relays.

G. Engine-generator set test results are to be certified to comply with specification parameters or necessary corrective actions implemented and tests repeated until compliance is certified at no additional cost to owner.

H. At conclusion of testing, service engine-generator set including replacing air, oil and fuel filters, changing lubrication oil, checking and refilling batteries, adjusting fan belts for proper tightness, and refilling of cooling system as required.

I. Provide fuel for load testing of engine-generator set.

END OF SECTION

SECTION 263623
AUTOMATIC TRANSFER SWITCHES

PART 1 - GENERAL

1.01 RELATED WORK
A. Section 26 0000 – General Electrical Requirements
B. Section 26 0529 – Hangers and Supports for Electrical Systems
C. Section 26 3213 – Engine Generators

1.02 DESCRIPTION OF SYSTEM
A. Provide automatic transfer switch, 3 phase, 60 Hz, 3 pole, with solid neutral for voltage and current as indicated on drawings.

1.03 REFERENCE STANDARDS
A. ICS 10 Industrial Control and Systems Part 1: Electromechanical AC Transfer Switch Equipment
B. UL1008 Automatic Transfer Switches

1.04 SUBMITTALS
A. Submit shop Drawings for equipment provided under this Section.

1.05 QUALITY ASSURANCE
A. Obtain automatic transfer switches from one source and by single manufacturer.
B. Regulatory Requirements:
   1. Comply with NFPA 70 for components and installation.
   2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
   3. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): “The articles listed in FAR 25.104(a) that are acquired as construction materials.”

1.06 DELIVERY, STORAGE, AND HANDLING
A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, fumes, water, corrosive substances, construction debris, and traffic. Provide temporary heaters in switchgear as required to prevent condensation.
B. Deliver individually wrapped for protection, and mounted on shipping skids. Mark crates, boxes, and cartons clearly to identify equipment. Show crate, box, or carton identification number on shipping invoices.
C. Use factory-installed lifting provisions. Handle carefully to avoid damage to internal components, enclosure, and finish.

1.07 WARRANTY
A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.
B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.01 MATERIALS
A. Acceptable Manufacturers: Asco by Schneider Electric, Cummins, Russelectric by Siemens, or Zenith by ABB

2.02 AUTO-TRANSFER SWITCH
A. Auto-transfer switch:

1. Mechanically held, electrically operated type
2. Interlocked to ensure only 2 possible positions, normal and emergency.
3. Rated for continuous duty in unventilated sheet metal enclosure
4. Suitable for all classes of loads at maximum rated voltages
5. Withstand rating that meets or exceeds withstand rating of transfer switch feeder breakers.
6. Shall be open transition type.

B. Provide main contacts with silver alloy wiping action type protected by arcing contacts.
C. Provide switch components accessible from front of enclosure.
D. Provide 3 cycle short circuit rating to guarantee contact opening and no damage when transfer switch is served by molded case circuit breakers.
E. Provide switch with the following items:
   1. Adjustable 1 to 3 second time delay to override momentary voltage dips and outages.
   2. Time delay on transfer to emergency. Adjustable from 1 to 300 seconds (factory set at 3 seconds).
   3. Time delay on retransfer to normal. Adjustable from 2 seconds to 30 minutes.
   4. Full phase protection consisting of 2 phase relays and one close differential relay. Phase relays shall be set to 70% drop out, 90% pick up, and differential relays set for 92 to 95% pick-up and 83 to 85% drop-out.
   5. Pushbutton reset to normal.
   6. Pushbutton to bypass time delay on retransfer to normal.
   7. Pilot light to indicate normal position.
   8. Pilot light to indicate emergency position.
   9. Auxiliary contact to close when normal power fails.
   10. Auxiliary contact to open when normal power fails.
   11. Auxiliary contact on same shaft as main contacts (closed on normal).
   12. Auxiliary contact on same shaft as main contacts (closed on emergency).
   13. Pushbutton, or selector switch, or graphical display input to provide "Test," "Auto," and "Engine Start."
   14. Contacts to start engine-generator when normal power fails.
   15. Time delay engine start, adjustable from 0 to 5 seconds.
   16. Adjustable time delay on retransfer to normal source with 5 minute unloaded running time of standby plant:
       a. Minimum delay 2 minutes
       b. Maximum delay 25 minutes
       c. Built in circuitry to nullify time delay if emergency source fails and power is available at normal source.
   17. Relay to prevent transfer to emergency until voltage and frequency of generating plant have reached 90% of rated value.
   18. Provide bi-direction in-phase monitor or dual motor operator with programmed neutral to allow voltage decay in motor and transformer circuits.

2.03 ELEVATOR CONTROL INTERFACE

A. Provide auxiliary contacts to provide emergency system status to elevator controller.
B. Contacts required are:
   1. Emergency power signal
   2. Pre-transfer warning signal
C. Pre-transfer warning signal relay to change state prior to operation of transfer switch in either direction.
D. These contacts are in addition to other required contacts.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install equipment in accordance with manufacturer's recommendations.
B. Provide equipment protection during and subsequent to installation.
C. Provide wiring between transfer switch and elevator controller. Final connections at elevator controller by Elevator Contractor.

3.02 OPERATION

A. Parallel "start engine-generator" contacts of automatic transfer switches, such that failure of normal source at any switch shall start engine.
B. Transfer of one switch from normal to emergency shall not preclude any other switch from transferring.
C. Engine generator cool down cycle shall not start until all transfer switches have timed out back to normal source.

3.03 ACCEPTANCE TESTING

A. Testing by Electrical Contractor
B. Visual and Mechanical Inspection:
    1. Compare equipment nameplate data with drawings and specifications.
    2. Inspect physical and mechanical condition.
    3. Verify manual transfer warnings are attached and visible.
    4. Verify tightness of control connections.
    5. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer’s published data.
    6. Perform manual transfer operation.
    7. Verify positive mechanical interlocking between normal and alternative sources.
    8. Inspect anchorage, alignment, grounding, and required clearances.
C. Electrical Tests:
    1. Verify settings and operation of control devices.
    2. Perform automatic transfer tests:
        a. Simulate loss of normal power.
        b. Return to normal power.
        c. Simulate loss of emergency power.
    3. Verify correct operation and timing of following functions:
        a. Normal source voltage-sensing relays.
        b. Engine start sequence.
        c. Time delay upon transfer.
        d. Alternate source voltage-sensing relays.
        e. Automatic transfer operation.
        f. Time delay and retransfer upon normal power restoration.
        g. Engine cool down and shutdown feature.
D. Adjust or replace equipment as needed to comply with manufacturer's specifications and resubmit corrected test reports.

END OF SECTION

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SECTION 264113
LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 26 0526 – Grounding and Bonding for Electrical Systems
B. Section 26 0533 – Raceway and Boxes for Electrical Systems

1.02 DESCRIPTION

A. Section includes lightning protection systems consisting of air terminals, roof conductors, bonding conductors, down conductors, fastener connections, and grounding.

1.03 REFERENCE STANDARDS

A. ANSI/NEMA GR1 - Grounding Rod Electrodes and Ground Rod Electrode Couplings
B. NFPA 70 - National Electrical Code
C. NFPA 780 - Standard for the Installation of Lightning Protection Systems
D. UL 467 – Grounding and Bonding Equipment
E. UL 96 - Lightning Protection Components
F. UL 96A - Installation Requirements for Lightning Protection Systems

1.04 SUBMITTALS

A. Product Data:
   1. Submit manufacturer's descriptive and technical literature and catalog cuts.
B. Shop Drawings:
   1. Submit installation shop drawings for the overall lightning protection system. Include physical layout of the equipment, mounting details, and relationship to other parts of the work.
   2. Submit detail drawings for each major component.
   3. Submit location, size, and material of grounding electrodes, and connection type.
   4. Submit roof adhesive data for air terminals mounted on single-ply roofing.
C. Certification, signed by Contractor, that roof adhesive for air terminals is approved by manufacturers of both the terminal assembly and the single-ply roofing material.
D. Copy of Owner's UL Master Label Certificate.
E. Manufacturer's Installation Instructions:
   1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation.
F. Closeout Submittals:
   1. Project record documents:
      a. Record active location of lighting protection system components.
   2. Operation and maintenance data:
      a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventative maintenance instructions.

1.05 QUALITY ASSURANCE

A. Qualifications:
   1. Lightning protection system materials:
      a. Consists of standard products by a manufacturer regularly engaged in production of lightning protection systems.
      b. UL Listed
   2. Lightning protection system installer: UL Listed.
B. Regulatory Requirements:
   1. Lightning protection system: Comply with NFPA 780, UL 96, and UL 96A.

2. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): “The articles listed in FAR 25.104(a) that are acquired as construction materials.”

C. Certifications:
1. Furnish Owner with UL Master Label Certificate upon completion of installation providing proof that the lightning protection system is in compliance with UL 96 and UL 96A standards.

1.06 SEQUENCING

A. Coordinate installation of lightning protection with installation of other building systems and components, including supporting structures and building materials, metal bodies requiring bonding to lightning protection components, exterior and interior building finishes, and building roofing.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Thompson Lightning Protection Company
B. Harger Lightning Protection, Inc.
C. Heary Brothers Lightning Protection Company, Inc.
D. National Lightning Protection Corporation
E. Erico International Corporation
F. Approved Equal

2.02 LIGHTNING PROTECTION SYSTEM COMPONENTS

A. NFPA 780, UL 96.
B. Materials: Air terminals, main and cross-run roof conductors, bonding and down conductors, conductor fasteners, air terminal supports, chimney bands, clips, and connections: Class I
1. Air terminals: Solid type with a safety tip, 10” in height minimum, above the object to be protected when spaced at intervals not exceeding 20 ft, with mounting base.
C. ANSI/NEMA GR1 Grounding Electrodes: 3/4” x 10 ft long copper-clad steel ground rod.
D. Concrete-Encased Electrodes: As shown on drawings.
E. Ground Ring Electrode: As shown on drawings.
F. Ground Connectors: Conform to UL 96
1. Bronze of the clamp type and bronze clamp accessories.
2. Provide in accordance with the requirements in Section 26 0526 – Grounding and Bonding for Electrical Systems.
G. Galvanic Compatibility of Materials:
1. Air terminals, conductors, fasteners, and connectors shall be galvanically compatible with surfaces they are mounted to.
2. Copper materials in all locations except where the use of aluminum materials is necessary for galvanic compatibility.
3. Aluminum materials on copper roofs are not acceptable.
4. Aluminum materials where mounted on aluminum roofing, siding, or other aluminum surfaces.
H. Bimetallic fittings when joining metals that are not galvanically compatible.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install lighting protection to comply with UL 96A, NFPA 70, and NFPA 780. Conform to the most stringent requirement in NFPA 780.

B. Bond exterior metals including flashing, roof drains, vent stacks, fans, water pipes, metal raceways, enclosures, frames, and other non-current carrying metal parts of electrical and mechanical equipment on roof to lightning protection system.
C. Bond lower end of exhaust ducts, vent stacks, etc., passing through roof.
D. Run bonding jumpers continuously horizontally or down from point of bond to point of connection to main conductor.
E. Make down conductors electrically continuous, with direct paths from air terminals to ground connections. Avoid sharp bends and narrow loops. Protect down conductors, where necessary, to prevent physical damage or displacement to the conductor. Use PVC Schedule 40 conduits. Provide conduits in accordance with requirements in Section 26 0533 – Raceway and Boxes for Electrical Systems.
    1. Provide down conductors for every 100 feet of building perimeter.
    2. For structural steel construction, utilize steel columns (bond top and bottom) in lieu of down lead conductors – every other column and not to exceed an average of 60 foot spacing.
F. Conceal system conductors and interior conductors.
G. Notify Architect at least 48 H before concealing lightning protection system components.
H. Below-grade or concealed cable connections: Use approved exothermic-welded connections for all conductor splices and connections between conductors and other components.
I. Exposed cable connections: Use approved mechanical connections.
J. Air terminals mounted on single-ply roofing: Use adhesive recommended by manufacturer of air terminals and approved by manufacturer of roofing material. Comply with adhesive manufacturer's installation instructions. For roofing work, refer to Division 07 - Thermal and Moisture Protection.
K. Attach each down conductor to the grounding electrode by exothermic welding.
L. Provide grounding electrodes with top 2 ft below finished grade.
M. Ramps and covered passageways shall be protected by the lightning protection system.
N. For construction utilizing post tensioning systems to secure precast concrete sections, do not use the post tension rods as down conductors. Bond tension rods to the lightning protection and grounding system – follow recommendations of the post tension rod manufacturer.

3.02 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the present of moisture, unless moisture is permanently excluded from the junction of such materials.
B. Use conductors with suitable protective coatings where conditions would cause deterioration or corrosion of conductors.

3.03 FIELD QUALITY CONTROL

A. Apply for inspection by Underwriters Laboratories, Inc. (UL) to obtain UL Master Label Certificate.
B. Verify that lightning protection surge arrestor devices are installed on all incoming power and communications lines, in order to obtain UL Master label Certificate.

END OF SECTION

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SECTION 264300
SURGE PROTECTIVE DEVICES (SPD)

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 26 0000 - General Electrical Requirements
B. Section 26 0526 - Grounding and Bonding for Electrical Systems
C. Section 26 2416.13 - Lighting and Appliance Panelboards
D. Section 26 2416.16 - Distribution Panelboards
E. Section 26 2726 - Wiring Devices

1.02 DESCRIPTION

A. Provide Type 1 Surge Protective Devices (SPD) for the protection of AC electrical circuits formerly known as Transient Voltage Surge Suppression (TVSS) System. Provide high energy surge current diversion and be suitable for application in Type 1 environments.
B. Modes of Protection:
   1. Line to Ground, Line to Neutral and Neutral to Ground for services with a neutral
   2. For Services without a neutral, Line to Line and Line to Ground
C. Provide common and normal modes of protection.

1.03 REFERENCE STANDARDS

A. ANSI/UL 1449 Surge Protective Devices Fourth or Third Edition
B. IEEE C62.41 – Recommended Practice on Surge Voltages in Low Voltage AC Power Circuits FIPS PUB 94
C. IEEE C62.11 – Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (> 1 kV)
D. IEEE C62.41.1 Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
E. IEEE C62.41.2 Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits
F. IEEE C62.45 IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and less) AC Power Circuits
G. IEEE C62.62 IEEE Standard Test Specifications for Surge Protective Devices (SPDs) for Use on the Load Side of the Service Equipment in Low Voltage (1000V and less) AC Power Circuits
H. National Electrical Code – Article 285
I. NEMA LA 1 – Surge Arresters
J. National Fire Protection Association – NFPA 20, 70, 75, and 780
K. UL 96A Installation Requirements for Lightning Protection Systems

1.04 SUBMITTALS

A. Submit Shop Drawings for equipment provided under this Section.
B. Submit shop drawings and product information for approval and final documentation in quantities listed according to Conditions of the Contract. Identify customer name, customer location, and customer order number.
C. Submit ANSI/UL 1449 Listing documentation to indicate the following:
   1. Short Circuit Current Rating (SCCR)
   2. Voltage Protection Ratings (VPRs) for all modes
   3. Maximum Continuous Operating Voltage rating (MCOV)
   4. Nominal Discharge Current rating (I-n)
   5. Type 1 device
   6. VPR, MCOV, I-n, and Type 1 information is posted at www.UL.com under Certifications; search using UL Category Code: VZCA. SCCRs are posted in manufacturer's published documentation.

7. UL data and visual inspection takes precedence over manufacturer's published documentation.

D. Provide shop drawings including manufacturer installation instruction manual and line drawings detailing dimensions and weight of enclosure, internal wiring diagram illustrating all modes of protection in each type of SPD required, wiring diagram showing field connections, and manufacturer's recommended wire and breaker sizes (if required).

E. Upon request, modules using encapsulation shall be presented without encapsulation for visual inspection, proprietary technology included. MOV type and quantity shall reflect kA ratings on cutsheets, verification of diagnostic monitoring, thermal and overcurrent protection, etc.

1.05 QUALITY ASSURANCE

A. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): "The articles listed in FAR 25.104(a) that are acquired as construction materials."

PART 2 - PRODUCTS

2.01 MATERIAL

A. Acceptable manufacturers:
   1. Externally-mounted unit by the power distribution equipment manufacturer.

2.02 PERFORMANCE CHARACTERISTICS

A. SPD shall bear the UL Mark and shall be Listed to Third Edition of ANSI/UL 1449. "Manufactured in accordance with" is not equivalent to UL Listing and does not meet intent of specification.

B. Post SPD and performance parameters at www.UL.com under Category Code: VZCA. Products or parameter without posting at UL.com are not approved.

C. Minimum surge current capacity for Service Entrance units based on 8 x 20 microsecond current waveform:
   1. 200,000 A between each phase for line-to-line mode
   2. 200,000 A each phase for line-to-ground mode
   3. 200,000 A each phase for line-to-neutral mode
   4. 200,000 A for neutral-to-ground mode

D. Minimum surge current capacity for panelboard units based on 8 x 20 microsecond current waveform:
   1. 80,000 A between each phase for line-to-line mode
   2. 80,000 A each phase for line-to-ground mode
   3. 80,000 A each phase for line-to-neutral mode
   4. 80,000 A for neutral-to-ground mode

E. Sequential Surge Current Survivability:
   1. 1,000 sequential category surges without failure.

F. Current Rating:
   1. Rated for continuous current and AIC rating of equipment protected.
   2. Mark SPD Short-Circuit Current Rating on the SPD label.

2.03 OPERATING CONDITIONS

A. Temperature range: -40°F to 122°F

B. Relative humidity range: 0 to 95%, non-condensing

C. Audible noise level: > 40 dBA at 5 ft

D. SPD Surface Temperature: less than131°F

2.04 FABRICATION

A. SPD Modules:

1. UL Labeled as Type 1 (verifiable at www.UL.com), intended for use without need for external or supplemental overcurrent controls. Protect suppression component of every mode, including N-G, by internal overcurrent and thermal overtemperature controls. SPDs relying on external or supplementary installed safety disconnects do not meet intent of specification.
2. UL Labeled with 20kA I-nominal (I-n) (verifiable at UL.com) for compliance to UL 96A Lightning Protection Mater label and NFPA 780
3. Suppression components: Heavy-duty MOVs, selenium cells, or combination of both.
4. Provide surge current diversion paths for all modes of protection: L-N, L-G, N-G in WYE systems, and L-L, L-G in DELTA systems.
5. Provide service entrance SPD audible diagnostic monitoring by way of audible alarm.
6. Provide service entrance SPD with 1 set of NO/NC dry contacts for alarm conditions.
7. Provide visual LED diagnostics including a minimum of 1 green LED indicator per phase, and 1 red service LED. Include an audible alarm with on/off silence function and diagnostic test function (excluding branch).
8. If a dedicated breaker for the SPD is not provided in the switchgear, switchboard, or panelboard include an integral UL Recognized disconnect switch. Dedicated breaker to serve as a means of disconnect for distribution SPDs.
9. Meet or exceed the following criteria:
   a. ANSI/UL 1449 Listed Voltage Protection Ratings (VPRs) for 6kV 3000A testing as follows:

VOLTAGE	**L-N** **L-G** **N-G**	**L-L**
208Y/120V	≤800V	≤1200V
480Y/277V	≤1200V	≤2000V

10. ANSI/UL 1449 Listed Maximum Continuous Operating Voltage (MCOV) (verifiable at UL.com):

System Voltage	**Allowable System Voltage Fluctuation (%)**	**MCOV**
208Y/120	15%	150V
480Y/277	15%	350V

11. Provide serviceable, replaceable modules (excluding Branch).
12. Provide warranty for a period of 10 yrs, incorporating unlimited replacements of suppressor parts if they are destroyed by transients during the warranty period.

B. Service Entrance:
   1. Install 1 primary suppressor external to the service entrance in accordance with manufacturer instructions.
   2. Install SPD on line or load side.
   3. Bond SPD ground to service entrance ground.

C. Distribution Panelboards:
   1. Install 1 suppressor external to each designated distribution panelboard.
   2. Install surge suppression device in accordance with manufacturer instructions.

D. SPD Low-Impedance Interconnect Cable:

1. Provide low-impedance cable specifically listed for SPD installations.
2. Low impedance approximately 25% of conventional pipe and wire for improved clamping voltage.

PART 3 - EXECUTION

3.01 APPLICATION OF SPD

A. Provide UL approved disconnect switch at Service Entrance or Transfer Switch as a means of service disconnect if a breaker sized per manufacturer's recommendations is not available.
B. Provide independent means of servicing disconnect at Distribution, MCC, and Branch such that the protected panel remains energized. A 30A breaker (or larger based on manufacturer's recommendations) may serve this function.

3.02 INSTALLATION

A. Install per manufacturer's recommended practices.
B. Provide short and straight conductors not exceeding 3 ft in length. Manufacturer-approved cables may be used that allow conductor length to extend beyond 3 ft in length without affecting capability of unit.
C. Input conductors twisted together to reduce inductance.
D. Avoid 90-degree bends in cable.

3.03 QUALITY ASSURANCE

A. Factory test system before shipment. Include quality control check, "Hi-Pot" tests at 2 times rated voltage plus 1,000 V, ground leakage tests, and calibration.
B. Manufacturer Qualifications: Engage a firm with at least 5 yrs experience in manufacturing surge protective devices.
C. Manufacturer of equipment shall have produced similar electrical equipment for a minimum period of 5 yrs. When requested by Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with requirement.
D. Provide SPD compliant with the Restriction of Hazardous Substances (RoHS) Directive 2002/95/EC.

3.04 FIELD QUALITY CONTROL

A. Inspections before SPD startup:
    1. Visual Inspection:
        a. Verify installation per drawings.
        b. Verify phase, neutral, and ground conductors are properly sized and configured.
    2. Mechanical Inspection:
        a. Check connections for tightness.
        b. Check terminal screws, nuts and/or connectors for tightness.
    3. Electrical Inspection:
        a. Confirm input voltage.
        b. Confirm phase, neutral and ground connections are proper.

3.05 WARRANTY

A. Provide 10 yr manufacturer warranty.

END OF SECTION

SECTION 26 5000
LIGHTING

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 26 0000 - General Electrical Requirements
B. Section 26 0519 - Low-Voltage Electrical Power Conductors and Cables
C. Section 26 0526 - Grounding and Bonding for Electrical Systems
D. Section 26 0533 - Raceway and Boxes for Electrical Systems
E. Section 26 0923 - Lighting Control Devices

1.02 DESCRIPTION OF WORK

A. Provide complete and fully operational lighting system per Contract Drawings and Specifications.
B. Luminaires shall be provided complete with necessary accessories for proper installation.
C. Catalog numbers shown in luminaire schedule are basic luminaire types. Additional features, accessories and options specified, scheduled or necessary for proper installation shall be included.
D. Specifications and drawings convey the features and functions of luminaires only and do not show every item or detail necessary for the work.
E. Work includes final aiming and focusing of luminaires under direction of the Architect/Engineer.

1.03 REFERENCE STANDARDS

A. NECA/IESNA 500 - Standard for Installing Indoor Commercial Lighting Systems (ANSI)
B. NECA/IESNA 501 - Standard for Installing Exterior Lighting Systems (ANSI)
C. NECA/IESNA 502 - Standard for Installing Industrial Lighting Systems (ANSI)
D. NEMA LE 4 - Recessed Luminaires, Ceiling Compatibility
E. UL 773 - Plug-in Photocontrols for use with area lighting
F. UL 924 - Emergency Lighting and Power Equipment
G. UL 1574 – Track Lighting
H. UL 1598 – Luminaires
I. UL 2108 – Low Voltage Lighting Systems
J. UL 2388 – Flexible Lighting Products
K. UL 2562 – Pendant Cable
L. UL 8750 – LED Light Sources for use in Lighting Products
M. ANSI C78.377 – Chromaticity
N. IESNA LM-79 – Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products
O. IESNA LM-80 - Approved Method: Testing Lumen Maintenance of LED Light Sources
P. IESNA TM21-11 - Projecting Long Term Lumen Maintenance of LED Light Sources including Addendum A

1.04 QUALITY ASSURANCE

A. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): “The articles listed in FAR 25.104(a) that are acquired as construction materials.”
B. Luminaire and accessory components shall be constructed of materials appropriate for their use.
C. Luminaires, drivers, other components shall meet the requirements of all applicable State and Municipal codes and energy codes.
D. Provide luminaires listed and labeled by UL or other testing lab acceptable to local jurisdiction for their indicated use and installation conditions.

E. Contractor shall coordinate installation of lighting systems with all trades.
   1. Manufacturers listed in the luminaire schedule shall be assumed capable of supplying listed luminaires. Any such exceptions shall immediately be brought to the attention of Architect and Engineer.
   2. Multiple Name Specification:
      a. When multiple manufacturers are listed, Electrical Contractor shall choose which of the listed products are to be provided.
      b. Products of the same type shall be of same manufacturer.
   3. Single Name Specification:
      a. When only one product is suitable for the application and/or no other known acceptable products exist, only one manufacturer/product is listed in the Luminaire Schedule. For such instances, Electrical Contractor shall provide the listed product with no exceptions.
   4. Contractor shall coordinate and verify compatibility of luminaires with lighting control system
      a. Control protocol indicated for luminaires matches protocol of lighting control system specified. Contractor shall coordinate and verify compatibility of all dimming luminaires with control system to ensure that dimming is flicker free, continuous dimming through the dimming range noted on the luminaire schedule.

F. Substitution requests:
   1. Will be evaluated prior to Bid.
   2. Shall follow procedures set forth in this Section under paragraph 1.7 and in Section 01 2500 - Substitution Procedures.
   3. Shall be made not less than 10 days prior to bid date.
   4. Shall include the following information indicating that the proposed substitution is of similar construction quality and assembly, lumen output and distribution, color temperature, color consistency, and controllability:
      a. Specified and proposed manufacturer's product data sheet, noting options and features.
      b. Provide dimensioned drawing of luminaire.
      c. Provide photometric data in form of an electronic IES file on USB or via email.
   5. Equipment delivery lead time shall not be held as a valid reason for requesting luminaire substitution unless luminaire lead time from specified manufacturer is in excess of 14 weeks. It shall be sole responsibility of Electrical Contractor to determine necessary equipment lead times, deliver submittals for review in a timely fashion, and place orders accordingly to ensure timely delivery.
   6. When requesting a substitution, Electrical Contractor shall provide unit and extended pricing for specified luminaire, unit and extended pricing for proposed alternate, and unit and extended delta savings to owner to be realized by accepting proposed alternate. If requested, provide unit pricing for each luminaire type specified to provide a baseline comparison for substitution request.
   7. Electrical Contractor shall guarantee pricing on all luminaire types for which a substitution request has been granted. This price guarantee shall be per unit and shall be maintained through the end of construction, regardless of quantity purchased.
   8. For all luminaire types using an LED light source, provide independently tested, IESNA LM79 compliant photometry testing data and IESNA LM-80 Lumen Maintenance data.

1.05 WARRANTY

A. Exit Signs Utilizing LED Technology: Provide manufacturer’s warranty for a period of not less than five years from the date of substantial completion including parts and labor for full replacement of defective product.

B. LED Luminaires: Provide Manufacturer's warranty for a period of not less than five years from the date of substantial completion or the specified warranty period greater than five years for repair or replacement of defective electrical parts, including light source and driver.
C. Luminaires without integral LED sources: Provide manufacturer's warranty for a period of not less than one year from the date of substantial completion including parts and labor for full replacement of defective product.

1.06 SUBMITTALS

A. Electronic submittal format shall be limited to the greater of 500 pages or 30 MB to ensure that all pages load correctly. Bookmarks by luminaire type are required for ease of navigation. Submittals exceeding these limits should be broken in a logical fashion into multiple volumes for separate review. Measures to reduce file size should not compromise legibility or any other factors affecting ease of review.
B. Upon award of Contract, submit complete list of lighting products to be furnished, with manufacturer and catalog designations, including current unit cost. Unit price shall be for equipment only and not include installation or miscellaneous electrical costs.
C. Upon award of Contract, submit complete list of lighting products to be furnished, with manufacturer and catalog designations, including currently quoted lead times for product delivery. Should Electrical Contractor anticipate delivery schedule of any specified product may adversely impact construction schedule, they shall bring it to the attention of Owner/Architect at this time.
D. In addition to complying with requirements of Section 26 0000 - General Electrical Requirements, submittals shall include the following:
    1. Manufacturer's product data
    2. Installation instructions
    3. Maintenance data
    4. Parts list for each luminaire accessory
    5. Photometric Data: photometric data for luminaire, including optical performance as follows:
        a. Coefficients of utilization
        b. Luminance table
        c. Candela distribution data
        d. Zonal lumens
        e. Area and roadway luminaires shall include Isocandela Charts, IES Roadway Distribution Classification and IES BUG (Backlight – Uplight – Glare) ratings.
    6. Driver schedule indicating manufacturer, type, and catalog number for each luminaire
    7. Driver cut sheet for each driver used, referencing luminaire type(s)
    8. Product color/finish
        a. Where specific finish or color is not specified and options exist, submit color or finish samples to Architect/Engineer for selection.
E. Shop Drawings for equipment provided under this Section shall include the following:
    1. Overall submittal drawings indicating luminaire size, mounting (including ceiling type), light source, shielding, and voltage attributes, as well as manufacturer's product data, installation instructions, maintenance data, and parts list for each luminaire.
    2. Catalog cutsheets lacking sufficient detail will not be accepted.
    3. Detailed drawings of linear pendant mounted and suspended luminaires including dimensions, support spacing, suspension type, power feed type and locations, driver locations, wiring and controls configuration, luminaire joint locations and end plates. Provide canopy details that indicate coordination with the ceiling system provided.
    4. Detailed drawings for each cove and linear wall system configuration including dimensions, power feed locations, driver locations, luminaire joint locations, extension plates for end and corner sections and end plates.

a. LED strip luminaires mounted in architectural coves, provide dimensioned drawings and sections and include accessory cut sheets as specified. Within coves, all luminaires are to be mounted end to end with no more than 12” unlit split evenly between ends

5. Detailed drawings for LED systems including LED color, color consistency, rated life, warranty, and scale plans with luminaire layout, number, type and location for drivers, and a complete bill of materials.
6. Detailed drawings for continuous recessed or continuous surface mounted luminaires including dimensions, power feed locations, driver locations/quantity, luminaire joint locations, extension plates for end and corner sections and end plates as applicable.
7. Detailed drawings for custom LED handrail systems including dimensions, power feed locations, driver locations/quantity, luminaire joint locations as applicable.
8. Submit documentation that indicates specified products have been tested, or will be tested, for compatibility with the lighting controls being procured and will perform as specified. Control devices or system shall be able to control luminaires with flicker free, continuous dimming, in range specified. Electrical Contractor, luminaire manufacturer and lighting control manufacturer shall be financially responsible for any incompatibilities.
9. Detailed drawings for nonstandard/custom luminaires indicating dimensions, weights, method of field assembly, components, features, and accessories. Details shall be scaled to a legible size.
10. Detailed drawings for fiber optic systems including scaled plans with cable layout number and type of fiber bundles, illuminator quantity and location, and a complete bill of materials.
11. Drawings for site lighting shall include pole data with wind loading, complete dimensions and finish, pertinent physical characteristics and accessories including mounting details, driver type and location and any specified control options.
12. Photometric Data: Where indicated on luminaire schedule and Contract Drawings, supply complete photometric data for luminaire, including optical performance rendered by independent testing laboratory developed according to methods of the Illuminating Engineering Society of North America as follows:
    a. Coefficients of utilization
    b. Luminance table with data presented numerically, showing maximum luminaire luminance at shielding angles. Readings should be taken both crosswise and lengthwise in case of linear luminaire or luminaire with an asymmetric distribution.
    c. Candela distribution data, presented graphically and numerically, in 5° increments (5°, 10°, 15°, etc.). Data developed for up and down quadrants normal, parallel, and at 11-1/2°, 45°, 67-1/2° to source if light output is asymmetric.
    d. Zonal lumens stated numerically in 10° increments (5°, 15°, etc.) as above.
13. No variation from the general arrangement and details indicated on drawings shall be made on shop drawings unless required by actual conditions. All variations shall be marked on drawings submitted for approval.

F. Provide luminaires with factory or field finish as directed by Architect/Engineer. Verify final finish requirements before releasing luminaires for fabrication.
G. Where specific finish or color is not specified and options exist, submit color or finish samples to Architect for selection. Luminaires not having color or finish acceptable to Architect shall be replaced at no additional cost.

1.07 SAMPLES

A. Upon return of submittals, and prior to release for manufacturing, Contractor shall furnish one working sample of each luminaire for which sample requirement is noted in Luminaire Schedule.

1. All requested samples shall be furnished as specified on luminaire schedule including but not limited to: light output, correlated color temperature, distribution, lens type and finish EXCEPT sample shall be wired with minimum 6-ft cord and plug for energization at 120V.

B. Shipping: Samples shall be complete with specified LED module(s), cord and plug, ready for hanging, energizing, and examining, and shall be shipped, prepaid by Contractor, to Architect/Engineer or as otherwise advised.
C. Samples may not be returned, nor included in quantities listed for project.
D. Sample must be actual working unit.
E. All custom luminaires require a submission of material finish samples, component approval and a complete operating prototype luminaire. Prototype to be submitted prior to commencement of final luminaire fabrication and shall include specified LED modules. Modifications may be required as a result of prototype review. These modifications and others that do not materially affect the cost of the luminaire shall be incorporated at no additional cost to Owner.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Luminaires:
   1. As shown on Luminaire Schedule
B. LED Drivers:
   1. Shall be manufacturer recommended compatible driver.
   2. All LED drivers shall be dimming type standard unless otherwise noted. Refer to construction documents for control per application.
   3. Manufacturers must be compatible with lighting control system(s) provided and control luminaires to specified minimum output per Luminaire Schedule and controls intent documents.
C. Emergency LED Battery Pack:
   1. Bodine, Dual-Lite, Iota or as specified in the Luminaire Schedule
D. Low Voltage Transformers:
   1. Q-Tran or as specified in the Luminaire Schedule
E. LED Modules:
   1. Philips Lumileds, Xicato, Cree, GE, Nichia, Osram Sylvania, Bridgelux, Citizen or as specified in the Luminaire Schedule

2.02 FABRICATION AND MANUFACTURER

A. Luminaires:
   1. Construction
      a. Luminaires shall bear label indicating circuit voltage. Labels shall not be visible from normal viewing angles.
      b. Luminaires shall be constructed with joints made by means of welded, brazed, screwed, or bolted construction methods.
      c. Housings shall be so constructed that all electrical components are accessible and replaceable without removing luminaires from their mountings.
      d. Surface temperatures of luminaires with integral drivers shall not exceed 90°C in 30°C ambient.
      e. Luminaires recessed in ceilings utilized as air handling plenums shall be certified as suitable for the purpose and conform to NEC Article 300.
      f. Miter cuts shall be accurate, joints shall be flush and without burrs.
      g. Troffers with doors shall have spring-loaded door cam latches unless otherwise noted for special environments and applications.

h. Luminaires shall be free of light leaks and designed to provide sufficient ventilation of source to provide the photometric performance documented. Low voltage transformers and drivers shall be vented per manufacturer's specifications.
i. Provide inscription for exit and stairway signs to conform to applicable codes. Provide battery back-up as specified.
j. Verify types of ceiling construction with General Contractor prior to releasing luminaires for fabrication and delivery and provide luminaires adapted to ceiling construction used.
k. Coordinate recessed luminaire mounting appurtenances, flanges and trims with construction of ceiling in which luminaire is to be recessed. Provide correct luminaire mounting assembly.
l. Luminaire frames shall be manufactured of non-ferrous metal or be painted after fabrication.

2. LED Luminaires are considered a lighting system with dependent components that must be evaluated as a complete system. Each LED luminaire includes a light emitting source, provisions for heat transfer, electrical control, optical control, mechanical support and protection, as well as aesthetic design elements. All LED luminaires shall:
   a. Be NRTL 3rd party tested to applicable UL standards. Where remote drivers are specified, all drivers shall also have UL listing or equivalent and comply with code requirements.
   b. Be tested to IESNA LM-79-19 testing using absolute photometry criteria.
   c. Be reported greater or equal to 70% lumen maintenance at 50,000 hours of operation.
   d. Be rapid cycle stress tested.
   e. Have integral LED modules with a minimum operating temperature of -20°C.
   f. Have modules that are capable of being easily replaced upon failure with a manufacturer provided replacement module without voiding the UL listing of the luminaire.
   g. Have driver housings easily accessible for ease of maintenance.
   h. Have a maximum operating temperature at LED junction to not exceed 90°C over the expected operating range of the luminaire.
   i. Be RoHS compliant, lead and mercury free.
   j. Have an LED operating frequency of + or – 120 Hz.
   k. Must meet the appropriate Federal Communications Commission (FCC) requirements for FCC 47 CFR 15 (consumer use) and/or FCC 47 CFR Part 18 (industrial use)
   l. Be Class A Sound rated.
   m. Be supplied with power supply that complies with IEEE C. 62.41-1991.
   n. Operate at 120 or 277 volts, ±10%.
   o. Have reverse polarity protected at all hardwired connections and have high voltage protection in the event connections are reversed or shorted during the installation process.
3. Lenses, Reflectors and Diffusers
   a. All lenses or louvers shall be removable but held so that normal motion will not cause them to drop out.
   b. All glass used in luminaires shall be made from thermal shock resistant borosilicate glass.
   c. Optical lenses shall be free from spherical and chromatic aberrations.
   d. Acrylic lenses shall be 100% virgin acrylic material.
   e. Diffuser materials shall be UV stabilized in applications exposed to sunlight.
   f. Troffer lenses shall be 0.125" thick, unless otherwise noted.

g. Alzak reflectors and louvers shall be low iridescent equivalent to Coil Anodizers. All Alzak parabolic cones shall be guaranteed against discoloration for a minimum of ten years.
h. Reflector cones shall not have visible source flashing in the cone.

4. Optics and Adjustments
   a. Adjustable Angle Luminaire: Luminaires with adjustment beam angle shall contain reliable angle locking devices.
5. Finishes
   a. Provide luminaires with finish as shown in the luminaire schedule. Verify final finish requirements before releasing luminaires for fabrication.
   b. Painted luminaires shall be painted after fabrication or "post painted".
   c. Ferrous parts and supports shall be rust proofed after fabrication.
   d. For weatherproof or vaportight installations, painted finishes of luminaires and accessories shall be weather resistant using proper primers or galvanized and bonderized epoxy, so that entire assembly is completely corrosion resistant for service intended and rated for an outdoor life expectancy of not less than 20 years.
6. Wiring
   a. Luminaires shall be completely wired at the factory and as required by code.
   b. Internal wiring shall contain no splices.
   c. Connections shall be made with insulated "wire nut" type mechanical connectors except that driver connections shall comply with NEC Article 410.
   d. Luminaires shall be provided with flexible conduit, pigtails, and equipment for external connections.
   e. Recessed luminaires installed in inaccessible ceilings shall be UL listed for through wiring with the junction box accessible from the luminaire opening.
   f. Cords shall be fitted with proper strain reliefs and watertight entries where required by application.
7. Ceiling Coordination
   a. Verify type of ceiling construction prior to releasing luminaires for fabrication and delivery.
   b. Provide mounting appurtenance, flanges, sloped ceiling adaptors where required.
   c. Provide mounting assembly, clips or other mechanical mounting lugs as required for support of luminaires.
8. Track-Lighting Systems:
   a. A lighting track system is defined as a manufactured assembly designed to support and energize luminaires that are capable of being readily repositioned on the track. Its length may be altered by addition or subtraction of sections of track. Lighting track may be either flexible or rigid depending on the specific application.
   b. Provide lighting track types as specified in Luminaire Schedule, in lengths as indicated on lighting plans.
   c. All line voltage track lighting systems shall be provided with integral current limiters or be fed from supplementary overcurrent protection panels to limit power consumed by track.
   d. Lighting track system includes current carrying conductors which may convey either line voltages (120V or 277V) or low voltages (12V or 24V). Characteristics of lighting track that conveys line voltages are different than a lighting track system that conveys low voltages and as such are governed by different requirements. Therefore, they are considered individually in these Specifications.
      1) Line voltage (120V or 277V) Lighting Track systems:

a) Provide components, including track, fittings, and luminaires from the same manufacturer as recommended by manufacturer for the intended use. All components shall be UL Listed and comply with the National Electric Code Standards for Lighting Track.
b) Maintain continuity of conductors through feeds, splice fittings and boxes. Relative positions of live and neutral conductors must always be maintained along continuous run so that track fittings connect into the track in a consistent manner.
c) Support lighting track at intervals recommended by the track manufacturer.
d) One or two circuit Lighting Track shall be supplied with separate neutral busbars and have the ability to have each circuit separately dimmed as required when using standard voltage and low voltage luminaires with either magnetic or electronic transformers.
e) Lighting Track shall have the ability to be dimmed or switched in selected sections in addition to dimming or switching an entire track configuration or track run.
f) One and two circuit 120 volt Lighting Track shall be rated at 120/250 volt, 60 Hz, 2,400 watts maximum each circuit. Neutral busbar(s) shall be oversized and comparable to #10 AWG 30 amp wire to reduce the possibility of overheating due to non-linear loads and harmonics.
g) One and two circuit 277 volt Lighting Track shall be rated at 277 volt, 50/60 Hz, 5,540 watts maximum each circuit. Neutral busbar(s) shall be oversized and comparable to #10 AWG 30 amp wire to reduce the possibility of overheating due to non-linear loads and harmonics.
h) A separate grounding busbar shall be integral in all track lengths.
i) 277 volt Track fittings shall be identified by a red rotor and a 277 volt label.

2) Low voltage (12V or 24V) Lighting Track systems:
a) Provide components, including track conductors, remote mounted transformers, fittings, and luminaires from the same manufacturer as recommended by the manufacturer for the intended use. Components shall be UL Listed as applicable for low voltage use.
b) Maintain continuity of conductors through feeds, splice fittings and boxes. Relative positions of conductors must always be maintained along continuous run so that track fittings connect into track in a consistent manner.
c) Support lighting track at intervals recommended by track manufacturer.
d) One and two circuit low voltage Lighting Track shall be supplied with three conductors and have the ability to have each circuit separately switched with either magnetic or electronic transformers provided by the track manufacturer. Two circuit low voltage Lighting Track can only be dimmed if both circuits are fed from the same transformer and as a result, separate circuit dimming shall not be attempted or permitted.
e) All transformers shall be supplied with both primary and secondary voltage over-current protection devices that shall remain readily accessible for maintenance and testing purposes.
f) Lighting Track shall have the ability to be dimmed or switched in selected sections in addition to dimming or switching an entire track configuration or track run. Separate, single circuit transformers are required for each independently controlled circuit with the use of electrically isolated couplers.
g) Conductors used in low voltage Lighting Track shall be, at minimum, equivalent to #10 AWG 30 amp wire or heavier and be capable of carrying a

300 watt load (at 12 volts) up to 32 ft from transformer feed within range of luminaire voltage tolerance. At 24 volts, conductors shall be capable of supplying a 600 watt load up to 60 ft from transformer feed within range of luminaire voltage tolerance.

h) If taut strung cable conductors are used as low voltage Lighting Track system, they shall have a Kevlar core to prevent strain on outer current carrying conductors.

i) Only insulated type taunt strung cable conductors shall be used in order to comply with local electrical codes governing installation.

9. Outdoor Lighting Systems:
   a. Provide luminaires, mounting arms, brackets, poles, hand-hole covers, base components, and all other accessories for a complete assembly. Manufacturers shall be responsible for proper fitting of elements and structural integrity of unit
   b. Provide poles as shown on luminaire schedule.
      1) Poles shall have hand-holes.
      2) Fusing for each luminaire head shall be located in hand-hole near base of pole.
      3) Pole base anchor bolts shall be galvanized.
   c. Exterior Luminaires:
      1) Shall operate at a minimum ambient temperature of 0°F.
      2) Shall be fully gasketed, with UL wet location label.
      3) Shall have approved wire mesh screens for ventilation openings.
      4) Anodized aluminum reflectors shall have minimum of 0.00079” anodizing thickness.
   d. Pole/Luminaire combination shall have EPA rating that will withstand site wind conditions.
   e. All castings and extrusions shall be given minimum one coat of baked-on clear lacquer, unless painted finish is specified.
   f. Aluminum surfaces shall receive a duronodic or polyester powder paint finish.
   g. Cast-in Luminaire housings installed directly in concrete shall be fabricated of hot dip galvanized steel or cast aluminum or composite.
   h. Where cast aluminum housings are used, give two coats of asphaltum paint prior to installation.
   i. Provide 1/8” thick x 2” diameter solid neoprene grommets at each point light luminaire surfaces are mounted to concrete structure.

2.03 LED SOURCES

A. Static white LED sources shall be:
   1. Minimum CRI of 85 unless noted otherwise on Luminaire Schedule
   2. Less than 5% flicker
   3. Within 0.004 on the CIE 1976 diagram for color spatial uniformity
   4. Within 0.007 on the CIE 1976 diagram for color maintenance over the rated lifetime of the source
   5. Binned within a 3-step MacAdam ellipse minimum, or as indicated in Luminaire Schedule
   6. Color temperature as noted on Luminaire Schedule
   7. Have a published life rating based on the point at which LED sources reach L70 lumen maintenance and tested in accordance with IES LM80-08 Approved Method: Testing Lumen Maintenance of LED light sources and IES TM-21-11: Projecting Long Term Lumen Maintenance of LED Light Sources
   8. L70 rated life shall be a minimum of 50,000 hours.
   9. LED modules, unless noted otherwise, shall be provided by light fixtures manufacturer and integral to luminaire.

10. Screw-base LED replacement lamps, where required and listed on the luminaire schedule, shall meet dimming, output, CCT and CRI as specified. 25,000 hours is acceptable L70 rated life for these products.

2.04 DRIVERS

A. Drivers for use in cold or freezer rooms, parking structures, loading docks, and outdoors shall be low temperature type.
   1. Driver shall have lowest temperature rating available in standard manufacture for its type.
B. Drivers shall be located in luminaire they serve, unless otherwise noted.
C. LED Drivers and Power Supplies shall:
   1. Operate system LEDs within the current limit specification of the LED manufacturer.
   2. Be supplied with over-temperature protection circuitry.
   3. Be within a NEMA enclosure.
   4. Be equipped with knockouts to accommodate standard conduit sizes
   5. Have a Power Factor to be = or > than 0.9
   6. Dimmable LED drivers must be compatible with dimming system(s) provided and control luminaires per luminaire schedule and controls documentation.
   7. ETL certified, CBM and UL Listed, high power factor, and meet or exceed NEMA and ANSI Standards.
   8. Class A sound rated
   9. Equipped with resetting thermal sensitive device.
   10. For operation at 60 Hz and voltage as scheduled.
   11. Meet or exceed all ANSI or NEMA standards
   12. Capable of operating LEDs with less than 5% flicker
D. Emergency LED Drivers shall:
   1. Be UL 924 listed
   2. Operate LED luminaire at 10W minimum output for 90 minutes with efficacy equal to or greater than the normal power efficacy.
   3. Have high temperature nickel-cadmium battery.
   4. Be installed inside or on top of luminaires
   5. Have solid state charging
   6. Battery to be recharged within 24 h
   7. Automatic testing every 30 days for 30 seconds and once a year for 90 minutes. Provide with flashing indicator light and audible alarm.

2.05 LOW VOLTAGE TRANSFORMERS

A. Transformers and power supplies shall be:
   1. Sized to compensate for voltage drop over indicated distances
   2. Locally fused
B. Transformers shall have line voltage switch within reach.
C. Provide adequate ventilation to meet code and manufacturers requirements.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Marking:
   1. Voltage identification: Luminaires designed for voltages other than 110-125 volt circuits shall be clearly marked with rated voltage.
   2. Markings must be clear and shall be located to be readily visible to service personnel but invisible from normal viewing angles when luminaires are in place.
B. Installation of Luminaires:
   1. Housing, glassware, reflectors and refractors shall be clean and free of chips, cracks and scratches.

2. Install decorative luminaires, reflector cones, baffles, aperture plates, lenses, trims, and decorative elements of recessed luminaires after completion of ceiling tile, plastering, painting, and general cleanup is completed. Where luminaire location or construction does not permit sequential installation, all reflectors, lenses, flanges and other visible surfaces shall be carefully protected.
3. Light leaks between ceiling trim of recessed luminaires and ceiling are not allowed.
4. Locations
    a. Install luminaires at locations and heights as indicated.
    b. Do not scale electrical drawings for locations of luminaires.
    c. Architectural reflected ceiling plans show locations of luminaires.
    d. Where noted on the drawings, the exact location of luminaires shall be confirmed (in the field) with the Architect/Engineer prior to installation.
    e. Where luminaires are to be concealed, or surface mounted in highly visible public spaces, a small sampling of luminaires shall be installed, adjusted and aimed for Architect/Engineer's review approval, prior to installing remaining luminaire of same type.
    f. Mount all luminaires so as to maintain full range of motion.
    g. Install luminaires plumb, square, and level with ceilings and walls.
    h. Coordinate stem, rod, chain, or aircraft cable hanger lengths with job conditions. Provide extra length of adjustable supports where diffusers are mounted directly above light fixtures to facilitate air balancing efforts.
    i. Industrial type luminaires in unfinished areas, which are near obstructions such as ducts and pipes, shall be:
        1) Suspended so that bottom of luminaire is no higher than bottom of obstruction
        2) Located at height of lowest luminaire
        3) Minimum height: 8’-0”
        4) Shall not be located until locations of obstructions are determined.
        5) Where a minimum height of 8’-0” is unachievable, wall mounted luminaires will be utilized.
5. Support
    a. Support surface mount luminaires from building structure.
    b. Metal decking shall not be pierced for luminaire support.
    c. Provide luminaires and/or luminaire outlet boxes with hangers to support luminaire weight.
    d. Troffers shall be held in place by support clips.
    e. Provide plaster frames for recessed luminaires in plaster ceilings.
    f. Rigid metallic pipe stems shall be utilized for the support of pendant mounted luminaires, unless otherwise noted.
    g. Stem hangers shall be equipped with aligner box covers or canopies so that stems hang vertically, irrespective of the angle of the surface they are mounted from.
    h. Wherever a luminaire or its hanger canopy is attached to a surface mounted outlet box, a finishing ring shall conceal the outlet box.
    i. Yokes, brackets and supplementary supporting members needed to mount luminaires to suitable ceiling members shall be furnished and installed by Contractor. Verify mounting hardware required prior to installation.
    j. Recessed luminaires shall be supported with 12 ga wire hangers, 2 per luminaire, at diagonally opposite corners.
    k. Troffers and luminaires over 55 lbs, such as 4’ x 4’ shall be supported with 12 ga wire hangers, 4 per luminaire, 2 at 45 degree diagonals, and two perpendicular to structure.

Wire hangers and attachment to structure shall be capable of supporting 4 times luminaires weight.

l. In areas with seismic requirements, suspended or pendant mounted luminaires shall be able to swing 45 degrees in any direction without hitting an obstruction. In the event hitting an obstruction is unavoidable, guy wires will be used to secure the luminaire in place.
m. Surface luminaires installed in grid ceilings shall be supported by independent support clips and 12 ga wire.
n. Exit signs installed in grid ceilings shall be supported by electrical box hanger and additional 12 ga wire installed from box to structure.
o. Support surface mounted luminaires greater than 2 ft in length at a minimum of each additional 2 ft, or as recommended by manufacturer.
p. Brace suspended luminaires installed near ducts or other constructions with solid pendants or threaded rods.
q. Rigidly align continuous rows of luminaires.
r. Luminaire types with remote mounted driver shall have:
1) Proper support for driver weight.
2) Mounting distance from remote driver to luminaire per manufacturer's recommendations.

6. Mounting and Enclosures
a. Install flush mounted luminaires to eliminate light leakage.
b. For luminaires mounted adjacent to insulation, provide barrier to prevent insulation from coming in contact with luminaire, unless luminaire is approved for installation in contact with such insulation.
c. Provide approved fire rated enclosures around luminaires in fire rated ceilings.
7. Conduit and Wiring
a. Wire for connections to modules and auxiliaries shall be suitable for temperature, current, and voltage conditions.
b. Recessed luminaires shall have final connections made with flexible metal conduit, not in excess of 72”, with THHN conductors and green wire ground conductor.
c. Conduit shall be hidden from normal view in all possible cases. In public areas where surface mounted conduit must be used, contractor shall install conduit as unobtrusively as possible. Contractor shall obtain field approval by the architect for all exposed conduit runs prior to rough in.
8. In-Grade Luminaires:
a. Where installed in tree grates, furnish burial light lens and louver to tree grate manufacturer for coordination of opening.
b. Provide adequate drainage system per manufacturer's recommendations.

C. Installation of Outdoor Pole Bases
1. Contractor shall provide bases for luminaires.
2. Provide handhole for electrical connection within 4’-0” of pole base.
3. Contractor shall:
a. Rough-in conduits
b. Coordinate spacing, base dimensions, heights, orientation of bases, etc. as necessary.
4. Where square or rectangular poles or luminaire heads are used, Contractor shall verify orientation with Architect/Engineer.

D. Pole Installation:
1. Install luminaires, poles, hardware, etc., for complete system.
2. Use web fabric slings (not chain or cable) to raise and set poles.

E. Grounding:
   1. Ground luminaires and metal poles according to Division 26 Section "Grounding and Bonding for Electrical Systems".
   2. Poles:
      a. Install 10 ft driven ground rod at each pole.
   3. Nonmetallic Poles:
      a. Ground metallic components of lighting unit and foundations. Connect luminaires to grounding system with #10 AWG conductor.

3.02 SUBSTANTIAL COMPLETION

A. Quality Control:
   1. At Date of Substantial Completion, replace LED modules/LED luminaires which are not operating properly.
   2. Protection wrapping on lensed or louvered luminaires shall be removed before installation of furniture, but after finish work is complete.
   3. Deliver spare equipment to Owner's representative.

B. Tests:
   1. Give advance notice of dates and times for field tests.
   2. Provide instruments to make and record test results.
   3. Verify normal operation of each luminaire after luminaires have been installed and circuits have been energized.
   4. Verify operation of luminaires with lighting control system and daylight harvesting systems. Any dimmed fixtures shall exhibit no signs of flickering.
   5. Replace or repair malfunctioning luminaires and components, then retest. Repeat procedure until all units operate properly.
   6. Report results of tests.

C. Adjusting and Cleaning:
   1. Clean luminaires of handling marks, dust and dirt.
   2. Cleaning and touch-up work shall be performed in accordance with luminaire manufacturer's recommendations.
   3. Damaged luminaires or components shall be replaced with new.
   4. Keep luminaires clean and protected for remainder of construction period.
   5. Verify orientation of directional luminaires prior to installation.
      a. This includes wall washers, cove lighting, floodlights, exterior area lights and adjustable accent luminaires. Contractor shall provide electrician's services to aim, adjust, and focus luminaires, as required, at direction of Architect/Engineer. These electricians shall be available at times designated by Architect/Engineer and shall be provided at no extra charge to Owner over base bid. Contractor shall provide equipment for luminaries' focus including ladders and mechanical lifting systems.
   6. Program preset dimming system lighting levels.
   7. Program ambient light sensors integral to luminaires for appropriate illumination levels as indicated in control narrative or in lighting control specifications.
   8. Program occupancy sensors integral luminaires for appropriate time delay as indicated in control narrative or in lighting control specifications.
   9. Exterior poles, bollards, bases and other exterior luminaires shall be painted to match factory color where finish has been damaged.
   10. No light leaks shall be permitted at ceiling line from any visible part or joint.

D. Training
   1. Contractor shall provide Owner with 1 complete hardcopy and 1 digital copy of Operations and Maintenance manuals.

a. All “Approved as Noted” comments shall be corrected/picked-up in this record manual set.
b. Each manual shall contain specific information pertaining to the equipment installed. Each manual shall contain at a minimum:
    1) Detailed as built shop drawings for all lighting equipment installed.
    2) Manufacturer’s product cut sheets for all equipment installed keyed by type as to as built drawings.
    3) Manufacturer’s complete installation instructions for all equipment installed keyed by type to as built drawings.
    4) Equipment maintenance requirements and schedules.
    5) Equipment manufacturer contacts.
    6) Equipment manufacturer warranties.
        a) Luminaires
        b) Drivers
        c) LED modules

2. Contractor shall provide qualified personnel onsite to provide a minimum of one day of training to Owner's representatives.
3. This training shall cover:
    a. Luminaire use and maintenance
    b. Architectural lighting system use and maintenance

END OF SECTION

SECTION 27 0000
GENERAL COMMUNICATIONS REQUIREMENTS

PART 1 - GENERAL

1.01 SCOPE

A. This section details references, standards, guidelines, requirements and conditions common to all Division 27 work.

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

1.02 DESCRIPTION

A. Intent of drawings and specifications is to obtain complete systems tested, adjusted, and ready for operation.

B. Except as otherwise defined in greater detail, terms "provide", "furnish" and "install" as used in Division 27 contract documents shall have the following meanings:
   1. "Provide" or "provided" shall mean "furnish and install".
   2. "Furnish" or "furnished" does not include installation.
   3. "Install" or "installed" does not include furnishing.

C. Include incidental details not usually shown or specified, but necessary for proper installation and operation.

D. Check, verify and coordinate work with drawings and specifications prepared for other trades. Include modifications, relocations or adjustments necessary to complete work or to avoid interference with other trades.

E. Included in this contract are connections to equipment provided by others. Refer to Architectural, Electrical, Integrated Automation, Mechanical, Security and final shop drawings for equipment being furnished under other sections for exact locations of outlets and various connections required.

F. Information given herein and on drawings is as exact as could be secured but is not guaranteed. Do not scale drawings for exact dimensions.

G. Where architectural features govern location of work, refer to architectural drawings.

H. Perform work in "neat and workmanlike" manner as defined in ANSI/NECA 1 "Standard Practices for Good Workmanship in Electrical Contracting".

1.03 RELATED WORK

A. Related Division 27 Sections include:
   1. Section 27 0526 - Grounding and Bonding for Communications Systems
   2. Section 27 0528.29 - Hangers and Supports for Communications Systems
   3. Section 27 0528.33 - Raceway and Boxes for Communications Systems
   4. Section 27 0528.36 - Cable Tray for Communications Systems
   5. Section 27 0528.39 - Surface Raceways for Communications Systems
   6. Section 27 0553 - Communications Systems Identification
   7. Section 27 1000 - Structured Cabling
   8. Section 27 1100 - Communications Equipment Room Fittings
   9. Section 27 1300 - Communications Backbone Cabling
   10. Section 27 1500 - Communications Horizontal Cabling

B. Related sections in other Divisions of Work:
   1. Section 26 0593 – Electrical Systems Firestopping
   2. Also refer to individual technical sections identified above.

C. Utility Services:

D. Temporary Services:
   1. Refer to Division 01 - Temporary Facilities and Controls.

2. Clean and repair existing materials and equipment that remain or will be reused.

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

F. Painting:
1. Furnish equipment with factory applied prime finish unless otherwise specified.
2. If factory finish on equipment furnished by Contractor is damaged in shipment or during construction, refinish equipment to satisfaction of Engineer.
3. Furnish one can of touch up paint for each factory finish, which will be final finished surface of product.
4. Contractor is responsible for painting of plywood in Telecommunications Equipment Rooms. Refer to Drawings.

1.04 REQUIREMENTS OF REGULATORY AGENCIES

A. Rules and regulations of Federal, State and local authorities and utility companies, in force at time of execution of contract shall become part of this specification.

1.05 REFERENCES AND STANDARDS

A. Design, cable and component selection, and installation practices shall conform with following:
1. ANSI/NFPA 70 - National Electrical Code
2. Local Electrical Code
3. Country, state and local health, safety and building codes
4. UL 444 - Communications Cables
5. Standards identified in individual Technical Sections.
6. BICSI Telecommunications Distribution Methods Manual (TDMM)
7. TIA 568.0-D through.4-D - Commercial Building Telecommunications Cabling Standard (including applicable Addenda)
8. TIA 569-E - Commercial Building Standard for Telecommunications Pathways and Spaces

B. Agencies or publications referenced herein refer to the following:
1. ANSI American National Standards Institute
2. ASME American Society of Mechanical Engineers
3. ASTM American Society for Testing and Materials
4. BICSI Building Industry Consulting Services International
5. FIPS Federal Information Processing Standards
6. FCC Federal Communications Commission
7. ICEA Insulated Cable Engineers Association
8. IEEE Institute of Electrical and Electronics Engineers
9. NEC National Electrical Code
10. NECA National Electrical Contractors Association
11. NEMA National Electrical Manufacturers Association
12. NESC National Electrical Safety Code
13. NETA National Electrical Testing Association
14. NFPA National Fire Protection Association
15. NIST National Institute of Standards and Technology
16. OSHA Occupational Safety and Health Administration
17. TIA Telecommunications Industry Association
18. UL Underwriters Laboratories, Inc.

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

1.06 DEFINITIONS

A. The following definitions are applicable to communications environments and shall apply to this document and its companion sections for clarification and direction.
   1. Entrance facility - an entrance to building for both public and private network service cables and/or wireless services including entrance point of building and continuing to Entrance Room.
   2. Entrance Room - room where both public and private network service cables and/or wireless services are terminated. Service provider(s) point-of-demarcation (DEMARC) is typically located here.
   3. Equipment Room (Telecom): an environmentally controlled centralized space for telecommunications equipment that usually houses main or intermediate cross-connect. Backbone cabling, cabling to Building Entrance and horizontal cabling may be terminated here.
   4. Guarantee - promise or an assurance that attests to quality or durability of product or service or that task will be performed in specified manner. Used interchangeably with "Warranty" in these documents.
   5. Intra-building - within single building.
   6. Inter-building - between 2 or more buildings.
   7. IP Telephony – Use of Internet Protocol (IP) for two-way transmission of conversations. Sometimes referred to as “Voice over Internet Protocol (VoIP)”.
   8. Rack Unit - standard measurement of vertical mounting space on an equipment rack. Each Rack Unit is 1-3/4” high.
   9. Voice over Internet Protocol – Refer to IP Telephony.

B. Typical NEMA Enclosures and Usage
   1. Refer to Section 26 0000 – General Electrical Requirements.

1.07 ABBREVIATIONS AND ACRONYMS

A. The following abbreviations and acronyms shall apply to this document and its companion sections for clarification and direction.
   1. AFF Above Finished Floor
   2. ATM Asynchronous Transfer Mode
   3. AWG American Wire Gauge
   4. BAS Building Automation Systems
   5. BTU British Thermal Unit
   6. CATV Community Antenna Television
   7. CCTV Closed-Circuit Television
   8. CDDI Copper Distributed Data Interface (Cisco Systems trade name for TP-PMD)
   9. cm centimeters
   10. °C degrees Celsius
   11. °F degrees Fahrenheit
   12. DTMF Dual Tone Multi Frequency
   13. EIA Electronic Industries Alliance
   14. EF Entrance Facility
   15. ER Entrance Room
   16. EIDF Equipment Intermediate Distribution Facility
   17. FDDI Fiber Distributed Data Interface
   18. ft feet
   19. GbE Gigabit Ethernet
   20. Hz Frequency in Hertz (k = kilo, M = Mega, G = Giga)
   21. ID Inside Diameter
   22. in inch

23. IPT IP Telephony
24. kg kilogram
25. lbs pounds
26. LAN Local Area Network
27. MATV Master Antenna Television
28. MC Main Cross-connect
29. mmeters
30. mm millimeters
31. Mbps Megabits per second
32. µm micrometer (10^{-6} meter)
33. OD Outside Diameter
34. PBX Private Branch Exchange (Telephone Switch)
35. pF pico-Farad (10^{-12} Farad)
36. PVC Polyvinyl Chloride
37. RU Rack Unit
38. sq ft square feet (area)
39. TP-PMD Twisted Pair Physical Medium Dependent
40. WAN Wide Area Network
41. WLAN Wireless Local Area Network
42. VoIP Voice over Internet Protocol

B. Refer also to technical sections for additional terminology.

1.08 LISTING

A. Refer to technical sections of this Division of work for listing requirements.

1.09 SUBMITTALS

A. Submit shop drawings for equipment provided under this Section:
   1. Refer to Division 01 - Submittal Procedures.
   2. Note that for satisfying submittal requirements for Division 27, "Product Data" is usually more appropriate than true "Shop Drawings" as defined in Division 01. However, expression "Shop Drawings" is generally used throughout specification.
   3. Mark catalog sheets and drawings to indicate specific items submitted.
      a. Markings shall be reproducible (e.g. arrow, boxed, encircled, checkmark).
      b. Where sheet includes multiple product options, mark proposed option(s).
   4. Include proper identification of equipment by name and/or number, as indicated in specification and shown on drawings.
   5. When manufacturer's reference numbers are different from those specified, provide correct cross-reference number for each item. Mark and annotate submittals accordingly.
   6. Group submittals by Section to include complete documentation of related systems, products and accessories. Where applicable, dimensions shall be marked in units to match those specified.
   7. Submittals shall be in electronic form or on paper per Division 01.
      a. Documents in electronic form shall be ADOBE *Acrobat* PDF.
      b. Paper documents shall be original catalog sheets or photocopies thereof.
      c. Facsimile (fax) sheets will not be accepted.
   8. Engineer’s Review is to confirm compliance with performance, interoperability, physical, and other pertinent requirements of project. Review is not to confirm quantities nor that all required items have been submitted.
   9. When equipment and items specified include accessories, parts and additional items under one designation, submittals shall be complete and include required components.
   10. Include wiring diagrams for electrically powered or controlled equipment.

11. Submit equipment room layouts drawn to scale, including equipment, raceways, accessories and clearance for maintenance.
12. Where submittals cover products containing potentially hazardous non-metallic materials, include "Material Safety Data Sheet" (MSDS) from manufacturer stating physical and chemical properties of components and precautionary considerations required.
13. Submit shop drawings or product data as soon as practicable after signing contracts. Submittals must be approved before installation of materials and equipment.
14. Submittals, which are not complete, not permanent, or not properly checked by Contractor, will be returned without review.
15. "Coordination Drawings", which are normally prepared by Contractor to coordinate work among various trades and to facilitate installation, shall not be submitted for Division 27 work unless specifically requested in technical sections. These types of drawings typically include dimensioned piping, ductwork, communications and/or electrical raceway layouts.
    a. Unless specifically requested in Division 27 technical sections, submittals of coordination drawings will be returned without review.

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

C. Operation and Maintenance Manuals:
1. Refer to Division 01 - Operation and Maintenance Data.
2. Upon completion of work but before final acceptance of system, submit to Architect for approval, 3 copies of operation and maintenance manuals in loose-leaf binders. If "one copy" is larger than 2” thick or consists of multiple volumes, submit only one set initially for review. After securing approval, submit 3 copies to Owner.
3. Manuals shall be organized by specification section number and shall have table of contents and tabs for each piece of equipment or system.
4. Manuals shall include the following:
    a. Copies of shop drawings
    b. Manufacturer's operating and maintenance instructions. Include parts lists of items or equipment. Where manufacturer's data includes several types or models, applicable type or model shall be designated.
    c. CD ROM's of O&M data with exploded parts lists where available
    d. Phone numbers and addresses of local parts suppliers and service companies
    e. Internet/WEB page addresses where applicable
    f. Wiring diagrams
    g. Start up and shut down procedure
    h. Factory and field test records
    i. Additional information, diagrams or explanations as designated under respective equipment or systems specification section
5. Instruct Owner's representative in operation and maintenance of equipment. Instruction shall include complete operating cycle on all apparatus.
6. O&M manuals and instructions to Owner shall be provided prior to request for final payment.

D. Record Documents:
1. Refer to General Conditions of Contract, and Division 01 - Closeout Procedures. Prepare complete set of record drawings in accordance with Division 01.

1.010 JOB CONDITIONS

A. Building Access:
1. Arrange for necessary openings in building to allow for admittance of all apparatus.

B. Cutting and Patching:

1. Refer to General Conditions of Contract, and Division 01 - Cutting and Patching.
2. Perform cutting and patching required for complete installation of systems unless otherwise noted. Patch and restore work cut or damaged to original condition. This includes openings remaining from removal or relocation of existing system components.
3. Provide materials required for patching unless otherwise noted.
4. Do not pierce beams or columns without permission of Architect and then only as directed. If openings are required through walls or floors where no sleeve has been provided, hole shall be core drilled to avoid unnecessary damage and structural weakening.
5. Where alterations disturb lawns, paving, walks, etc., replace, repair or refinish surfaces to condition existing prior to commencement of work. This may include areas beyond construction limits.

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

1.011 WORK BY OWNER

A. Owner will provide:
1. Active electronics for interface with building voice and data cabling systems
2. Connections from telephone and data equipment to Contractor provided cabling
3. Connections from Backbone Voice Cables to Horizontal Voice Cables
4. Passive Broadband distribution hardware (coaxial cable taps and splitters)
5. Active Broadband headend and distribution hardware (e.g. video processing, distribution amplifiers)
6. Equipment Racks and/or Cabinets

1.012 QUALITY ASSURANCE

A. Refer to the individual technical sections for general product quality requirements, manufacturer qualifications, and contractor qualifications and certification requirements.
B. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): “The articles listed in FAR 25.104(a) that are acquired as construction materials.”

1.013 GUARANTEE

A. Refer to Division 01 for general Guarantee (Warranty) requirements.
B. Refer to technical sections for Guarantee requirement for each system.
1. Where no guarantee requirements are called out, guarantee as called out in Division 01 equipment, materials, and workmanship to be free from defect.

C. Repair, replace or alter systems or parts of systems found defective at no extra cost to Owner.
D. Wherein fulfilling requirements of any guarantee, if Contractor disturbs any work guaranteed under another contract, restore such disturbed work to condition satisfactory to Architect and guarantee such restored work to same extent as it was guaranteed under such other contract.
E. Guarantees shall include labor, material and travel time.

PART 2 - PRODUCTS

2.01 PRODUCT SUBSTITUTIONS

A. Refer to Division 01 - Product Requirements.

PART 3 - EXECUTION

3.01 GENERAL

A. Verify elevations and measurements prior to installation of materials.

3.02 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Division 01.
B. Store and protect products under provisions of Division 01.
C. Store in clean, dry space.
D. Maintain factory wrapping or provide cover to protect units from dirt, water, construction debris, and traffic.
E. Handle in accordance with manufacturer's written instructions.
F. Handle carefully to avoid damage to components, enclosure, and finish. Lift only with lugs provided for the purpose.

3.03 FLOOR, WALL, ROOF AND CEILING OPENINGS

A. Coordinate location of openings, chases, furred spaces, etc. with appropriate Contractors. Provide during progress of construction sleeves and inserts that are to be built into structure.
B. Temporary sleeves, if used to form wall openings, shall be removed prior to installation of permanent materials. Permanent sleeves for wall penetrations shall be minimum 24 ga galvanized sheet metal unless otherwise noted.
C. Steel sleeves, when required, shall be Schedule 40 carbon steel pipe with integral water stop.
D. For core drilled holes, size and location shall be reviewed and approved by Structural Engineer prior to execution.
E. Submit product data and installation details for penetrations of building structure. Submittal shall include schedule indicating penetrating materials, (including steel conduit, PVC conduit, cables, cable tray), sizes of each, opening sizes and sealant products intended for use.
F. Where penetrations of fire-rated assemblies are involved, seal penetrations with appropriate firestopping systems as specified in Division 26.
G. Openings for penetrations shall be minimum 1/2” larger on all sides than outside dimensions of raceways or cables. However, where fire resistant penetrations are required, size openings in accordance with recommendations of firestopping systems manufacturer.
H. Seal non fire-rated floor penetrations with non-shrink grout equal to Embeco by Master Builders, or urethane caulk, as appropriate.
I. Seal non-rated wall openings with urethane caulk.
J. Where penetrations occur through exterior walls into building spaces, use steel sleeves with integral water stop, similar to type "WS" wall sleeves by Thunderline Corporation. Seal annular space between sleeves and pipe with "Link-Seal" modular wall and casing seals by Thunderline Corporation, or sealing system by another manufacturer approved as equal by Architect. Sealing system shall utilize Type 316 stainless steel bolts, washers and nuts.
K. Finish and trim penetrations as shown on details and as specified hereinafter.
L. Provide chrome or nickel plated escutcheons where raceways pass through walls, floors or ceilings and are exposed in finished areas. Size escutcheons to fit raceways for finished appearance. Finished areas shall not include mechanical/electrical rooms, janitor’s closets, storage rooms, etc., unless suspended ceilings are specified.

3.04 EQUIPMENT ACCESS

A. Install raceways, junction and pull boxes, and accessories to permit access to equipment for maintenance. Relocation of raceways, or accessories as required to provide access, shall be provided at no additional cost to Owner.
B. Install equipment with ample space allowed for removal, repair or changes to equipment. Provide ready accessibility to equipment and wiring without moving other equipment, which is to be installed or which is already in place.
C. Access doors in walls, chases, or inaccessible ceilings will be provided under Division 08 - Access Doors and Frames, unless otherwise indicated. Access doors shall be for purpose of providing access where equipment requiring servicing, repairs or maintenance is located in walls, chases or above inaccessible ceilings.

D. Locate communications outlets and equipment to fit details, panels, decorating or finish at space. Architect reserves right to make minor position changes of outlet locations before work has been installed.
E. Verify room door swings before installing wall-mounted communications outlets and install boxes on latch side of door unless otherwise noted.

3.05 EQUIPMENT SUPPORTS

A. Provide supporting steel not indicated on drawings as required for installation of equipment and materials including angles, channels, beams, hangers.
B. Concrete anchors, used for attachment to concrete, shall be steel shell with plug type. Plastic, rawhide or anchors utilizing lead are not allowed.
C. Do not support equipment or cable pathways from metal roof decking.

3.06 SUPPORT PROTECTION

A. In occupied areas, mechanical rooms and areas requiring normal maintenance access, certain equipment must be guarded to protect personnel from injury.
B. Provide minimum 1/2” thick Armstrong Armaflex insulation or similar product applied with Armstrong 520 adhesive on lower edges of equipment, including bus duct, cable tray, pull boxes and electrical supporting devices suspended less than 7 ft above floors, platforms or catwalks in these areas.
C. Threaded rod or bolts shall not extend beyond supporting element and shall be protected as described above.

3.07 CABLE PROTECTION

A. Protect cabling and termination components from contact with, and potential application of, foreign materials.
    1. Foreign material is defined as material that is not part of cabling assembly and termination components when delivered from manufacturer.
    2. Examples include paint overspray and drywall compound.
B. Cabling and components that come into contact with foreign materials shall be replaced at no cost to project.
    1. Solvents and other cleaning agents shall not be used to remove foreign materials that have already accumulated on cabling and components.

3.08 HOUSEKEEPING PADS

A. Not applicable to this Division of work.

3.09 ACCEPTANCE TESTING

A. Prior to testing, submit to owner (or Owner’s representative) and Engineer, proposed schedule for acceptance testing.
    1. This notification shall be minimum of 10 working days in advance to allow for participation by Owner and/or Engineer.
B. Prior to testing, submit written description of intended test procedures and submit sample test forms to Engineer.
    1. Submitted information shall include proposed file naming format to be used in identifying cable, pair or optical fiber which is subject of test record.
    2. Failure to provide above information shall be grounds for Engineer or Owner to reject any Documentation of related testing and to require repeat of affected test.
C. Conduct tests during course of construction when identifiable portion(s) of installation is complete.
    1. Alternatively, testing can be conducted after entire installation is complete if this does not delay project schedule.
D. Provide equipment and personnel necessary to conduct acceptance tests.

E. Testing shall be completed and accepted by Owner and Engineer before Owner furnished equipment and cross connects are installed.
F. Document tests.
G. When equipment or systems fail to meet minimum test requirements, replace or repair defective work or materials as necessary and repeat inspection and test. This shall be at no additional cost to the owner. Replacement materials shall be new.
H. This Contractor is responsible for certifying, in writing, equipment and system test results. Certification shall include identification of portion of system tested, date, time, test criteria and name and title of person signing test certification documents.
I. Maintain copies of certified test results, including those for failed tests, at project site. At completion of project, include copies of test records and certifications in O&M Manuals.

3.010 START-UP

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

3.011 DOCUMENTATION

A. Upon completion of installation, Contractor shall provide System Documentation. Documentation shall include:
   1. Acceptance Test Results
   2. Record Drawings
   3. All Approved Submittals
   4. Manufacturer’s Warranty Documents
B. Submit System Documentation in accordance with Division 01 "Project Record Documents".
   1. Documents shall be submitted in same electronic format in which they were received from Architect and Engineer.
   2. Document updates shall be performed in native software format matching original design team documents.
      a. Scans of hand marked documents shall not be allowed.
   3. Update documents to reflect installed conditions for equipment shown on documents.
C. Submit documentation within ten (10) working days of the completion of testing of each testing phase (e.g. subsystem, cable type, area, floor) or 3 weeks prior to scheduled occupancy of subject area, whichever is sooner. This is inclusive of Test Result and draft Record Drawings.
   1. Draft drawings may include mark-ups done by hand.
   2. Machine generated (final) copies of Record Drawings shall be submitted within 30 working days of completion of each testing phase.
   3. Documentation will include all aspects of systems covered by these specifications that are required for systems to be fully functional.
   4. For structured cabling this includes the horizontal link from the TO to the HC, backbone cabling from the HC to the MC, cross-connections, interconnections and/or patch cords that are the responsibility of the contractor.
D. Submit Acceptance Test Results in electronic form for review and distribution.

1. Interim documentation of Test Results (if applicable) may be submitted via email or on CD-ROM.
2. Final documentation of Test Results shall be submitted on CD-ROM.
3. Test results shall be submitted in format(s) native to test instrument(s) used in performing testing.
4. Where unique software (other than an MS-Word™ compatible Word Processor or MS-Excel™ spreadsheet) is required for viewing of test results, Contractor shall provide along with above documentation, **[quantity]** licensed copy of such software. Software shall run on MICROSOFT Windows-based personal computer.

E. Acceptance Test results shall include description of sub-system tested, equipment/cable/outlet I.D., reference and test setup, test equipment type/model and serial number(s), equipment location and direction of test (if applicable), test frequencies/wavelengths, date and operator name(s).

F. Engineer or Owner may request that 10% random re-test be conducted on cable system - at no additional cost - to verify documented findings. Tests shall be a repeat of those defined above and in technical sections.
   1. Owner may also perform independent testing to verify results.
   2. If findings contradict documentation submitted by Contractor, additional testing can be requested to extent determined necessary by Engineer or Owner, including 100% re-test. This re-test shall be at no additional cost to Owner.

G. Documentation - including hard copy and electronic forms of Test Data and Record Drawings - shall become property of Owner.

H. Refer also to Technical Sections for requirements specific to covered subsystems.

3.012 CLEANING

A. After installation is complete, Contractor shall clean all systems.

B. Vacuum debris from system components, enclosures, junction boxes and pull boxes prior to testing and again prior to completion.

C. Thoroughly clean equipment of stains, paint spots, dirt and dust. Remove temporary labels not used for instruction or operation.

END OF SECTION

SECTION 270526
GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.01 SCOPE

A. This section includes product and execution requirements for Grounding and Bonding that are unique to communications systems and not included in Division 26 sections.

1.02 DESCRIPTION

A. Grounding and Bonding infrastructure for communications includes Cabling, Busbars and Connectors.

1.03 RELATED WORK

A. Related Division 27 Sections include:
   1. Section 27 0000 - General Communications Requirements
   2. Section 27 0528.33 - Raceway and Boxes for Communications Systems
   3. Section 27 0528.36 - Cable Tray for Communications Systems
   4. Section 27 0553 - Communications Systems Identification
   5. Section 27 1000 - Structured Cabling
   6. Section 27 1100 - Communications Equipment Room Fittings
   7. Section 27 1300 - Communications Backbone Cabling
   8. Section 27 1500 - Communications Horizontal Cabling

B. Related sections in other Divisions of Work:
   1. Section 26 0526 - Grounding and Bonding for Electrical Systems

1.04 REFERENCES AND STANDARDS

A. Refer to Section 27 0000 - General Communications Requirements which identifies pertinent References and Standards.

B. In addition, the following apply:
   1. IEEE/ANSI 142 - Recommended Practice for Grounding of Industrial and Commercial Power Systems.
   2. IEEE 837 - Standard for Qualifying Permanent Connections Used in Substation Grounding.
   3. UL 467 Electrical Grounding and Bonding Equipment
   4. ANSI J-STD-607-A - Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
   5. ANSI J-STD-607-D - Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

1.05 DEFINITIONS

A. Refer to Section 27 0000 - General Communications Requirements which provides information on Definitions used in this and related sections.

B. Additional definitions (per referenced standards):
   1. Telecommunications Main Grounding Busbar: Busbar placed in convenient and accessible location and bonded by means of bonding conductor for telecommunications to building service equipment (power) ground.
   2. Telecommunications Grounding Busbar: Interface to building telecommunications grounding system generally located in telecommunications room. Common point of connection for telecommunications system and equipment bonding to ground, and located in telecommunications room or equipment room.
   3. Telecommunications Bonding Conductor: Conductor that interconnects telecommunications bonding infrastructure to building's service equipment (power) ground.
   4. Telecommunications Bonding Backbone: Conductor that interconnects tele-communications main grounding busbar to telecommunications grounding busbar.

5. Grounding Equalizer: Conductor that interconnects elements of telecommunications grounding infrastructure.
6. Exothermic Weld: Method of permanently bonding two metals together by controlled heat reaction resulting in molecular bond.
7. Irreversible Compression: Permanent mechanical bond between conductors or conductor and connector using mechanical or hydraulic tool.

1.06 ABBREVIATIONS AND ACRONYMS

A. Refer to Section 27 0000 - General Communications Requirements which provides information on Abbreviations and Acronyms used in this and related sections.
B. Additional abbreviations and acronyms (per referenced standards):
   1. Telecommunications Main Grounding Busbar - TMGB
   2. Telecommunications Grounding Busbar - TGB
   3. Telecommunications Bonding Backbone - TBB
   4. Grounding Equalizer - GE

1.07 WORK BY OWNER

A. Refer to Section 27 0000 - General Communications Requirements which identifies Work by Owner affecting sub-system(s) covered by this section.

1.08 SUBMITTALS

A. Refer to Section 27 0000 - General Communications Requirements which provides general guidelines for product or installation information to be submitted by Contractor.

1.09 QUALITY ASSURANCE

A. Refer to Section 27 0000 - General Communications Requirements which identifies general quality assurance requirements for the Project.

1.010 GUARANTEE

A. Refer to Division 01, General Conditions, and General Requirements - Guarantee Documents for general warranty requirements.

PART 2 - PRODUCTS

2.01 TELECOMMUNICATIONS BUSBARS

A. Material: Copper (aluminum not permitted)
   1. 1/4” thick
B. Pre-drilled
   1. 3/8” Diameter
   2. Hole spacing per ANSI Joint Standard J-STD-607-A
   3. Hole pattern shall accommodate two-hole lugs
C. Insulators and stand-off brackets shall electrically isolate busbar from wall or other mounting surface.
D. Busbars shall be listed by nationally recognized testing laboratory.
E. Size:
   1. Telecommunications Main Ground Busbar (TMGB) – 20” x 4” (minimum)
   2. Telecommunications Grounding Busbar (TGB) – 12” x 2” (minimum)

2.02 CONDUCTORS

A. Material: Stranded copper (aluminum not permitted)
B. Bonding Conductors shall be insulated.
   1. Green Jacket or Black Jacket marked with Green Tape or Green adhesive labels per NEC Guidelines

C. Size:
   1. Telecommunications Bonding Conductor (TMGB to Grounding Electrode): As indicated on Project Drawings
   2. Telecommunications Bonding Backbone (TBB; TMGB to TGB): As indicated on Project Drawings
   3. Grounding Equalizer (GE): As indicated on Project Drawings

2.03 CONNECTIONS

A. Mechanical Connectors
   1. Connector Body shall:
      a. Be high-strength, high-conductivity cast copper alloy
      b. Be 2 bolt type
   2. Bolts, nuts, washers and lock-washers: Silicon Bronze
      a. Shall be supplied as part of connector body
      b. Split bolt connector types are not allowed
   3. Connector shall:
      a. Meet or exceed UL 467
      b. Be clearly marked with catalog number, conductor size and manufacturer.

B. Compression Connectors
   1. Connector Body: pure wrought copper.
      a. Conductivity shall be no less than 99% by IACS standards.
   2. Connector shall:
      a. Meet or exceed performance requirements of IEEE 837, latest revision
      b. Be factory filled with an oxide-inhibiting compound
      c. Be clearly marked with manufacturer, catalog number, conductor size and required compression tool settings
   3. Connection shall be irreversible.

C. Exothermic Weld Connections
   1. Not Allowed

PART 3 - EXECUTION

3.01 SEQUENCING AND SCHEDULING

A. Permanently attach communications grounds prior to energizing communications equipment.

3.02 TOPOLOGY

A. Refer to the project drawings.

3.03 INSTALLATION

A. Provide required elements and miscellaneous hardware necessary to establish Telecommunication Grounding infrastructure as specified.
B. Install Products in accordance with manufacturer's instructions.
   1. Install Compression Connectors with compression, tool and die system, as recommended by manufacturer of connectors.
C. Grounding connections shall be tight and shall be made with UL listed grounding devices, fittings, bushings, etc.
D. On the Telecommunications Bonding Conductor, Telecommunications Bonding Backbone (TBB) and Grounding Equalizer (GE) all connections shall be Compression type.
E. Locate TGBs and TMGB per drawings.
F. Telecommunications Bonding Backbone (TBB) shall be continuous and not interrupted by Telecommunications Grounding Busbars (TGB).
   1. TGBs shall be bonded to TBB via tap off of TBB.
      a. Exception is "last" TGB on TBB (e.g. furthest from TMGB).

2. Grounding Equalizer(s) (GE) shall connect to TGBs to be interconnected.

G. Insulate Busbars from their support.

H. Connections shall be bare metal to bare metal contact.
   1. Clean surfaces of paint, dirt, oil, etc.

I. Connections shall be exposed and visible for inspection at all times.
   1. Do not install insulation over ground connections.

J. Terminate each grounding conductor on its own terminal lug.
   1. Multiple conductors on single lug not permitted.

3.04 FIELD QUALITY CONTROL

A. Inspect grounding and bonding system conductors and connections for tightness and proper installation.

B. Test resistance of each TGB to ground.
   1. Maximum resistance to ground shall be less than 5 Ohms.

3.05 DOCUMENTATION

A. Accurately record actual locations of grounding electrode(s), busbars and backbone grounding conductors.

END OF SECTION

SECTION 270528.29
HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.01 SCOPE

A. This section includes product and execution requirements for items unique to communications systems and not included in Division 26 sections.
B. Refer to Section 27 0000 – General Communications Requirements and 26 0529 - Hangers and Supports for Electrical Systems - Part 1 for requirements for Reference Standards, Submittals, Quality Assurance, Delivery/Storage/Handling, and Guarantee.

1.02 RELATED WORK

A. Related Division 27 Sections include:
   1. Section 27 0000 - General Communications Requirements
   2. Section 27 0528.33 - Raceway and Boxes for Communications Systems
   3. Section 27 0528.36 - Cable Tray for Communications Systems
   4. Section 27 1000 - Structured Cabling
   5. Section 27 1100 - Communications Equipment Room Fittings
   6. Section 27 1300 - Communications Backbone Cabling
   7. Section 27 1500 - Communications Horizontal Cabling
B. Related sections in other Divisions of Work:
   1. Section 26 0529 - Hangers and Supports for Electrical Systems

1.03 REFERENCES AND STANDARDS

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

PART 2 - PRODUCTS

2.01 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

A. Refer to Section 26 0529 - Hangers and Supports for Electrical Systems - Part 3 for:
   1. Hanger Rods
   2. Beam Clamps
   3. Wall Anchors
   4. Metal Framing

2.02 J-TYPE CABLE SUPPORT HOOKS

A. Cable support hooks shall be a wide-base type for use in a non-continuous pathway.
B. Hook material shall be Galvanized metal or Nylon for smooth cable pull and corrosion resistance.
   1. Hook may be coated to reduce cable friction.
   2. Hook material shall be rigid. Flexible material not allowed.
C. Hooks shall:
   1. Comply with UL, cUL, NEC and TIA requirements for structured cabling systems.
   2. Be designed to limit cable bending per cable manufacturers’ recommendations.
   3. Be capable of being installed in a single- or multiple-hook (“tree”) configuration.
   4. Incorporate a latch or other mechanism to retain cable.

PART 3 - EXECUTION

3.01 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

A. Refer to Section 26 0529 - Hangers and Supports for Electrical Systems - Part 3 for all products identified in Part 1.

3.02 J-TYPE CABLE SUPPORT HOOKS

A. Where installed free-air above suspended ceiling or below raised floor, support cables using J-hook type cable supports installed in accordance with manufacturer's installation requirements.
B. Support hooks from structure. Do not support from ceiling grid, conduit or other trades work.
C. Space J-hook cable supports every 4 ft or in accordance with cable manufacturer's specifications, whichever distance is shorter.
D. J-hook fill capacities shall be per manufacturer's recommendations and shall consider diameter of cable type(s) being installed.

END OF SECTION

SECTION 27 0528.33

RACEWAY AND BOXES FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.01 SCOPE

A. This section includes product and execution requirements for items unique to communications and not included in Division 26 sections.

1.02 DESCRIPTION

A. Refer to Section 26 0533 - Raceway and Boxes for Electrical Systems - Part 1 for requirements for Standards, Submittals, Quality Assurance, Delivery/Storage/Handling, and Guarantee for:
   1. Outlet Boxes
   2. Pull and Junction Boxes
   3. Raceways and Wireways (including sleeves, expansion fittings, penetrations and seals)
   4. Indoor Service Poles
   5. Poke-through Fittings
   6. Floor Boxes
   7. Cable Supports

1.03 RELATED WORK

A. Related Division 27 Sections include:
   1. Section 27 0000 - General Communications Requirements
   2. Section 27 0526 - Grounding and Bonding for Communications Systems
   3. Section 27 0528.29 - Hangers and Supports for Communications Systems
   4. Section 27 0528.36 - Cable Tray for Communications Systems
   5. Section 27 0528.39 - Surface Raceways for Communications Systems
   6. Section 27 0553 - Communications Systems Identification
   7. Section 27 1000 - Structured Cabling
   8. Section 27 1100 - Communications Equipment Room Fittings
   9. Section 27 1300 - Communications Backbone Cabling
   10. Section 27 1500 - Communications Horizontal Cabling

B. Related sections in other Divisions of Work:
   1. Section 26 0533 - Raceway and Boxes for Electrical Systems

1.04 REFERENCES AND STANDARDS

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

PART 2 - PRODUCTS

2.01 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

A. Refer to Section 26 0533 - Raceway and Boxes for Electrical Systems - Part 2 for Outlet Boxes for Communications, Pull and Junctions Boxes for Communications, Raceways for Communications, and other products identified in Part 1.

2.02 COMMUNICATIONS RACEWAYS

A. OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY (INNERDUCT)
   1. UL 2024; flexible type, approved for riser installation
   2. Outdoor Innerduct: Smooth outside and ribbed inside
   3. Indoor Innerduct: Corrugated
   4. Color:
      a. Riser: Orange
   5. Manufacturers: Carlon; Pyramid; Approved equal

2.03 MULTI-CELL FLEXIBLE RACEWAY

A. Manufacturers: MaxCell™.
B. Multi-cell flexible raceway shall be a flexible, multi-celled, textile innerduct system designed for communications.
C. Multi-cell flexible raceway shall meet the following physical requirements:
    1. UL 2024; flexible type, approved for riser (OFCR FT-4) installation
    2. Tensile strength: 2500 lbs or better
    3. Melting Point: 480°F or better
    4. Resistant to ground chemicals and petroleum products
    5. Unaffected by mud, silt or debris after placement of cable.
D. Shall be pre-lubricated for lower friction during flexible raceway and cable installation.
E. Multi-cell flexible raceway color shall be WHITE.
    1. Multi-cell flexible raceway shall include a color coded stripe allowing for identification of each bundle.
F. Each cell shall include a color-coded pull tape.
G. Product shall be available in a variety of sizes and cell counts. Refer to project Drawings.

PART 3 - EXECUTION

3.01 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

A. Refer to Section 26 0533 - Raceway and Boxes for Electrical Systems - Part 3 for Outlet Boxes for Communications, Pull and Junctions Boxes for Communications, Raceways for Communications, and other products identified in Part 1.

3.02 COMMUNICATIONS RACEWAYS

A. Optical Fiber Communications Cable Raceway (Innerduct):
    1. Minimum innerduct size: 1”, unless otherwise noted on drawings.
    2. Extend innerduct to termination and/or storage enclosure.
    3. Provide couplings designed for innerduct size and type where innerduct enters a termination and/or storage enclosure.
    4. Splice innerduct segments using couplings designed for that purpose, where not installed in a continuous length.
    5. Provide 200 lb nylon pull cord in empty innerduct. Leave at least 12” of slack at each end of pull wire. Cap innerduct at both ends.
    6. Label innerduct with tags indicating cable type and cables contained therein.
        a. Label in each maintenance hole, pull box and communications equipment room, where exiting a conduit and at 10 ft intervals in cable tray or where otherwise exposed.

3.03 MULTI-CELL FLEXIBLE RACEWAY

A. Segment conduits to increase capacity.
    1. Provide quantity and size per project Drawings.
B. Install per manufacturers recommendations.

END OF SECTION

SECTION 27 0528.36
CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.01 RELATED WORK

A. Related Division 27 Sections include:
   1. Section 27 0000 - General Communications Requirements
   2. Section 27 0526 - Grounding and Bonding for Communications Systems
   3. Section 27 0528.29 - Hangers and Supports for Communications Systems.
   4. Section 27 0528.33 - Raceway and Boxes for Communications Systems
   5. Section 27 1000 - Structured Cabling
   6. Section 27 1100 - Communications Equipment Room Fittings
   7. Section 27 1300 - Communications Backbone Cabling
   8. Section 27 1500 - Communications Horizontal Cabling

B. Related sections in other Divisions of Work:
   1. Section 26 0526 - Grounding and Bonding for Electrical Systems
   2. Section 26 0529 - Hangers and Supports for Electrical Systems
   3. Section 26 0533 - Raceway and Boxes for Electrical Systems
   4. Section 26 0548 - Vibration and Seismic Controls for Electrical Systems

1.02 REFERENCE

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

1.03 DESCRIPTION

A. Provide complete cable tray system including straight tray sections, fittings, splice plates, and cable tray supports to support cable systems in locations as indicated on drawings.

B. Cable tray system is intended to carry communications cable only. Fire alarm system and overhead page cables are not allowed.

1.04 REFERENCE STANDARDS

A. ASTM A 123 - Specification for Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and forged Steel Shapes, Plates, Bars, and Strip.

B. ASTM A 446 - Specification for Zinc-Coated (Galvanized) by Hot-Dip Process, Structural (Physical) Quality.

C. ASTM A 525 - Specification for Steel Sheet, Zinc-Coated Galvanized by Hot Dip Process.

D. ASTM A 607 - Specification for Steel Sheet and Strip, Hot-rolled and Cold-Rolled, High Strength, Low Alloy Columbium or Vanadium.

E. ASTM B 633 - Specification for Electro-deposited Coatings of Zinc on Iron and Steel.

F. NEMA VE 1 - Metal Cable Tray Systems.

G. NEMA VE 2 - Cable Tray Installation Guidelines

H. BICSI - Telecommunications Distribution Methods Manual (TDMM)

1.05 SUBMITTALS

A. Submit shop drawings for equipment provided under this Section.

B. Submit as-built drawings showing floor plan locations, elevation changes, and conduit drops.

PART 2 - PRODUCTS

2.01 MANUFACTURER

A. Acceptable Manufacturers
   1. Cooper B-Line (FLEXTRAY™)
   2. Chalfant Cable Trays
   3. Mono-Systems (Mono-Mesh™)
   4. MP Husky

5. Legrand (CABLOFIL®)
6. WBT

2.02 MATERIALS AND FABRICATION

A. Materials of Construction:
   1. Materials shall be adequately protected against corrosion or made of corrosion resistant material.
B. Wire Mesh Trays
   1. Tray shall be continuous, rigid, welded steel wire mesh cable management system.
   2. Maximum mesh dimension shall be 2 x 4 inches (50 x 100 mm).
      a. Wire diameter shall be at least 5 mm.
   3. Material shall be carbon steel wire, ASTM A510, Grade 1008. Wire welded, bent, and surface treated after manufacture
   4. Finish shall be Electro-Plated Zinc Galvanizing per ASTM B 633, Type III, SC 1 or Electro-plated yellow zinc dichromate in accordance with ASTM B 633, Type III, SC 2.
   5. Dimensions:
      a. Inside width: As indicated on Project Drawings
      b. Loading depth (NEMA VE 1): 4" minimum
   6. Tray system shall not present sharp edges, burrs or projections injurious to wiring.
   7. Hardware, including splice connectors and support components, shall be furnished by tray manufacturer.
   8. Tray shall be UL classified for use as an equipment grounding conductor.
   9. Tray shall be designed to support volume capacity of cables and provide safe mechanical support for spans up to 8 feet (2.4 meters) on center. Tested load deflection data is available either in accordance with NEMA VE 1 or IEC 61537 standards
   10. Splice plates shall be bolted type made specifically for tray type provided.
      a. Splice plate construction shall be designed to permit splice location at any point within support span without diminishing cable tray rated loading capacity.

2.03 SUPPORT SYSTEM

A. Supports shall comply with product requirements defined in specification section 26 0529 - Hangers and Supports for Electrical Systems.
B. Flexible cordage/wire shall not be used.

2.04 ACCESSORIES

A. Special accessories shall be furnished as required to protect, support, and install cable tray system.
   1. Accessories include section splice plates, expansion plates, blind-end plates, specially designed ladder dropouts and barriers.

PART 3 - EXECUTION

3.01 GENERAL

A. Provide complete cable tray system, including straight tray sections, fittings, splice plates, and cable tray supports to support cable systems in locations, as indicated on drawings.
B. Comply with manufacturer’s recommended installation practices in addition to applicable standards and codes.
C. Completed installation shall present smooth surfaces and rounded edges with no burrs, projections or sharp edges that may prove injurious to installed wiring.

3.02 WIRE MESH

A. Cut wires in accordance with manufacturer’s instructions.
B. Cut wires with side action bolt cutters to ensure integrity of galvanic protective layer.
C. Cut each wire with one clean cut to eliminate grinding or touch-up.

3.03 INSTALLATION

A. Install metallic cable tray in accordance with NEMA VE 1 and VE 2.
B. Provide manufacturer's standard clamps, hangers, brackets, splice plates, reducer plates, blind ends, connectors, and grounding straps as required.
C. Provide blind end plates for trays that dead end.
D. Provide full-width dropouts (4" minimum bend radius) where cables exit from tray bottom.
E. Join cable tray system sections at ends using manufacturer prefabricated splice plates.
    1. No more than one cable tray splice shall be placed between support spans.
F. Tray system shall be accessible, with sufficient space provided about cable trays to permit side and top access for installation and maintenance of cables.
    1. Coordinate installation of cable tray to maintain clearance between cable tray and other trades work.
    2. Clearance shall be minimum 18" on at least one side, 12" on top and 6" below cable tray.
        a. Perpendicular crossings not meeting clearance above tray are acceptable, in lengths not to exceed 60".
        b. Where clearances defined above cannot be met, contractor shall provide 4" conduits in quantity equivalent to specified cable tray
    3. Tray shall not restrict removal of ceiling panels or lighting assemblies.
    4. Notify Engineer for clarification and direction before proceeding with installation if access conditions cannot be met.
G. Do not install cable tray below re-heat coils, VAV boxes, traps, or other building components that require access from below.
H. Refer to specification section 27 1000 - Structured Cabling for separation requirements from potential EMI sources.
I. Provide prefabricated expansion splice plates at intervals as defined in NEMA VE 2 and where cable tray systems cross building expansion joints.
J. Provide minimum of 1 expansion splice plate in straight runs which exceed 12 ft for tray installations in exterior areas.
K. Field fabricate fittings in accordance with manufacturer's instructions.
    1. Minimum inside radius of fittings shall approximate **[12-inch (300-mm)] [18-inch (450-mm)]** radius available using ladder-type cable tray.
L. Where cable tray would penetrate fire rated wall, stop tray at wall and fasten tray end to wall.
    1. Provide quantity of 4" sleeves cross sectional area equivalent to cable tray.
        a. Each sleeve shall maintain maximum of 40% cable fill ratio.
        b. Provide plastic bushings on both ends of each sleeve.
    2. Sleeves shall extend beyond both sides of fire rated wall as required to meet UL fire rated assembly requirements. Final assembly shall carry UL listing to maintain fire and smoke rating of wall penetrated.
    3. Provide UL listed grounding connectors and conductors to extend cable tray grounding path through wall penetration.
M. Where cable tray distribution system encounters inaccessible ceiling area, provide sufficient 4" EMT sleeves/conduit through area to maintain same available cross sectional area as cable tray.
    1. Each sleeve/conduit shall maintain maximum of 40% cable fill ratio.
N. Place barriers to obtain size of each raceway as noted on drawings.
O. Secure barriers into cable tray system using prefabricated barrier strip clips. Join barriers at ends using manufacturer prefabricated barrier strip splices.
P. Provide bolts and nuts in all holes of cable tray fittings per manufacturer's installation instructions.
Q. Cable tray systems shall be electrically continuous.

R. Nicks and scratches and ends of cut sections with galvanized coatings shall be coated, with approved coating that matches cable tray finish, after tray installation.

3.04 SUPPORT

A. Support cable tray system utilizing trapeze hangers from building or other structural steel members, angle brackets from vertical structural steel members, upright angle brackets on pipe racks, or directly upon horizontal structural steel members of the building or pipe racks.
   1. Center run hangers are not allowed.
   2. Cable tray may be wall mounted only in cases where trapeze mounting from above is not possible due to obstructions. Contractor shall review such situations with Engineer for approval prior to installation.

B. Supports shall be constructed from formed shape channel members 1.625" x 1.625", pre-galvanized 14 Ga. steel complete with nuts, bolts, washers, lock washers and tray clamps as required for complete and finished installation.
   1. Where formed mounting assemblies are part of manufacturer's integrated cable tray system, these may be used in compliance with manufacturers recommended practices.

C. Threaded rod used for tray support shall be 3/8" minimum diameter.

D. Size, anchor, and space supports to sustain weight of cable tray system, cable, and tubes that are to be installed into cable tray, and 200 lbs excess on any individual section, with safety factor of 1.5 minimum when supported as simple span and tested per NEMA requirements. Load and safety factors are applicable to all tray components.

E. Calculate supports based on 60 lbs/ft load of cables and tubes. Support spans shall not exceed manufacturer's recommendations.

F. Total vertical tray deflection shall not exceed 1-1/2" between supports when tray is loaded to capacity.

G. Include dynamic loads in calculations for outside area installations.

H. Maximum allowable deviation of tray, from level horizontal plane measured across width of tray, is one half of one inch (1/2") with tray loaded to capacity.
   1. Approval of installation method does not relieve contractor from meeting above deviation requirement. If additional support is needed, as determined by project engineer, contractor shall provide additional support at no additional cost

3.05 GROUNDING

A. Cable tray systems shall be electrically continuous.
   1. Bonding Jumpers shall be used between discontinuous tray sections as called for in manufacturer's installation guidelines to maintain grounding continuity of cable tray system.
   2. Grounding connections to tray shall be made using a UL listed mechanical connection.

B. Connect each cable tray system subassembly to building ground system using grounding clamps and grounding conductors. Provide 3.0 ohm maximum resistance to building ground connection.

C. Cable tray shall not be connected to instrumentation grounding system.

D. Bond conduits to cable tray as defined by NEC references in NEMA VE-1 and VE-2.

END OF SECTION

SECTION 270553
COMMUNICATIONS SYSTEMS IDENTIFICATION

PART 1 - GENERAL

1.01 SCOPE

A. This section details product and execution requirements for labeling of communications cabling, termination components, pathways and spaces for Communications Systems.

1.02 DESCRIPTION

A. All components shall be clearly labeled to identify them as unique throughout the project.
B. Labeling requirements include identification of Rooms, Equipment Racks, Telecommunications Outlets, Horizontal and Backbone Cabling, Termination Hardware (Patch Panels, Blocks) and Grounding.

1.03 RELATED WORK

A. Related Division 27 Sections include:
   1. Section 27 0000 - General Communications Requirements
   2. Section 27 0526 - Grounding and Bonding for Communications Systems
   3. Section 27 1000 - Structured Cabling
   4. Section 27 1100 - Communications Equipment Room Fittings
   5. Section 27 1300 - Communications Backbone Cabling
   6. Section 27 1500 - Communications Horizontal Cabling
B. Related sections in other Divisions of Work:
   1. Refer to individual technical sections identified above (if applicable).

1.04 REFERENCES AND STANDARDS

A. Refer to Section 27 0000 - General Communications Requirements which identifies pertinent References and Standards.
B. Other applicable references and standards include:
   1. TIA-606-C - Administration Standard for the Telecommunications Infrastructure of Commercial Buildings.

1.05 DEFINITIONS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which provide information on Definitions used in this and related sections.

1.06 ABBREVIATIONS AND ACRONYMS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which provide information on Abbreviations and Acronyms used in this and related sections.

1.07 WORK BY OWNER

A. Refer to Section 27 0000 - General Communications Requirements which identifies Work by Owner affecting sub-system(s) covered by this section.

1.08 SUBMITTALS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which provide general guidelines for product and/or installation information to be submitted by contractor.
B. Prior to installation, provide samples of label types planned for the project.
   1. Samples shall include examples of lettering to be used and shall follow standards detailed below.

1.09 QUALITY ASSURANCE

A. Refer to Section 27 0000 - General Communications Requirements which identifies general quality assurance requirements for the project.

PART 2 - PRODUCTS

2.01 GENERAL

A. Labels and markings shall be physically and chemically resistant to damage that would make label unreadable.
B. Cable labels shall be self-laminating, White/Transparent Vinyl (or other substrates facilitating easy application and flex as cables are bent) and incorporate an integrated clear lamination which covers printed part of label when label is wrapped around cable.
    1. If cable jacket is white, provide cable label with printing area that is a color other than white to easily distinguish label from cable jacket.
    2. Labels shall be of adequate size to accommodate circumference of cable(s) being marked and properly self-laminate over full extent of printed area of label.
    3. Labels on larger cables (e.g. Copper Backbone) may be wrapped with clear non-removable tape.
C. Labels shall use aggressive adhesives that stay attached even to the most difficult to adhere to jacketing. Tags shall be non-removable.
    1. Exceptions:
        a. Telecommunications Outlet labels that are placed in recessed label holders.
        b. Telecommunications Ground tags secured with cable ties.
        c. Innerduct Tags secured with cable ties.
D. Labels for 110-type Termination Blocks shall be Color-coded to indicate the cable type (inter-building, intra-building backbone, horizontal, etc.). Refer to Part 3.

PART 3 - EXECUTION

3.01 GENERAL

A. Labeling shall be by mechanical means.
    1. Hand lettered designations are not allowed.
B. Tags shall be non-removable.
    1. Exceptions:
        a. Telecommunications Outlet labels that are placed in recessed label holders.
        b. Telecommunications Ground tags secured with cable ties.
        c. Innerduct Tags secured with cable ties.
C. Characters shall be Black Ink and printed on background of contrasting color.
D. Labels shall match hardware layout and design.
E. Labels shall be as large as practicable while fitting properly.
F. No lettering shall be smaller than 10-point.
G. Label cables with tag which is wrapped around cable sheath.
    1. Clean cable sheath thoroughly before applying label.
    2. Labels shall not be obscured by termination hardware.
H. Label equipment mounted above ceilings (e.g. telecommunications outlets, consolidation points, ceiling-mounted enclosures) with label affixed to exposed side of ceiling components.
    1. Labels shall be viewable by individuals standing on finished floor level.
    2. Affix labels with label edges square with edges of ceiling component to which they are affixed.
    3. Where equipment is mounted within enclosure flush-mounted into ceiling structure with enclosure panel viewable from finished floor level, affix label:
        a. along exposed enclosure panel edge
        b. on smooth enclosure panel surface in location which does not interfere with enclosure panel operation.
    4. Where equipment is mounted above accessible ceiling structure (e.g. acoustic ceiling tile with exposed support grid):

a. affix label on smooth support grid element located adjacent to ceiling tile providing most direct access to equipment mounted above.
b. append and prepend label with arrow characters indicating which adjacent ceiling tile provides equipment access
1) ARROW CHARACTER FONT SIZE SHALL MATCH LABEL FONT SIZE
2) ARROW CHARACTERS SHALL BE SEPARATED FROM LABEL TEXT BY 2 BLANK SPACES

5. Where equipment is mounted above inaccessible ceiling structure, affix label:
a. along frame edge of access panel providing access through inaccessible ceiling.
b. on smooth access panel frame surface in location which does not interfere with access panel operation.

3.02 ROOM IDENTIFICATION

A. Label Communications Backboard or Equipment Rack closest to entry door with unique identifying code.
B. Characters shall be 1”minimum.

3.03 EQUIPMENT RACK IDENTIFICATION

A. Label each Equipment Rack with a unique identifying code as follows:
1. TR-##, where:
a. "TR" is identifier for room where rack is located
b. "##" is sequential number for rack starting at "01".
B. Position Labels at top of rack.
C. Characters shall be 1-inch minimum.

3.04 TELECOMMUNICATIONS OUTLET

A. Label each Telecommunications Outlet (TO) connector with unique identifying code.
B. Telecommunications Outlet connector numbering shall result in logical numbering sequence in work area.
1. Labeling plans that results in random TO numbering in work area are not acceptable.
C. Place Faceplate labels on outside of cover.
D. Position Labels in recessed label holders on faceplate and covered with clear plastic covers.
1. Where Communications Outlet Faceplates not incorporating recessed holders are allowed, faceplate labels shall be protected with clear laminate.
E. Telecommunications Outlet labeling code shall be as follows:
1. TR-RPP-##, where:
a. “TR” is identifier for room where cable terminates in horizontal cross-connect.
b. “R” is identifier for Equipment Rack where cable terminates
1) ALPHA CHARACTER STARTING AT “A”.
c. "PP" is Patch Panel on which cable is terminated at HC.
1) NUMBER STARTING AT “01”.
2) PANEL NUMBERING SHALL BE FROM TOP (OF RACK) TO BOTTOM.
d. "##" is sequential POSITION of Jack on Panel
1) 1 - 48 IS TYPICAL
2) POSITION SEQUENCE SHALL BE LEFT-RIGHT AND TOP-BOTTOM.
2. Example: "3W-A03-25" represents 25th Jack Position in 3rd Panel on Equipment Rack “A” in Telecom Room "3W".

a. Faceplate labels can use common TR identifiers on each label strip. For example, two data jacks served from TR 3W sharing common label strip may be represented by:

3W	
A01-25	A01-26

3.05 HORIZONTAL CABLING

A. Label each horizontal cable at Telecommunications Outlet and at horizontal cross-connect with unique identifying code.
B. Cable shall be labeled at both ends within 4" of cable choke (end of jacket).
C. Horizontal labeling code shall be same as identified for Telecommunications Outlet above.

3.06 MODULAR PATCH PANEL

A. Label each patch panel and port at horizontal cross-connect with unique identifying code.
B. Patch panel labeling code shall be same as identified for Telecommunications Outlet above.
C. Room number is not required on modular patch panels.
D. Equipment Rack number is not required on modular patch panels.

3.07 BACKBONE COPPER CABLE

A. Label each backbone cable at both ends at termination point with unique identifying code.
B. Label cable sheath:
   1. At point where sheath ends
   2. At point on cable where viewing of label is not obscured by termination blocks or other visual barrier.
C. Label shall be on plastic tag tie-wrapped to cable sheath, or placed on adhesive labels adhered to cable sheath.
   1. If adhesive labels are used, place clear plastic tape over label to protect it and maintain adhesion to sheath.
D. Label Intra-building cables with:
   1. From and to locations,
   2. Pair numbers
      a. Where multiple cables are installed between same end-points, labeling shall indicate sequential pair numbering.
         1) FOR EXAMPLE 400-PAIR PROVIDED AS TWO 200-PAIR CABLES WOULD BE LABELED "001-200" AND "201-400".
   3. Date installed.
      a. Example 200-pair cable from ER106 to TR3164 installed October 2009:

ER106-TR3164
001-200
10/2009

3.08 TERMINATION BLOCKS

A. Provide color-coded designation strips with Termination Blocks.
B. Label termination positions on designation strips with position identifier.
C. Horizontal Cabling Blocks shall incorporate BLUE Designation Strips and shall identify:
   1. Telecommunications Outlet / Jack I.D.s
D. Intra-Building (within building) Backbone Cabling Blocks shall incorporate WHITE Designation Strips.
   1. Label Designation Strips with:
      a. Cable Origin & Destination
         1) REPEAT ON EVERY DESIGNATION STRIP.

b. Pair Count.
1) LABEL 1ST AND 25TH POSITIONS ON EACH ROW (E.G. 001 & 025, 026 & 050, ETC.).

2. Example ER106 to TR3164:

001	ER106-TR3164	025
026	ER106-TR3164	050

E. Voice "Multiplier" Blocks shall incorporate YELLOW Designation Strips.
1. Label each designation strip with "Multiplier"
2. LABEL 25-PAIR ROWS IN 100-PAIR MULTIPLIER BLOCK AS "A" (1ST 25-PAIR). "B" (2ND 25-PAIR), "C" AND "D".
3. LABEL PAIR COUNT
A. LABEL 1ST BLOCK 001 - 025; LABEL 2ND BLOCK 025 - 050, ETC.
b. LAbel 1st and 25th Positions on each row (e.g. 001 and 025, 026 and 050, etc.).
4. Example:

A001	MULTIPLIER	A025
B001	MULTIPLIER	B025

C001	MULTIPLIER	C025
D001	MULTIPLIER	D025

F. Feed Blocks (from Access/Service Provider) shall incorporate GREEN Designation Strips.
1. Label Designation Strips with:
a. Designation as "FEED CABLE"
b. Pair Count.
2. Example (Verizon as Service Provider):

1201	FEED (VERIZON)	1225
1226	FEED (VERIZON)	1250

G. Telephone system Equipment Blocks shall incorporate PURPLE Designation Strips.
1. Label Designation Strips with:
a. Designation (e.g. System or Equipment Type)
b. Pair Count.
2. Example (PBX):

001	PBX	025
026	PBX	050

3.09 BACKBONE FIBER OPTIC CABLING

A. Label each backbone cable at both ends at termination point with unique identifying code.
B. Label shall be placed on adhesive labels adhered to cable sheath.
C. Label Intra-building cables with:
1. From and to locations,
2. Fiber type (core/cladding diameter)
3. Fiber count
a. Where multiple cable is installed between same end-points, labeling shall indicate sequential fiber numbering.
1) FOR EXAMPLE 144-FIBERS PROVIDED AS TWO 72-FIBER CABLES WOULD BE LABELED "001-072" AND "073-144".
4. Date installed.
5. Example 72-fiber cable from ER106 to TR3164 installed October 2009:

3.010 FIBER OPTIC PATCH PANELS

A. Label each fiber coupling in patch panel or workstation outlet with unique identifying code.
B. Patch panel labels shall be visible from front of panel without opening panel cover.
C. Place labels in manufacturer designated labeling areas.
D. Label Fiber Optic Patch Panels with unique labeling code to identify:
   1. Cable Destination
   2. Fiber type (core/cladding diameter)
   3. Fiber (or coupler) number of each panel position.
      a. Port I.D. shall be from Top to Bottom, Left to Right,
      b. Manufacturers port labeling is acceptable.
E. Label Fiber Optic Patch Panels with unique labeling code to identify:
   1. Patch panel number in rack
   2. Fiber (or coupler) number of each panel position.
      a. Port I.D. shall be from Top to Bottom, Left to Right,
      b. Manufacturers port labeling is acceptable.
F. Room number is not required on fiber optic patch panels.
G. Equipment Rack number is not required on fiber optic patch panels.

3.011 INNERDUCT

A. Innerduct containing fiber optic cable installed under this project shall be labeled where exposed.
   1. Includes areas where innerduct is installed in trays and in equipment rooms.
B. Label innerduct with durable Yellow Polyethylene tag that reads "CAUTION FIBER OPTIC CABLE"
   1. Tag shall provide blank spaces for adding fiber count and cable destination information.
C. Label Tag to include:
   1. Identifier(s) of cable(s) contained therein.
      a. Use Backbone Cable labeling formats as described above.
D. Hand lettering is acceptable on tag
   1. Use an indelible type ink.
E. Tag shall be secured to Innerduct using self-locking ties.

3.012 TELECOMMUNICATIONS GROUNDS

A. Label Grounds as close as practicable to point of termination.
B. Labels shall be non-metallic and include the following:

WARNING
IF THIS CONNECTOR OR CABLE IS LOOSE OR MUST BE REMOVED, PLEASE CALL THE BUILDING TELECOMMUNICATIONS MANAGER.

END OF SECTION

SECTION 27 1000
STRUCTURED CABLING

PART 1 - GENERAL

1.01 SCOPE

A. This section details product and execution requirements for Structured Cabling for Communications Systems.

1.02 DESCRIPTION

A. Systems shall include cabling, termination hardware and active components, installed as indicated on drawings and specifications.
B. Cables and equipment shall be provided, tested, and terminated, including proper grounding and bonding.

1.03 RELATED WORK

A. Related Division 27 Sections include:
   1. Section 27 0000 - General Communications Requirements
   2. Section 27 0526 - Grounding and Bonding for Communications Systems
   3. Section 27 0528.29 - Hangers and Supports for Communications Systems
   4. Section 27 0528.33 - Raceway and Boxes for Communications Systems
   5. Section 27 0528.36 - Cable Tray for Communications Systems
   6. Section 27 0553 - Communications Systems Identification
   7. Section 27 1100 - Communications Equipment Room Fittings
   8. Section 27 1300 - Communications Backbone Cabling
   9. Section 27 1500 - Communications Horizontal Cabling
B. Related sections in other Divisions of Work:
   1. Refer to individual technical sections identified above (if applicable).

1.04 REFERENCES AND STANDARDS

A. Refer to Section 27 0000 - General Communications Requirements which identifies pertinent References and Standards.
B. In addition:
   1. TIA 568.0-D through.4-D - Commercial Building Telecommunications Cabling Standard (including applicable Addenda)
   2. TIA 569-E598 - Commercial Building Standard for Telecommunications Pathways and Spaces.
   3. BICSI Telecommunications Distribution Methods Manual (TDMM)
   4. TIA-598-D: Optical Fiber Cable Color Coding.
   5. TIA 455-21-A: Mating Durability for Fiber Optic Interconnecting Devices
   6. TIA 526-14-C: Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant
   7. TIA-526-7-A: Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
   8. UL-910: Tests for Flame Propagation and Smoke-Density Values for Electrical and Optical-Fiber Cables used in Spaces Transporting Environmental Air
   9. UL-1666: Tests for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts
   10. IEEE 802.3af and 802.3at Power-over-Ethernet Standards.
   11. IEEE 802.3an 10 Gigabit Standard

1.05 DEFINITIONS

A. Refer to Section 27 0000 - General Communications Requirements for general terminology used in Division 27 sections.

B. In addition, the following definitions are applicable to communications environments and shall apply to this document and its companion sections for clarification and direction:
   1. Backbone Cabling - cable or conductors between telecommunications rooms, or floor distribution terminals, entrance facilities, and equipment rooms within or between buildings. Backbone cabling may be twisted pair copper, fiber optic or coaxial.
   2. Cable - assembly of 1 or more conductors or optical fibers within enveloping sheath, constructed so as to permit use of conductors singly or in groups.
   3. Cable ID - unique alpha-numeric identification used for tagging of backbone or horizontal cabling.
   4. Channel - end-to-end transmission path to which application-specific equipment is connected. Same as "Permanent Link", but also includes patch cords at Telecommunications Outlet and in Telecom Room.
   5. Consolidation Point (CP): A location for interconnection between horizontal cables extending from the horizontal cross-connect and horizontal cables extending to the telecommunication outlet at the workstation.
   6. Contractor: Telecommunications Contractor or sub-contractor(s) responsible for installation, termination, test and documentation of communications cabling, termination components, pathway hardware, telecommunications equipment room hardware and related components detailed in technical sections of this Division of work.
   7. Cross-Connect - group of connection points between cabling runs and/or equipment used to administer building wiring using patch cords or wire jumpers.
   8. Horizontal Cabling - Cables connecting Telecommunications Outlets to horizontal or intermediate cross-connect. Sometimes referred to as "Station Cabling".
   9. Horizontal Cross-connect (HC) – Connection of horizontal cabling to other cabling (e.g. horizontal, backbone or equipment) using patch cords or wire jumpers.
   10. Interconnection - Connection scheme using connecting hardware for the direct connection of a cable to another cable without a patch cord or jumper
   11. Main Cross-connect (MC) – Connection between backbone cables, entrance cables and equipment cables using patch cords or wire jumpers.
   12. Outlet ID - unique alpha-numeric identification used for referencing Telecommunications Outlet or connectors therein.
   13. Permanent (Cable) Link - includes Telecommunications Outlet, horizontal (station) cable and termination hardware in Telecom Room.
   14. Service Loop - Surplus cable, typically located at or near point of termination to enable future changes.
   15. Telecommunications Outlet (TO) - device assembly located in work area on which horizontal cabling terminates and which can receive modular connectors. It is interface between Station Cable and end user's equipment.
   16. Telecom Room - an enclosed space for housing telecommunications equipment, horizontal and backbone cable terminations, and cross-connect cabling, that is recognized location of horizontal cross-connect.
   17. Zone Box - An enclosure used to house one or more of the following; a) a consolidation point, b) a horizontal connection point, c) building automation system outlets.
   18. Zone Cabling - Extends permanent horizontal cabling to a shared termination (consolidation) point in the work area. Passive system extends link to workstation through at interconnect at the Consolidation Point (CP). Active system includes system electronics at the CP.

C. “10-gigabit” or “10G” performance criteria, if applicable, refers to support of 10GBASE-T application over 4-connector channel up to 100 meters and meeting requirements of TIA-568-C.2.

1.06 ABBREVIATIONS AND ACRONYMS

A. Refer to Section 27 0000 - General Communications Requirements for general terminology used in Division 27 sections.

B. In addition, the following abbreviations and acronyms shall apply to this document and its companion sections for clarification and direction:

1. 8P8C Eight-Position, Eight-Conductor. Used in clarifying jack type; a.k.a. "RJ-45".
2. CM Communications cable rated for General Purpose use
3. CMP Communications cable rated for use in Plenum areas
4. CMR Communications cable rated for use in Risers and vertical runs
5. CP Consolidation Point
6. ELFEXT Equal-Level Far-End Cross Talk (pair-to-pair)
7. FEXT Far-End Cross Talk
8. F/UTP Foiled Unshielded Twisted Pair

   No shielding around individual pairs and an overall foil shield under the cable jacket
9. HC Horizontal Cross-connect
10. HCP Horizontal Connection Point (e.g. for TIA-862)
11. IDF Intermediate Distribution Frame
12. MC Main Cross-connect
13. MDF Main Distribution Frame
14. MPTL Modular Plug Terminated Link
15. N Newton
16. NEXT Near End Cross Talk
17. OFNP Optical Fiber Nonconductive Plenum
18. OFNR Optical Fiber Nonconductive Riser
19. OTDR Optical Time Domain Reflectometer
20. PBX Private Branch Exchange (Telephone Switch)
21. PoE Power-over-Ethernet
22. PSNEXT Power Sum Near End Cross Talk
23. S/FTP Screened Foiled Twisted Pair

    (Individual foil shield around each individual pair and an overall braided shield under the cable jacket.)
24. S/UTP Screened Unshielded Twisted Pair

    (No shielding around individual pairs and an overall braided shield under the cable jacket.)
25. SF/UTP Screened Foiled Unshielded Twisted Pair

    (No shielding around individual pairs and overall foil and braided shields under the cable jacket.)
26. TO Telecommunications Outlet
27. TR Telecommunications Room
28. USOC Universal Service Order Code
29. UTP Unshielded Twisted Pair

    (No shielding around pairs nor overall under cable jacket.)
30. U/FTP Unshielded Foiled Twisted Pair

    (Individual foil shield around each individual pair and no overall braided shield under the cable jacket.)

1.07 WORK BY OWNER

A. Refer to Section 27 0000 - General Communications Requirements which identifies Work by Owner affecting sub-system(s) covered by this section.

1.08 SUBMITTALS

A. Refer to Section 27 0000 - General Communications Requirements which provides general guidelines for product or installation information to be submitted by Contractor.

B. In addition, Submit:

1. Contractor Certification documents which document their participation in Installers Program operated by Manufacturer of Cabling or Termination Components used.
    a. Upon request, Certified Installer(s) assigned to Project shall be identified to Engineer.
2. Meeting agenda for Pre-Construction Coordination Meeting

1.09 QUALITY ASSURANCE

A. General:

1. Cable and Equipment Manufacturer(s) shall be company specializing in communications cable, accessories and/or equipment with minimum of 5 years documented experience in producing cable, accessories and/or equipment similar to those specified herein.

B. Contractor Qualifications:

1. Qualified personnel utilizing state-of-the-art equipment and techniques shall complete cable and equipment installation and termination.
2. Contractor shall have been in this business for minimum of 5 years and shall have successfully completed **[4] [quantity]** projects **[equal in] [50% of]** magnitude of system specified in the following sections.

C. Contractor shall have necessary certifications to provide for Warranty as specified herein.

1. Contractor shall be an active participant in Installers Program operated by Manufacturer of Cabling or Termination Components used.
    a. Contractor shall be participant in this program at time of Bidding and remain so throughout project.

1.010 GUARANTEE

A. Refer to Division 01, General Conditions, and General Requirements - Guarantee Documents and Section 27 0000 - General Communications Requirements for general guarantee requirements.

B. Warranty structured cable system as follows:

1. 4-pair Category-rated Horizontal Copper Permanent Link for no-less than 20 years from date of substantial completion of work.
2. Copper Backbone for no-less than 2 years from date of substantial completion of work. Cabling and Connecting Components shall carry 20 yr component warranty.
3. Fiber Optic Backbone for no-less than 20 years from date of substantial completion of work.

C. Warranty shall be direct from manufacturer(s) of cabling and connecting components to Owner.

PART 2 - PRODUCTS

2.01 GENERAL

A. Refer to individual Technical Sections.

2.02 POWER OVER ETHERNET

A. All cable and connecting components that comprise the TIA horizontal cabling “Permanent Link” from Horizontal Cross-connect to Telecommunications Outlet shall be compliant with the applicable requirements for “DTE Power via the MDI” to provide at least 25.5Wat the Powered Device as defined by the IEEE 802.3at standard.

B. Connecting hardware shall comply with IEC 60512-99-001 for engaging and separating connectors under electrical load and connectors used in twisted pair communication cabling with remote power.

2.03 SYSTEM REQUIREMENTS

A. Structured cabling products shall be designed to work together as a fully-warranted system.

B. Acceptable Category 6 systems shall be:
   1. Belden REVConnect 2400
   2. CommScope SYSTIMAX GigaSPEED XL
   3. Leviton CX6200 Cat 6 Premium UTP System
   4. Panduit Enhanced Category 6 System (Panduit cable only)
   5. Siemon Premium 6 Z-MAX
C. Acceptable Category 6A systems shall be:
   1. Belden REVConnect 10GX12
   2. CommScope SYSTIMAX GigaSPEED X10D
   3. Leviton CX6700 Cat 6A Enhanced+ UTP System
   4. Panduit Category 6A MaTriX system (Panduit cable only)
   5. Siemon Z-MAX 6A

PART 3 - EXECUTION

3.01 PRE-CONSTRUCTION COORDINATION MEETING

A. Prior to preparing and submitting submittals, Contractor shall arrange and conduct a pre-construction coordination meeting to review and coordinate Structured Cabling requirements.
   1. Attendees shall include:
      a. Owner’s project manager and Information Technology / Information Services representative(s)
      b. Coordinate group names above to match names used for each project/client.Division 27 Engineer
      c. Construction Manager / General Contractor project manager and site superintendent / field foreman
      d. Division 27 project manager and site superintendent / field foreman
      e. Structured Cabling contractor project manager and site superintendent / field foreman, if different from Division 27 personnel
      f. Division 26 project manager and site superintendent / field foreman
   2. Meeting agenda topics shall include:
      a. Review and coordinate details of Structured Cabling scope, including:
         1) CABLE LABELING SCHEMES
         2) DIMENSIONED TELECOM ROOM LAYOUTS
         3) TELECOM RACK LAYOUTS DIMENSIONED IN RACK UNITS
         4) COLOR SCHEMES FOR:
            A) TELECOM OUTLET CABLING
            B) TELECOM OUTLET JACKS
            C) TELECOM OUTLET FACEPLATES
         5) WIRELESS ACCESS POINT TELECOM OUTLET REQUIREMENTS
      b. Coordinate division of work among trades.
      c. Review construction schedule and identify milestones related to Structured Cabling including telecom room turnover dates, test results submittal.
   3. Schedule meeting with minimum two weeks’ notice.
      a. Publish agenda for meeting and distribute to invited attendees when meeting is scheduled.
   4. Contractor shall take detailed notes during meeting and publish meeting notes within one week after meeting.
      a. Contractor shall distribute notes to invited attendees and Architect.

3.02 GENERAL

A. Refer to individual technical specification sections for detailed Cable Routing and Installation, Testing and Documentation requirements. The following apply to communications cabling and termination work.
B. Installation shall be per manufacturers' recommendations.
C. Label cables and termination components per Section 27 0553 - Communications Systems Identification.

3.03 CABLE INSTALLATION

A. Run cabling in raceways provided, or as designated on floor plans, and support from building structure.
   1. Where installed in free-air, support cables using J-hook type cable supports installed in accordance with manufacturer’s installation requirements. Refer to Section 27 0528.29 - Hangers and Supports for Communications Systems for installation requirements.
      a. J-hook fill capacities shall be per manufacturer’s recommendations and shall consider diameter of cable type(s) being installed.
      b. Route cable/hooks at right angles, parallel to construction.
   2. Where installed in Cable Tray, lay cables neatly in tray.
      a. Do not tie.
      b. Provide sufficient slack in cables to allow for unequal expansion coefficients of cable tray and cables. This requirement is in addition to slack required at cable tray expansion joints.
B. Route and support cable in Equipment Rooms and Telecom Rooms utilizing "D-type" mounting rings, J-hooks and overhead cable runway.
C. Cable shall be free of tension at both ends.
   1. In cases where cable must bear stress, provide Kellems grips to spread stress over longer length of cable.
D. Provide required installation tools to facilitate cable pulling without damage to cable jacket.
E. Keep cables clear of other trades work.
F. During pulling operation provide an adequate number of workers to allow cable observation at points of raceway entry and exit, as well as to feed cable and operate pulling machinery.
G. Pull cables in accordance with cable manufacturer's recommendations and ANSI/IEEE C2 Standards.
H. Pull cable by hand unless installation conditions require mechanical assistance.
I. Do not exceed recommended pulling tensions and bending radii.
   1. Where mechanical assistance is used, ensure that maximum tensile load for cable is not exceeded.
      a. This may be in form of continuous monitoring of pulling tension, use of "break-away" or other approved method.
   2. Replace cables bent or kinked to radius less than recommended dimension.
      a. This shall be at no expense to Owner.
J. Install cables splice-free unless otherwise specified.
K. Avoid abrasion and other damage to cables during installation.
   1. Visually inspect cables for cuts, blisters and abrasions during installation.
L. Pulling lubricant may be used and shall:
   1. Be non-injurious to cable jacket and other materials used.
   2. Not harden or become adhesive with age.
M. Repair damage to interior spaces caused by installation of cable, raceway or other hardware. Repairs must match preexisting color and finish of walls, floors and ceilings.
N. Replace contractor-damaged ceiling tiles to match color, size, style and texture.
O. Provide pull cord (200 lb minimum) with cable installed in conduit or innerduct.
P. Neatly lace, dress and support cabling.

Q. In vertical pathway, support cables on each floor using industry recognized support methods designed specifically for that purpose.
   1. Strap vertical runs as required, to prevent sagging of cables.
R. To reduce effects of EMI, adhere to the minimum cable separation distances defined in TIA-569-E.

3.04 FIELD TESTING

A. Refer to Section 27 0000 - General Communications Requirements for general guidelines regarding requirements for scheduling and performing compliance testing.
B. Cabling shall be 100% fault free unless otherwise noted. If any Link is found to be outside specification defined herein, identify and correct problem up to and including replacement of cable and associated termination(s). Then repeat applicable tests.
C. Test each cabling sub-system (e.g. backbone, horizontal, etc.) end-to-end.
D. Where sub-systems are to be interconnected or cross-connected by the contractor, test individual sub-system followed by a test of the connected links
   1. Performance and documentation requirements shall default to the lesser of the two connected systems if different.
   2. Example 1: Combined Backbone-Horizontal Link
      a. Test and document individual Backbone and Horizontal Cabling Sub-systems.
      b. Cross-connect sub-systems.
      c. Repeat testing on combined cabling from MC - TO through HC.
      d. Performance and documentation requirements shall be based in this example on backbone cabling (continuity, pair integrity, etc.).
   3. Example 2: Interconnected Zone Cabling Link
      a. Test and document individual HC – CP links.
      b. Install interconnect cabling CP – TO
      c. Repeat testing on combined cabling from HC – TO through CP.
      d. Performance and documentation requirements shall be based in this example on TIA Permanent Link for Horizontal Cabling.
E. Test instrument shall be configured using template for exact cable under test (e.g. by manufacturer product designation).
   1. If no template is available, enter cable parameters for the cable per manufacturer's product data.
      a. Nominal Velocity of Propagation (NVP) used for copper cable type under test shall be traceable to manufacturers' product data.
      b. Refractive Index used for fiber optic cable type under test shall be traceable to manufacturers' product data.
   2. Test results obtained using incorrect cable parameters will be rejected.
F. Test instrument shall be calibrated as defined by instrument manufacturer at least once every 12 months**.**
   1. Test instrument calibration date shall be present in test results documentation.
G. Refer to individual Technical Sections for system-specific guidelines regarding requirements for scheduling and performing compliance testing.

3.05 DOCUMENTATION

A. Refer to Section 27 0000 - General Communications Requirements for general guidelines regarding requirements for project Documentation.
B. Refer to individual Technical Sections for system-specific guidelines regarding requirements for project Documentation.
C. Information added by Contractor to Record Drawings shall include:
   1. Backbone and horizontal cable routes

2. Telecommunications outlet locations and identification
3. Other detail necessary to document cable installation

3.06 OWNER TRAINING

A. Provide training for Owner's personnel on operation and maintenance of total system and each component.
B. Training to include:
   1. Overview of System Topology and General Concepts
   2. Overview of Product Used
   3. Overview of Equipment Room Layouts
   4. Overview of Labeling Formats
   5. Overview of Test Results and their meaning
   6. Overview of Documentation
C. Training shall be held at **[Project Site][Other]** and shall be conducted during normal working hours.
D. Training session duration shall be not less than one (1) h.
   1. Provide (1) such sessions.
   2. Coordinate with owner to schedule session(s). Provide adequate notification to allow owner to schedule staff.
E. Attendance shall be by owner staff and/or contract maintenance personnel**.**
   1. Number of Students per session shall be 6.
   2. Materials shall be provided for the number of students indicated.
F. Provide example course materials and instructor background in advance of training session(s).
G. Owner may videotape session(s) for use as future refresher materials for owner technical staff.

END OF SECTION

SECTION 271100
COMMUNICATIONS EQUIPMENT ROOM FITTINGS

PART 1 - GENERAL

1.01 SCOPE

A. This section details product and execution requirements for Communications Equipment Room Fittings for Communications Systems.

1.02 DESCRIPTION

A. Communications Equipment Room Fittings include:
   1. Cabinets, Racks, Frames and Enclosures
   2. Cable Runway
   3. Termination Blocks
   4. Patch Panels
   5. Power Strip/Surge Suppressor

B. Refer to Project Drawings for Equipment Room layout and equipment placement.

1.03 RELATED WORK

A. Refer to Section 27 0000 - General Communications Requirements which identifies related specification sections in this and other Divisions (if applicable).

1.04 REFERENCES AND STANDARDS

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

B. Related Division 27 Sections include:
   1. Section 27 0000 - General Communications Requirements
   2. Section 27 0526 - Grounding and Bonding for Communications Systems
   3. Section 27 0528.29 - Hangers and Supports for Communications Systems
   4. Section 27 0528.33 - Raceway and Boxes for Communications Systems
   5. Section 27 0528.36 - Cable Tray for Communications Systems
   6. Section 27 0553 - Communications Systems Identification
   7. Section 27 1000 - Structured Cabling
   8. Section 27 1300 - Communications Backbone Cabling
   9. Section 27 1500 - Communications Horizontal Cabling

C. Related sections in other Divisions of Work:
   1. Refer to individual technical sections identified above (if applicable).

1.05 DEFINITIONS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which provide information on Definitions used in this and related sections.

1.06 ABBREVIATIONS AND ACRONYMS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which provide information on Abbreviations and Acronyms used in this and related sections.

1.07 WORK BY OWNER

A. Refer to Section 27 0000 - General Communications Requirements which identifies Work by Owner affecting sub-system(s) covered by this section.

1.08 SUBMITTALS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which provide general guidelines for product or installation information to be submitted by Contractor.

1.09 QUALITY ASSURANCE

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which identify general quality assurance requirements for the Project.

1.010 GUARANTEE

A. Refer to Division 01, General Conditions, and General Requirements - Guarantee Documents for general warranty requirements.
B. Refer to Section 27 1000 - Structured Cabling for particular Warranty requirements for Structured Cabling. Those requirements apply to cable and components covered in this section.

PART 2 - PRODUCTS

2.01 CABINETS, RACKS, FRAMES AND ENCLOSURES

A. Manufacturers: Hoffman, CPI, Ortronics, Panduit, Damac or Siemon
B. Equipment racks shall be:
    1. Constructed of painted aluminum
    2. Color Black
    3. Supplied with ground bar (19” wide by 1” high) and #6 AWG ground lugs
    4. Supplied with minimum of 12 releasable cable support ties (e.g. "hook and loop")
    5. Supplied with spare screws (minimum of 50)
    6. Configured with Channel uprights spaced to accommodate industry standard 19” mounting
C. Free Standing Equipment Rack shall comply with general requirements above and shall:
    1. Be 84” in height
        a. Have minimum of 45 usable rack mounting units (RU)
    2. Be self-supporting
    3. Have Minimum base footprint of 15” x 20”
    4. Be double-sided drilled and tapped to accept 12-24 screws
        a. Uprights shall be drilled on back to accept cable brackets, clamps, power strip(s).
        b. Hole pattern on rack front and back shall be per EIA/TIA specifications (5/8” – 5/8” – 1/2”).
D. Cable Management
    1. Manufacturers: Hoffman, CPI, CommScope, Ortronics, Panduit or Siemon
    2. Horizontal Cable Management Panels shall:
        a. Be painted steel
        b. Be 3.5” high
        c. Have minimum of 5 distribution rings (3.75” x 3.75” minimum dimension)
            1) DISTRIBUTION RINGS SHALL BE PLASTIC.
        d. Incorporate cable routing guides and supports on rear of panel.
    3. Vertical Cable Management shall:
        a. Provide for cable routing on front and rear of each rack
        b. Be 8” wide (minimum) when installed between two racks
        c. Be 8” wide when installed at end of rack row
        d. Mount on spacers attached to rack uprights and not on upright
        e. Be accessible from front and rear of rack
        f. Be designed to space slots/fingers at 1 RU intervals to align with rack-mounted equipment
E. Equipment Rack Ground Busbar
    1. Material: Copper
    2. Mounts horizontally in rack.
    3. Mounting configuration EIA universal mounting hole pattern , tapped #12-24.
F. Miscellaneous
    1. Releasable Cable Support Ties shall be:

a. Hook & Loop type
b. Individual units with latch
1) ROLL OF HOOK & LOOP MATERIAL IS NOT ACCEPTABLE.

2.02 CABLE RUNWAY

A. Manufacturers: CPI, B-Line
B. Cable Runway shall:
1. Be constructed of 0.065” thick steel
2. Utilize tubular stringers to support rungs.
a. Stringers shall be 1-1/2” high.
b. Rungs shall be welded to stringers and shall be spaced 9” on center.
3. Be painted with black epoxy
C. Runway width(s) shall be as shown on drawings.

2.03 TERMINATION BLOCKS

A. Manufacturers: Refer to System Requirements list in 27 1000
B. Blocks shall be 110-style high-density cross-connect blocks.
C. Each horizontal row of block shall be capable of terminating one 25 pair binder group of Backbone Copper Cable, or six 4 pair Copper Cables.
D. Mechanical termination on blocks shall:
1. Have ability to terminate 22-26 AWG plastic insulated, solid and stranded copper conductors.
2. Provide direct connection between horizontal or backbone cable and jumper wires.
3. Be designed to maintain cable pair twists as closely as possible to point of mechanical termination.
E. Blocks for Horizontal Cabling shall use 4-pair connecting blocks; blocks for backbone cabling shall use 5-pair connecting blocks.
1. Blocks shall identify pair position by color designation.
a. Colors shall be Blue, Orange, Green and Brown for Horizontal Cables.
b. Colors shall be Blue, Orange, Green, Brown and Slate for Backbone Cables.
c. Markings shall designate Tip and Ring conductors.
F. Backbone Voice Blocks shall:
1. Be wall-mounted with legs
2. Meet or exceed TIA Category 3 performance criteria
3. Terminate up to 100 pairs (each block)
G. System Terminal Blocks shall:
1. Be wall-mounted with legs.
2. Meet or exceed TIA Category 3 performance criteria.
3. Terminate up to 100 pairs (each block).
4. Be pre-wired in 5-pair increments utilizing 25-pair tails wired to each base.
a. Tail length shall be 6”.
b. Tails shall be terminated in male 50-pin telco (“Amphenol” or “RJ-21”) connectors.
c. Tails shall exit from bottom of block.
d. Blocks shall be factory tested.
e. Factory terminated cables shall utilize 5-pair connecting blocks with standard Backbone Voice Cable color designation.
H. Horizontal Cable Managers (Jumper Troughs) designed for use with blocks shall be:
1. Manufactured with high-strength, flame-retardant thermoplastic
2. Designed for easy cable insertion or withdrawal
3. 2 RUs high
4. Rack- or wall-mountable (with legs) to match block configuration

I. Horizontal Cable Managers designed for use at top of column of blocks shall be 188B type. 188B type cable manager shall:
   1. Be constructed of metal with two plastic distribution rings
   2. Have legs to allow space for routing cables behind Backboard
   3. Have dimensions 6.5” high x 10.7” wide

J. Vertical Cable Managers for wall-mounted Termination Blocks shall utilize distributing rings.
   1. Rings shall be metal and be split to facilitate passage of jumper wires.
   2. Minimum Dimension of each ring shall be 5” square (minimum).

2.04 MODULAR PATCH PANELS

A. Manufacturers: Refer to System Requirements list in 27 1000

B. Panels shall:
   1. Consist of Modular-to-IDC connector system
   2. Be rack-mountable in standard EIA 19” equipment racks
   3. Be 2 RUs high
   4. Accommodate 48-port modular jacks in two rows of 24-ports
   5. Be designed to terminate 4-pair, 100-Ohm UTP cables
   6. Have ability to terminate 22-26 AWG plastic insulated, solid and stranded copper conductors.
   7. Be designed to maintain cable's pair twists as closely as possible to point of mechanical termination.
   8. Have cable support and strain relief devices to secure cables at IDC connector.
      a. Panel and cable support hardware shall ensure that cabling minimum bend radius requirements are satisfied.
   9. Have port identification numbers on both front and rear of panel.
   10. Have color-coded pair designations on rear of panel.

C. Modular Jacks in Panel shall:
   1. Be non-keyed, 8 position, 8-conductor (8P8C)

D. Panels shall meet or exceed TIA Category 6 performance criteria.

2.05 FIBER OPTIC PATCH PANELS

A. Manufacturers: Corning, Siemon, Panduit or Ortronics.

B. Patch Panels shall:
   1. Be enclosed assemblies
   2. Incorporate hinged or retractable front cover
   3. Be rack mountable on standard TIA 19” equipment racks
   4. Provide for strain relief of incoming cables
   5. Incorporate radius control mechanisms to limit bending of fiber to manufacturer's recommended minimums of 1.2”, whichever is larger
   6. Provide protection to both "facilities" and "user" sides of couplings.
   7. Be configured to require only front access when patching
   8. Incorporate patch cable routing space internal to patch panel enclosure.
      a. Routing space shall be front-accessible.
   9. Include provisions for permanent labeling of fiber optic cables.
      a. Labeling shall be accessible from front of patch panel and shall not require disassembly of patch panel enclosure or removal of front cover.

C. Couplings shall be mounted on assembly that snaps into patch panel enclosure.
   1. This assembly shall be designed to accept variety of coupler types including, ST, SC, duplex SC and high-density mini-connectors.
   2. Coupling type shall be duplex LC
   3. Coupling Color shall be as follows:

a. Multimode: BEIGE
1) EXCEPTION: LASER-OPTIMIZED 50/125 MULTIMODE COUPLINGS SHALL BE AQUA
b. Single-mode: BLUE

D. Access to inside of panel enclosure during installation shall be from front and rear.
1. Panels that require disassembly of cabinet to gain entry will not be accepted.

E. Incoming cables shall not be accessible from patching area of panel.
1. Enclosure shall provide physical barrier to access of such cables.
2. Where factory-terminated cable assemblies ("pigtails") are spliced to cable, enclosure shall incorporate hardware for securing of splice tray and required cable, buffer tube and pigtail slack.

2.06 POWER STRIP/SURGE SUPPRESSOR

A. Manufacturers: CPI, Hubbell, Ortronics, Wiremold
B. Power Strip/Surge Suppressor shall:
1. Be rack mountable in 19” equipment racks
2. Provide Transient suppression to 13,000 A
a. Protection shall be in 3 modes (hot-neutral, hot-ground and neutral-ground)
3. Provide High Frequency Noise Suppression:
a. >20-dB @ 50-kHz
b. >40-dB @ 150-kHz
c. >80-dB @ 1-MHZ
d. >30-dB @ 6 to 1000 MHZ
4. Provide minimum of 320 Joules of AC energy absorption
5. Be equipped with minimum 12 ft power cord
6. Be rated for 20A load at 120V
C. Horizontally mounted suppressors shall be equipped with minimum 6 receptacles.
1. Minimum 2 receptacles shall be spaced to accommodate transformers.
D. Vertically mounted suppressors shall be equipped with minimum 10 receptacles.
1. Suppressor shall be maximum 48” long.

PART 3 - EXECUTION

3.01 GENERAL

A. Refer to project Drawings for communications equipment room layout and equipment placement.
B. New communications equipment rooms must be free from dust, dirt, and other foreign materials before installation of any termination hardware or termination of copper or fiber optic cables.
1. Door to room must be closed during termination if area outside room is not dust-free.
C. Follow manufacturer’s recommended installation and termination practices.
D. Provide necessary assistance to allow Owner or Carrier personnel to establish service on new cable system.
1. Includes general wiring overview, cable pair identification, and cross connect documentation (if applicable).

3.02 EQUIPMENT RACKS AND CABLE MANAGEMENT

A. Provide equipment racks as shown on project Drawings.
B. Assemble racks per manufacturer’s recommendations. Remove paint at the point(s) of contact of assembly hardware or use internal-external tooth lock washers to pierce paint to maintain ground continuity.
C. Bolt racks to floor.
D. Secure racks to cable runway as described below.

E. Provide Horizontal and Vertical Cable Management in equipment racks per project Drawings
   1. Ground bar and #6 AWG Ground lug,
   2. Minimum of fifty (50) 12/24 mounting screws,
   3. Minimum of twelve (12) releasable (e.g. "hook & loop") cable support ties.
F. Bond each rack mounted ground bar to telecommunications ground bus bar (TGB).
   1. Use #6 AWG or larger copper conductor (green jacket).

3.03 CABLE RUNWAY

A. Provide cable runway and accessories necessary for complete system.
B. Size and layout of cable runway shall be as shown on project Drawings.
C. Install above equipment racks at 7’-6”.
D. Align with equipment racks as shown on drawings
E. Brace to racks with support brackets made by runway or rack manufacturer intended for this purpose.
F. Use radius drops where cables drop from tray to rack and at elevation changes of 6” or more.
G. Maximum allowable deviation of runway from level horizontal plane measured across length of cable runway shall be 1/2”, with tray loaded to capacity.
H. Where cable runway is supported from building structure:
   1. Provide 3/8” threaded rods for support of 12” wide or smaller runway.
   2. Provide 1/2” threaded rods for support of runway greater than 12” in width.
I. Bond runway components together using manufacturer's standard accessories.
J. Fasten cables to runway at intervals not to exceed 4 ft.

3.04 TERMINATION BLOCKS

A. Provide blocks to accommodate an additional 20% growth at each location.
B. Terminate Backbone Voice Cables on termination blocks.
   1. Strip lengths & termination of all cabling to be per manufacturers recommendations.
C. Provide 110 blocks as follows:
   1. Backbone Voice Cabling at horizontal cross-connect in wall-mounted patch field.
   2. Backbone Voice Cabling at main cross-connect in wall-mounted patch field.
   3. System Terminal Blocks at main cross-connect in wall-mounted patch field.
D. Install Blocks:
   1. No higher than 72” AFF to top-most block
   2. Top to bottom, left to right beginning no closer than 12” from left wall
E. Provide horizontal troughs between each termination block.
F. Provide horizontal troughs at top of each block column.
G. Provide vertical managers to right and left of each block column.
H. Cabling entering and exiting fields shall be neatly laced, dressed and supported.
I. Contractor shall be responsible for jumper wiring between horizontal and backbone cabling.
J. Provide System Terminal Blocks as shown on drawings.
   1. Contractor shall not be responsible for jumper wiring between System Terminal Blocks and Backbone Voice Cable Blocks.
   2. Contractor shall not be responsible for connection of 50-pin telco connectors to Owner furnished telephone equipment.
K. Provide Feed Blocks as shown on drawings.
   1. Connect Feed Blocks to Carrier Demarcation (DEMARC).

3.05 MODULAR PATCH PANELS

A. Provide panels per project documents.
B. Mount patch panels in 19” equipment racks.
C. Position cables in sequence of:
   1. Telecommunications Outlet ID for horizontal cabling

2. Pair number for backbone cabling

D. Terminate cables using 568B wiring standard.
E. Provide horizontal management above and below each patch panel.
F. Provide minimum of 4 screws to secure each patch panel onto rack.

3.06 FIBER OPTIC PATCH PANELS

A. Provide Fiber Optic Patch Panels and coupling assemblies as shown on drawings.
   1. Provide minimum of 4 screws to secure each patch panel onto rack.
B. Provide couplings in coupling assemblies and mount coupling assemblies and blank covers in patch panels.
C. Position fibers consecutively - starting with lowest number - and mapped "position for position" between patch panels.
   1. There shall be no transpositions in cabling.
D. Keyways on duplex couplings shall be oriented to establish "cross-over" in cabling system.
   1. Convention defined by TIA-568-C.0 (Annex B, Section B.3.2) shall be used.
   2. Reverse-pair positioning shall not be used.
E. Provide blank covers for unused coupling assembly spaces in panels.
F. Follow manufacturer's guidelines for connector type(s) provided.
   1. Clean connectors with specialized dry-cleaning product from Fluke or Cletop.
G. Provide dust caps for couplings.
H. Where factory-terminated cable assemblies ("pigtails") are spliced to cable, prepare and splice cables and fibers per manufacturers' guidelines.

3.07 POWER STRIP/SURGE SUPPRESSOR

A. Provide power strip/surge suppressor in each rack.

3.08 FIELD TESTING

A. General
   1. Refer to Section 27 0000 - General Communications Requirements and 27 1000 – Structured Cabling for guidelines regarding documentation requirements.
   2. Refer to referenced technical sections for detailed requirements to testing of each cable sub-system.

3.09 DOCUMENTATION

A. General
   1. Refer to Sections 27 0000 - General Communications Requirements and 27 1000 – Structured Cabling for guidelines regarding documentation requirements.

END OF SECTION

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SECTION 271300
COMMUNICATIONS BACKBONE CABLING

PART 1 - GENERAL

1.01 SCOPE

A. This section details product and execution requirements for backbone cabling for Communications Systems.

1.02 DESCRIPTION

A. Backbone Cabling links telecommunications rooms or floor distribution terminals, entrance facilities, and equipment rooms within or between buildings.
B. Backbone cable types include:
   1. Twisted-Pair Copper
   2. Fiber Optic
C. Refer to Project Drawings which detail Backbone Cable System topology and conductor/fiber counts.

1.03 RELATED WORK

A. Related Division 27 Sections include:
   1. Section 27 0000 - General Communications Requirements
   2. Section 27 0526 - Grounding and Bonding for Communications Systems
   3. Section 27 0528.29 - Hangers and Supports for Communications Systems
   4. Section 27 0528.33 - Raceway and Boxes for Communications Systems
   5. Section 27 0528.36 - Cable Tray for Communications Systems
   6. Section 27 0553 - Communications Systems Identification
   7. Section 27 1000 - Structured Cabling
   8. Section 27 1100 - Communications Equipment Room Fittings
   9. Section 27 1500 - Communications Horizontal Cabling
B. Related sections in other Divisions of Work:
   1. Refer to individual technical sections identified above (if applicable).

1.04 REFERENCES & STANDARDS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which identify pertinent References and Standards.

1.05 DEFINITIONS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which provide information on Definitions used in this and related sections.

1.06 ABBREVIATIONS AND ACRONYMS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which provide information on Abbreviations and Acronyms used in this and related sections.

1.07 WORK BY OWNER

A. Refer to Section 27 0000 - General Communications Requirements which identifies Work by Owner affecting sub-system(s) covered by this section.

1.08 SUBMITTALS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which provide general guidelines for product or installation information to be submitted by Contractor.
B. In addition, submit:

1. One 3 ft section of each cable type from cable reels sent to site for Engineer's final approval.
    a. Section shall have manufacturer's cable markings visible.

1.09 QUALITY ASSURANCE

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which identify general quality assurance requirements for the Project.

1.010 GUARANTEE

A. Refer to Division 01, General Conditions, and General Requirements - Guarantee Documents for general warranty requirements.
B. Refer to Section 27 1000 - Structured Cabling for particular Warranty requirements for Structured Cabling. Those requirements apply to cable and components covered in this section.

PART 2 - PRODUCTS

2.01 GENERAL

A. Cables and Termination hardware shall be technically compliant with and installed in accordance with referenced TIA documents.
B. Cables shall be Underwriters Laboratory (UL) listed, comply with Article 800 (Communications Circuits) of National Electrical Code and shall meet specifications of NEMA (low loss), UL 444, and ICEA (where applicable).

2.02 TWISTED PAIR CABLING

A. General:
    1. Manufacturers: CommScope, Superior Essex, Mohawk
    2. Cable shall be standard exchange type telephone cable.
        a. This is defined as paired multi-conductor, thermoplastic insulated, copper cable characterized by an average mutual capacitance of 83 (+4/-5) nano-Farads per mile at 1000 Hz.
    3. Cabling shall:
        a. Be constructed of individually twisted pairs.
        b. Be suitable for installation in environment defined.
        c. Be packaged to minimize tangling and kinking of cable during installation.
    4. Identify conductors by insulation color.
    5. Color code shall follow industry standard of 10 distinctive colors to identify 25 pairs.
        a. Marking of each mate of primary conductor in pair with color of that primary conductor is optional.
    6. When cables of larger than 25 pairs are required, cable core shall be assembled into 25-pair sub-units.
    7. Wrap super units with solid color thread that follows primary color scheme of white, red, black, yellow and violet.
    8. Cable jacket shall be marked at 2 ft intervals indicating manufacturers' identification, pair count, AWG and sequential footage.
B. Backbone UTP Cable (Intra-building):
    1. Cable shall meet following minimum requirements:
        a. Size: 24 AWG solid annealed copper pairs
        b. Number of Pairs: as shown on Project Documents
        c. Impedance: 100 Ohms ± 15%
        d. Jacket Color: Black or Grey
        e. Shield: Overall, continuous corrugated aluminum bonded to outer jacket
        f. Cable Rating: NEC Article 800 Type CMR, UL listed

2.03 FIBER OPTIC CABLE

A. General
   1. Manufacturers (Cable): Corning, Siemon, Berk-Tek, CommScope
   2. Manufacturers (Optical Fiber): Corning, Alcatel
   3. Fibers utilized in installed cable shall be traceable to manufacturer.

B. Optical Fiber - General
   1. Optical fibers shall:
      a. Be sufficiently free of surface imperfections and occlusions to meet optical, mechanical, and environmental requirements of this specification.
      b. Have been subjected to minimum tensile proof test by fiber manufacturer equivalent to 100 kpsi.
   2. Factory optical fiber splices are not allowed.
   3. Coatings shall be mechanically strippable without damaging optical fiber.

C. 50 micron Multimode Optical Fibers:
   1. Fiber Type: Multimode; doped silica core surrounded by concentric glass cladding
   2. Strand Count: As shown on Drawings
   3. Transmission Windows: 850 nm, 1300 nm
   4. Core Diameter: 50 micron ± 3 micron
   5. Cladding Diameter: 125 micron ± 2 micron
   6. Coating Diameter: 245 micron ± 5 micron
   7. Maximum Attenuation:
      a. 850 nm: 3.5 dB/km (at 23° ± 5°C)
      b. 1300 nm: 1.5 dB/km (at 23° ± 5°C)
      c. Attenuation performance is typical for generic 50 micron fiber grades. Better performance is available and can be considered for longer, inter-building links if required. When tested in accordance with FOTP-3, "Procedure to Measure Temperature Cycling Effects on Optical Fibers, Optical Cable, and Other Passive Fiber Optic Components", average change in attenuation over rated temperature range of cable shall not exceed 0.50 dB/km with 80% of measured fibers not exceeding 0.25 dB/km.
   8. Minimum LED Bandwidth:
      a. 850 nm: 500 MHz*km
      b. 1300 nm: 500 MHz*km
   9. Effective Modal Bandwidth:
      a. 850 nm: 500 MHz*km
   10. Point Discontinuity: < 0.2 dB at specified wavelengths.
   11. Minimum supported Gigabit Ethernet distances shall be:
      a. 850 nm window: 300m
      b. 1300 nm window: 500m
   12. Minimum supported Serial 10 Gigabit Ethernet distances shall be:
      a. 850 nm window: 80 m

D. Single-mode Optical Fibers:
   1. Single-mode Optical Fibers:
   2. Fiber Type: Single-mode
   3. Strand Count: as shown on Drawings
   4. Transmission Windows: 1310 nm, 1550 nm
   5. Core Diameter: 8.3 micron
   6. Cladding Diameter: 125 micron ± 1 micron
   7. Coating Diameter: 245micron± 10 micron

8. Maximum Attenuation:
   a. 1310 nm: 1.0 dB/km (at 23° ± 5°C)
   b. 1550 nm: 0.75-dB/km (at 23° ± 5°C)
   c. When tested in accordance with FOTP 3, "Procedure to Measure Temperature Cycling Effects on Optical Fibers, Optical cable, and Other Passive Fiber Optic Components", average change in attenuation over rated temperature range of cable shall not exceed 0.05 dB/km at 1550 nm. Maximum attenuation change shall not exceed 0.15 dB/km at 1550 nm.
9. Point Discontinuity: < 0.1 dB at specified wavelengths

E. Indoor Backbone Fiber Optic Cable
1. Cable shall:
   a. Be suitable for installation in free air, in building risers, in conduit, in cable tray and in innerduct.
   b. Be dielectric materials (no conductive materials).
2. Cable shall meet the following specifications:
   a. Buffer Diameter: 900 micron (tight buffer)
   b. Jacket Color
      1) All: BLACK
      2) Multimode: ORANGE
         a) Exception: LASER-optimized 50/125 Multimode: AQUA
      3) Single-mode: YELLOW
      4) Hybrid (Multimode + Single-mode): BLACK
   c. Cable Rating: OFNR
   d. Strength Member: Aramid Yarn
   e. Storage Temperature: -40°F to 158°F (no irreversible change in attenuation)
   f. Operating Temperature: -34°F to 158°F (no irreversible change in attenuation)
   g. Humidity Range: 0 to 100%
   h. Maximum Tensile Strength:
      1) During Installation – 2700 N (no irreversible change in attenuation)
      2) Long Term – 1000 N
   i. Bending Radius:
      1) During Installation - 20 times cable diameter
      2) No Load - 10 times cable diameter

2.04 FIBER OPTIC CONNECTORS

A. Manufacturers: Corning, Siemon, Panduit, Ortronics.
B. Connectors shall:
1. Be LC-type.
2. Accept fibers having clad diameter of 125 micron.
3. Accept fibers having buffered diameter of 900 micron.
4. Sustain minimum of 200 mating cycles.
C. Connector ferrule shall be ceramic or glass-in-ceramic.
D. Connectors shall meet the following performance criteria:

Test Procedure	Max. Attenuation Change
1. Cable Retention (TIA-455-6)	0.2 dB
2. Durability (TIA-455-21)	0.2 dB
3. Impact (ANSI/TIA/EIA-455-2)	0.2 dB
4. Temperature Life (TIA/EIA-455-4)	0.2 dB
5. Humidity (TIA/EIA-455-5)	0.2 dB

E. Optical fiber shall be:

1. Secured within connector ferrule with adhesive, or
2. Mechanically secured and mated to a factory-installed fiber stub that is fully bonded into the ferrule. Mechanical “splice” inside connector shall include an index matching gel.

F. Attenuation per connector shall not exceed 0.5 dB.
G. Reflectance (maximum) when mated with patch-cord made up of connectors of comparable design shall be as follows:
   1. Multimode: -20 dB
   2. Single-mode: -26 dB
H. Color of LC Connector shall be as follows:
   1. Multimode: BEIGE
      a. Strain-relief boot of connector terminating LASER-optimized 50 micron fiber shall be AQUA.
   2. Single-mode: BLUE
I. Strain-relief boot of ST Connector shall indicate fiber type as follows:
   1. Multimode: BLACK
   2. Single-mode: YELLOW

PART 3 - EXECUTION

3.01 CABLE INSTALLATION AND TERMINATION

A. General
   1. Provide cables as shown on Project Documents.
   2. Size cables as shown on Project Documents.
   3. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling for general cable installation requirements.
B. Backbone UTP Voice Cable:
   1. Terminate cables on backbone voice cable blocks.
      a. Maintain cables pair twists to within 1” of termination.
      b. Remove cable jacket only to extent required to make terminations.
   2. Ground metallic cable sheath (if applicable) per Code.
      a. Provide armored cable ground kit for armored cable terminations. Install as directed by kit manufacturer.
         1) Ground inter-building cable at one end
         2) Ground intra-building cabling at both ends
   3. Connect armored cable ground kit to wall-mounted TGB located in telecom room.
C. Fiber Optic Cable
   1. Route backbone fiber optic cable in innerduct.
   2. Ground metallic cable sheath (if applicable) per Code.
      a. Provide armored fiber ground kit for armored cable terminations. Install as directed by kit manufacturer.
         1) Ground inter-building cable at one end
         2) Ground intra-building cabling at both ends
      b. Connect armored fiber ground kit to rack mounted grounding reference.
   3. Terminate fiber strands on Fiber Optic Connectors mated to couplings mounted in Fiber Optic Patch Panels.
      a. Terminate all fibers.
   4. Follow manufacturer's guidelines for connector type(s) provided.
      a. Clean connectors with specialized dry-cleaning product from Fluke, ProLabs or Cletop.
   5. Fibers with coatings <900 micron shall be furcated (fanned-out) to minimum of 900 micron before termination.

a. Provide buffer tube fan-out kits for fibers terminated in patch panel couplings.

6. Provide cable slack in each backbone fiber optic cable.
   a. Slack shall be in addition to length of fiber required for termination requirements.
   b. Store cable slack in enclosure designed for this purpose.
   c. Slack required shall be as follows:
      1) Backbone Intra-Building: Minimum of 16 ft (each cable if applicable) coiled and secured at one end (preferably at Telecom Room).
      2) Backbone Inter-Building: Minimum of 50 ft (each cable if applicable) coiled and secured at one end (preferably at Equipment Room).
      3) Maintenance Holes/Manholes: Minimum of 1-1/2 times inside dimension of Maintenance Hole/Manhole.

3.02 FIELD TESTING

A. General
   1. Refer to Section 27 0000 - General Communications Requirements for general guidelines regarding requirements for scheduling and performance of compliance testing.
      a. Contractor shall be responsible for testing each system end-to-end.

B. Backbone UTP Cable Testing
   1. Verify voice cable pairs for wire map (transposed/reversed/split pairs) and shorts through toning of each conductor.
   2. Verify cable shield or coupled bonding conductor for end-to-end continuity.

C. Backbone Fiber Optic Cable Testing
   1. Pre-Installation Testing
      a. Pre-installation testing shall be done at contractor option.
      b. Submit cable manufacturer's test report for each reel of cable provided.
         1) Verify fiber attenuation, bandwidth and length values as specified on cable data sheets supplied with cable reels.
      c. Visually inspect reels and packaging for damage.
   2. Post-Installation Testing
      a. Clean fiber optic connectors before beginning testing.
         1) Using fiber tester capable of fiber end face inspection is strongly encouraged to help minimize requirement for retesting due to dirty connectors.
      b. Testing shall include:
         1) Optical Attenuation
         2) Optical Time Domain Reflectometry (OTDR)
         3) **[Optical Return Loss]**
      c. Optical Attenuation
         1) Light Source: VCSEL for 850 nm tests; FP LASER for 1300 nm tests
         2) Measure Optical Attenuation on terminated fibers.
            a) Include optical connectors and couplings installed at fiber endpoints.
         3) Test multimode fibers using TIA 526-14-C, Annex A.
         4) Test single-mode fibers using TIA 526-7-A. Annex E (Method A).
         5) Test fibers in both transmission directions.
         6) Test multimode fibers at 850 ± 30 nm and 1300 ± 20 nm wavelengths.
         7) Test single-mode fibers at 1310 ± 10 nm and 1550 ± 10 nm wavelength**[s]**.
         8) Fiber lengths less than or equal to 300 ft shall test to ≤ 2.0 dB loss.
         9) Fiber lengths greater than 300 ft shall test to loss value less than link loss budget for installed connectors and fibers.

d. Optical Time Domain Reflectometry (OTDR)
   1) OTDR testing shall not be used as the sole method for establishing optical attenuation link loss.
   2) Verify fiber integrity using an Optical Time Domain Reflectometer (OTDR).
      a) Includes terminated and (if applicable) un-terminated fibers.
   3) OTDR(s) shall incorporate high-resolution optics and short pulse-width options optimized for viewing of short cable sections.
      a) Pulse-width shall be 10-ns or less for cable lengths greater than 100 meters.
      b) Pulse-width shall be 5-ns or less for cable lengths less than 100 meters.
   4) OTDR traces shall be performed in one direction using access jumpers at transmit and receive ends.
      a) Remote end of tail cord has no requirement for reference grade termination
   5) OTDR traces shall be performed in two directions using access jumpers at transmit and receive ends
      a) Remote end of tail cord shall meet same reference grade requirements as launch end cord.
      b) Perform bi-directional OTDR measurements according to requirements of TIA-526-7-A, clauses H.6 and H.7.
      c) Minimum length of access jumper at launch end shall be minimum 330 ft long for multimode or 990 ft long for single-mode, unless recommended otherwise by test equipment manufacturer.
   6) Test multimode fibers at 850 ± 30 nm wavelength.
   7) Test single-mode fibers at 1310 ± 10 nm wavelengths.
   8) Examine traces for continuity and anomalies to confirm fiber link integrity.
      a) Point discontinuities in excess of 0.2 dB for multimode fibers or 0.1 dB for single-mode fibers shall be cause for rejection of cable.
      b) Any reflection in trace - except at patch panels - shall be cause for rejection of cable.
      c) Submitted test results shall show only fiber under test and shall have trace boundaries set to show fiber under test and not launch cords or other extraneous data.
      d) Set event markers to accurately reflect overall attenuation of installed fiber optic cable and connectors.
   9) OTDR tested links showing excessive backscatter immediately following connector shall have connector cleaned and/or re-polished and then retested.

3.03 DOCUMENTATION

A. General
   1. Refer to Section 27 0000 - General Communications Requirements for general guidelines regarding documentation requirements.

B. Backbone Copper Cable
   1. Document pair count assignments by cable.
   2. Document cross-connects between backbone, and horizontal or tie cabling.
      a. Documentation shall be in the form of a spreadsheet which relates backbone pair count with horizontal cable or tie cable information. Base horizontal cable information on outlet designation and pair count.

C. Backbone Fiber Optic Cable
   1. Files containing Attenuation and OTDR traces of individual optical fiber "signatures" shall be so named as to identify each individual fiber by location in cable system and fiber number or color.

2. OTDR test results shall be consistent in format and presentation, including:
    a. Scale
        1) Scale or window of test result view shall show only enough trace to view fiber under test plus launch cords at both ends.
        2) View shall not show backscatter beyond end of fiber.
    b. Pulse width
    c. Units (English or Metric)
    d. Cursor placement
    e. Labeling

END OF SECTION

SECTION 271500
COMMUNICATIONS HORIZONTAL CABLING

PART 1 - GENERAL

1.01 SCOPE

A. This section details product and execution requirements for Horizontal (Station) Cabling subsystem for Communications Systems.

1.02 DESCRIPTION

A. Horizontal cabling subsystem is portion of communication link that connects horizontal or intermediate cross-connect (typically at Telecom Room) and Telecommunications Outlet.

B. Horizontal Cable types include:

1. 4-pair Copper Unshielded Twisted Pair (UTP)

1.03 RELATED WORK

A. Related Division 27 Sections include:

1. Section 27 0000 - General Communications Requirements
2. Section 27 0526 - Grounding and Bonding for Communications Systems
3. Section 27 0528.29 - Hangers and Supports for Communications Systems
4. Section 27 0528.33 - Raceway and Boxes for Communications Systems
5. Section 27 0528.36 - Cable Tray for Communications Systems
6. Section 27 0553 - Communications Systems Identification
7. Section 27 1000 - Structured Cabling
8. Section 27 1100 - Communications Equipment Room Fittings
9. Section 27 1300 - Communications Backbone Cabling

B. Related sections in other Divisions of Work:

1. Refer to individual technical sections identified above (if applicable).

1.04 REFERENCES AND STANDARDS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which identifies pertinent References and Standards.

1.05 DEFINITIONS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which provide information on Definitions used in this and related Sections.

B. In this section, "Telecommunications Outlet" is considered to consist of Frame/Faceplate into which Modular Jacks or other couplings snap, Modular Jacks, blanks fitted to unused jack positions, and labeling/identification components.

1.06 ABBREVIATIONS AND ACRONYMS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which provide information on Abbreviations and Acronyms used in this and related Sections.

1.07 WORK BY OWNER

A. Refer to Section 27 0000 - General Communications Requirements which identifies Work by Owner affecting sub-system(s) covered by this section.

1.08 SUBMITTALS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which provide general guidelines for product or installation information to be submitted by Contractor.

B. In addition, submit:

1. Samples of each Telecommunications Outlet Faceplate type to confirm color and material.

2. One 3 ft section of each cable type from cable reels sent to site for Engineer's final approval.
    a. Section shall have manufacturer's cable markings visible.
3. Nominal Velocity of Propagation (NVP) for 4-pair Horizontal Copper Cable.

1.09 QUALITY ASSURANCE

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which identify general quality assurance requirements for the Project.

1.010 GUARANTEE

A. Refer to Division 01, General Conditions, and General Requirements - Guarantee Documents for general warranty requirements.
B. Refer to Section 27 1000 - Structured Cabling for particular Warranty requirements for Structured Cabling. Those requirements apply to all cable and components covered in this section.

PART 2 - PRODUCTS

2.01 GENERAL

A. Cables and Termination hardware shall be technically compliant with and installed in accordance with referenced TIA documents.
B. Cables shall be Underwriters Laboratory (UL) listed, comply with Article 800 (Communications Circuits) of National Electrical Code and shall meet specifications of NEMA (low loss), UL 444, and ICEA (where applicable).
C. Horizontal (Station) Cable and Termination Components (Jack, Patch Panel) are specified to function as System.
    1. Where required for warranty purposes, manufacturers of cabling and termination components used (if more than one) shall recognize each other in their Certification Programs.
D. 4-Pair Horizontal Copper Cables and Modular Jacks are application independent (e.g. no distinction between “voice” and “data”).

2.02 4-PAIR HORIZONTAL COPPER CABLE

A. Manufacturers: Refer to System Requirements list in 27 1000
B. Cables shall be suitable for installation in environment defined
C. Cabling shall be packaged to minimize tangling and kinking of cable during installation.
D. Configuration:
    1. Number of Pairs: 4 twisted pair
        a. Pair twists of any pair shall not be same as any other pair.
        b. Pair twist lengths shall be selected by manufacturer to ensure compliance with crosstalk requirements of TIA 568.
    2. Conductors: insulated solid annealed copper pairs
        a. Category 3 - 5e: 24 AWG
        b. Category 6 & 6A: 23 AWG
        c. Pairs of 4-pair cables shall be identified by banded color code in which conductor insulation is marked with dominant color and banded with contrasting color.
            1) By pair number, pair colors or dominant band are:
                a) Pair 1: Tip - White/Blue; Ring - Blue (or Blue/White)
                b) Pair 2: Tip - White/Orange; Ring - Orange (or Orange/White)
                c) Pair 3: Tip - White/Green; Ring - Green (or Green/White)
                d) Pair 4: Tip - White/Brown; Ring - Brown (or Brown/White)
    3. Shield: None
        a. Drain Wire: None

4. Cable Rating: NEC Article 800 Type CM, CMR or CMP UL listed
5. Maximum outside diameter:
    a. Category 6: 0.25 inches

E. Horizontal Data Cable:
1. Shall meet or exceed TIA Category 6 performance requirements.
2. Shall not incorporate an overall shield.
3. Jacket Color: Blue

F. Horizontal Voice Cable:
1. Shall meet or exceed TIA Category 6 performance requirements.
2. Shall not incorporate an overall shield.
3. Jacket Color White

G. Horizontal Surveillance Camera Cable:
1. Shall meet or exceed TIA Category 6 performance requirements.
2. Shall not incorporate an overall shield.
3. Jacket Color Orange

2.03 TELECOMMUNICATIONS OUTLET

A. Manufacturers: Refer to System Requirements list in 27 1000

B. Connectors (modular jacks, fiber optic couplings and coaxial connectors (as applicable)) shall snap onto faceplate.
1. In surface-mount designs (if applicable) Jacks and connectors may mount to frame onto which coverplate is mounted.

C. Work Area Faceplate
1. Wall-mounted faceplates intended to be used in general work areas shall:
    a. Be configured to mount on standard, single gang opening when wall mounted.
    b. Accommodate minimum of 4 modular jacks and connectors.
    c. Be constructed of high impact plastic (except where otherwise noted).
    d. Incorporate recessed designation strips at top and bottom of frame for identifying labels.
        1) Triple row faceplates with no provisions for labeling of middle outlet row are not acceptable.
        2) Designation strips shall be fitted with clear plastic covers.
        3) Designation strips and covers shall be positioned over faceplate mounting screws.
2. Faceplate Color: to match electrical device faceplates.

D. Wall-mount Telephone Faceplate
1. Faceplates intended to be used in locations where wall mounted telephone set is required shall:
    a. Be stainless steel construction.
    b. Accommodate 1 modular jack meeting performance requirements for "Voice" jack as defined above.
        1) Modular jack shall be positioned to mate with wall-mounted telephone.
    c. Mount on standard single gang opening.
    d. Include mating lugs for mounting wall-mounted telephone.

E. Faceplate - Wireless Access Point Location
1. Faceplates supporting Wireless Access Point (AP) shall:
    a. Accept 2 modular jacks or connectors.
    b. Be Surface-mounted.
    c. Be made of High Impact thermoplastic.
    d. Incorporate recessed designation strips at top and bottom of frame for identifying labels.

2. Faceplate Color: White

F. Faceplate - Surface Raceway
1. Faceplates intended to be used on surface raceway shall:
a. Accept 2 modular jacks or connectors.
b. Snap into raceway opening and be retained by integral latching tabs.
1) Match standard opening of raceway type(s) to be installed.
c. Have an optional extender bracket available to increase mounting depth.
d. Be made of High Impact thermoplastic.
e. Incorporate recessed designation strips for identifying labels.
1) Raceway faceplate color shall match color of raceway.

2.04 MODULAR JACK

A. Manufacturers: Refer to "Telecommunications Outlet" above.
B. Modular Jacks shall be:
1. 8-position, 8-conductor (8P8C)
2. Non-keyed
C. Jacks shall have an attached color-coded wiring instruction label as an aid to installer.
D. Interface between jack and station cable shall be insulation displacement type contact.
E. Termination components shall maintain cable's pair twists as closely as possible to point of mechanical termination.
F. Jack contacts shall have minimum of 50 micro-inches of gold plating.
G. Jacks shall be supplied with installed dust covers to protect jack opening and internal elements during installation until jack is in use.
1. No damage to Jack pinning shall result from insertion or removal of covers.
H. Data Jack shall:
1. Meet or exceed performance requirements of TIA Category 6.
2. Be color Blue
a. Alternately, color-coded Bezel or Icon may be used to identify Jack type.
I. Voice Jack shall
1. Meet or exceed performance requirements of TIA Category 6.
2. Be color White
a. Alternately, Color-coded Bezel or Icon may be used to identify Jack type.
J. MPTL connector shall
1. Meet or exceed performance requirements of TIA Category 6.
2. Comply with Annex F of TIA-568.2-D.

PART 3 - EXECUTION

3.01 GENERAL

A. Refer to project Drawings for outlet **[and Consolidation Point]** locations.
B. Provide Modular Jacks, Coaxial Connectors (if applicable) and Fiber Optic couplings (if applicable) in faceplates as shown on Project Documents.
1. Provide 1 faceplate per Telecommunications Outlet symbol shown on Project Documents.
C. Provide (1) Consolidation Point per CP symbol shown on Project drawings.
D. Maximum 4-pair Category-rated horizontal cable length shall not exceed 295 feet (90 m) measured from horizontal cross-connect (typically at TR) to Telecommunications Outlet.
1. Includes slack required for installation and termination.
2. Contractor is responsible for installing station cable to avoid unnecessarily long runs.
3. Any area that cannot be reached within above constraints shall be identified and reported to Engineer prior to installation.
E. Follow manufacturers recommended termination practices.

3.02 CABLE INSTALLATION AND TERMINATION

A. General
   1. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling for general cable installation requirements.
   2. Provide "Service Loop" for every Horizontal Cable in ceiling above outlet.
      a. Loop length shall be 3.3 ft
      b. Total length of 4-pair Category-rated horizontal cable including loop shall not exceed 295 feet (90 m).
      c. Place loop in ceiling at last support (e.g. J-Hook) before cables enter fishable wall, conduit, surface raceway or box.
      d. Coil loop in figure 8 configuration.
      e. Loop radius (minimum) shall be 4X minimum bend radius for cable.
   3. During installation, minimum bend radius shall be eight times outside diameter of UTP cables and 20 times outside diameter of fiber cables.

B. Horizontal Copper Twisted-Pair Cabling
   1. Provide horizontal copper twisted pair cable between horizontal cross connect (typically at Telecommunications Room) and Telecommunications Outlet.
   2. At Telecommunications Outlet, terminate each 4-pair Horizontal Cable on 8P8C Modular Jack.
      a. Terminating one cable on more than one jack is not allowed.
   3. At horizontal cross-connect, terminate:
      a. Each 4-pair cable on 8P8C Modular Jack in Patch Panel.
   4. Terminate cables using 568B wiring standard.
   5. Cable jacket shall be continuous to within 1/2” of termination.
   6. Preserve pair twists to point of termination.
   7. Refer to Section 27 1100 - Communications Equipment Room Fittings for termination instructions for Modular Patch Panel and Termination Block.

3.03 TELECOMMUNICATIONS OUTLET

A. Faceplates shall be configured to provide connectivity as required by location. Refer to drawings.

B. Mount modular jacks and connectors into faceplates and secure faceplates to outlet box, raceway or modular furniture.
   1. Use faceplate extender if required to provide adequate clearance between jack and furniture or raceway panel to maintain minimum cable bend radius.
   2. Provide blank(s) in unused jack/connector positions. Match color of blank to faceplate color.

C. Position Telecommunications Outlet for wall-mounted telephone in area clear of other utilities and wall mounted hardware.
   1. Coordinate with other trades to maintain 8” clear space (minimum) on all sides from faceplate centerline.

D. MPTL connectors shall be installed following connector manufacturer requirements.
   1. Contractor shall ensure installed MPTL will fit in available space at outlet-end of cable while maintaining cable bend radius requirements.

3.04 FIELD TESTING

A. Refer to Sections 27 0000 - General Communications Requirements and 27 1000 – Structured Cabling for guidelines regarding testing requirements common to all Division 27 Structured Cabling sections.
   1. In addition, refer to sub-sections below for cable type under test.

B. 4-Pair Horizontal Copper Cable

1. Test from:
   a. Horizontal Cross-connect (HC) to Jack at Telecommunications Outlet (TO).
   b. Horizontal Cross-connect to Jack at Consolidation Point (CP)
   c. HC – CP – TO. Test is in addition to HC-CP test described above.
2. Testing shall be per TIA-568 Permanent Link test configurations.
3. Maximum length of station cable shall not exceed 300 ft.
4. Cables shall be free of shorts within pairs, and be verified for Continuity, Pair Validity and Polarity, and Wire Map (Conductor Position on Modular Jack).
   a. Identify and correct defective, split or mis-positioned pairs.
5. In addition to above, Performance Testing shall be performed on all cables. Testing of Transmission Performance shall include the following:
   a. Length
   b. Insertion Loss / Attenuation
   c. Pair-to-pair NEXT
   d. PSNEXT
   e. Pair-to-pair ELFEXT (Equal Level Far End Cross-talk)
   f. PSELFEXT
   g. Return Loss
   h. Propagation Delay
   i. Delay Skew
6. Test cables to maximum frequency defined by standards covering specified performance category.
7. Perform Transmission Performance Testing using test instrument designed for testing to specified frequencies.
   a. Test records shall verify "PASS" on each cable and display specified parameters - comparing test values with standards based "templates" integral to unit.
8. MPTL cables shall be tested in accordance with TIA-568.2-D, Annex F, and test procedure shall follow recommended guidelines of test equipment manufacturer.
   a. Select MPTL test limit on test equipment when testing MPTL terminated cables.

3.05 DOCUMENTATION

A. Refer to Sections 27 0000 - General Communications Requirements and 27 1000 – Structured Cabling for documentation guidelines.

B. Information added by Contractor to Record Drawings relating to Horizontal Cabling shall include cable routes, outlet locations and numbering, location of Consolidation Points and other detail necessary to document cable installation.

C. Document interconnection between permanent link cabling from HC to Consolidation Points and the cabling from the CP to the TO.
   1. Documentation shall be in the form of a spreadsheet which relates permanent link pair count with individual links to TOs.
   2. Base cable information on CP and TO designation and pair count.

END OF SECTION

SECTION 275319
EMERGENCY RESPONDER RADIO REINFORCEMENT SYSTEM

PART 1 - GENERAL

1.01 SCOPE

A. This section includes product and execution requirements for Emergency Responder Radio Reinforcement system.

1.02 DESCRIPTION

A. Design and provision of a complete, turnkey Emergency Responder Radio Reinforcement system compliant with all applicable codes and standards referenced herein and as indicated on drawings.

B. The Emergency Responder Radio Reinforcement system shall include the following major components:
   1. Donor Antenna(s)
   2. Surge Protection
   3. Bi-Directional Amplifier / Repeater
   4. Splitters
   5. Directional Couplers/Taps
   6. Coverage Antennas
   7. Uninterruptible Power Supplies

1.03 RELATED WORK

A. Related Division 27 Sections include:
   1. Section 27 0000 - General Communications Requirements
   2. Section 27 0526 - Grounding and Bonding for Communications Systems
   3. Section 27 0528.29 - Hangers and Supports for Communications Systems
   4. Section 27 0528.33 - Raceway and Boxes for Communications Systems
   5. **[Consider which other Div 27 sections should be shown here]**

B. Related sections in other Divisions of Work:
   1. Section 26 4113 - Lightning Protection for Structures
   2. **[Consider which other division sections should be shown here]**

1.04 REFERENCES AND STANDARDS

A. Unless otherwise noted, design, products, installation, and completed work shall conform with the current version of the following, including applicable addenda and errata:
   1. United States Table of Frequency Allocations, current version
   2. Federal Communications Commission Table of Frequency Allocations, current version
   3. FCC 47 CFR Part 90.219
   4. FCC OET Bulletin 65
   5. IFC International Fire Code
   6. UL 2524-2018 Standard for In-building 2-Way Emergency Radio Communication Enhancement Systems
   7. NFPA 1: Fire Code
   8. NFPA 72: National Fire Alarm and Signaling Code
   9. NFPA 1221: Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems

1.05 ABBREVIATIONS AND ACRONYMS

A. Refer to Section 27 0000 - General Communications Requirements for general terminology used in Division 27 sections.

B. In addition, following abbreviations and acronyms shall apply to this document:
   1. ACG: Automatic Gain Control

2. AHJ: Authority Having Jurisdiction
3. ATP: Acceptance Test Plan
4. AWS: Advanced Wireless Service
5. BDA: Bi-Directional Amplifier
6. BOM: Bill-of-Material
7. BRS: Broadband Radio Service
8. BTS: Base Transceiver Station
9. CDMA: Code Division Multiple Access
10. C/N: Carrier-to-Noise Ratio
11. CWDM: Coarse Wave Division Multiplexing
12. DAS: Emergency Responder Radio Reinforcement System
13. DAS: Two-way Radio Communications Enhancement System
14. DAQ: Delivered Audio Quality
15. DWDM: Dense Wave Division Multiplexing
16. EBS: Educational Broadband Service
17. ESMR: Enhanced Specialized Mobile Radio
18. ERRC: Emergency Responder Radio Coverage
19. FCC: Federal Communications Commission
20. GUI: Graphical User Interface
21. iDEN: Integrated Enhanced Digital Network
22. LMR: Land Mobile Radio
23. LTE: Long Term Evolution
24. MIMO: Multiple-Input and Multiple-Output
25. MTBF: Mean Time Between Failure
26. NFPA: National Fire Protection Association
27. NMS: Network Management System
28. NTIA: National Telecommunications and Information Administration
29. PCS: Personal Communications System
30. PSE: Public Safety Entity
31. PSN: Public Safety Network
32. RF: Radio Frequency
33. RoF: Radio-over-Fiber
34. RoHS: Restriction of Hazardous Substances
35. RSL: Received Signal Level
36. RX: Receive
37. SISO: Single-Input, Single-Output
38. SMR: Specialized Mobile Radio
39. SMS: Short Message Service
40. SNMP: Simple Network Management Protocol
41. SOW: Statement of Work
42. TSL: Transmit Signal Level
43. TX: Transmit
44. VSWR: Voltage Standing Wave Ratio

1.06 DEFINITIONS

A. Refer to Section 27 0000 - General Communications Requirements for general terminology used in Division 27 sections.

B. In addition, the following definitions are applicable to this document:
   1. Active: DAS components that require AC/DC power for operation
   2. Channel: A path for an RF transmission between two points
   3. Component: A main system element of the DAS

4. Contractor: The prime contractor bidding the project
5. Passive: DAS components that do not require AC/DC power for operation

1.07 WORK BY OWNER

A. Refer to Section 27 0000 - General Communications Requirements which identifies Work by Owner affecting sub-system(s) covered by this section.

1.08 SUBMITTALS

A. Refer to Section 27 0000 - General Communications Requirements which provides general guidelines for product or installation information to be submitted by Contractor.
B. In addition, Submit:
   1. Initial RF site survey and analysis report, to include:
      a. Data collection point locations
      b. RF spectrum shots
      c. RF data plot maps
   2. Floor plans documenting proposed coverage antenna locations
   3. Floor plans documenting proposed donor antenna location
   4. RF propagation modeling maps
   5. Documentation that each PSN has reviewed and approved proposed equipment and Contractor's design
   6. Follow-up RF site survey and analysis report, to include:
      a. Data collection point locations
      b. RF spectrum shots
      c. RF data plot maps
      d. Documentation of changes to initial system design required due to results of follow-up RF site survey, where required, to include as applicable:
         1) Floor plans documenting proposed coverage antenna locations
         2) RF propagation modeling maps
         3) Documentation that each PSN has reviewed and approved proposed equipment and Contractor's design

PART 2 - PRODUCTS

2.01 GENERAL

A. Equipment required to provide emergency responder radio coverage shall be listed in accordance with UL 2524.
B. System shall be a BDA style turnkey system capable of integral support of RF signals for PSNs managed by FCC.
C. System shall support each PSN on each frequency currently being used by PSEs serving project area.
   1. Coordinate directly with each PSE prior to the commencement of design work to confirm frequencies active on the project's scheduled date of substantial completion.
D. System shall be expandable to support each frequency band allocated by FCC for PSN use without replacement of or addition to the system's passive infrastructure.
E. System shall be capable of receiving PSN AHJ approval.
F. System shall include filtering of all frequencies unused by PSN signals in area in which project is located.
G. System shall be capable of upgrade, without need for additional hardware or software, to support changes to other frequencies within deployed frequency bands to maintain PSN coverage as originally designed.
H. System shall be expandable to extend coverage for all Public Safety frequencies supported to future new additions without need for additional head end equipment.
I. Passive system components shall be:

1. Broadband
2. MIMO compatible
3. PIM (passive intermodulation) compliant

J. Active RF emitting devices used in emergency responder radio coverage systems shall have built-in oscillation detection and control circuitry.

2.02 ANTENNAS

A. Broadband Donor Antenna
1. Antennas shall feature multi-band design accommodating applicable Public Safety frequencies in a single pole-mounted antenna.
2. Temperature range: -40°F to 140°F.
3. Rated for outdoor use.

B. Coverage Antennas – Omnidirectional
1. Antennas shall feature multi-band design accommodating multiple frequency bands in a single ceiling-mounted antenna
2. Antenna beam width:
   a. Horizontal: 360° omnidirectional
   b. Vertical: 65-80° nominal
3. Temperature range: -40°F to 140°F.
4. Rated for indoor use.

C. Coverage Antennas - Directional
1. Antennas shall feature multi-band design accommodating multiple frequency bands in a single wall-mounted antenna
2. Antenna beam width:
   a. Horizontal: 110° directional
   b. Vertical: 90° nominal
3. Temperature range: -40°F to 140°F.
4. Rated for indoor use.

2.03 BI-DIRECTIONAL AMPLIFIERS

A. Where BDA is used to drive DAS, BDA shall be modular design and use digital filtering to mitigate interference.
B. BDA shall be standard 19" rack or wall mountable.
C. BDA shall be able to individually control power level of each frequency band amplified.

2.04 CABLING

A. Feeder and riser coaxial cables shall be plenum rated.
B. Backbone, antenna distribution, radiating, and fiber optic cables shall be plenum rated.

PART 3 - EXECUTION

3.01 PSN SUPPORT COORDINATION MEETING

A. Prior to Contractor’s design work commencement, Contractor shall arrange and conduct coordination meeting to review and coordinate Emergency Responder Radio Reinforcement system support of PSN frequencies.
1. At minimum, attendees shall include:
   a. AHJ and representatives of public safety entities utilizing supported PSN frequencies
   b. Owner’s project manager, facilities/buildings and grounds/maintenance representative, security representative, and information technology/information systems representative
   c. Construction Manager/General Contractor project manager and site superintendent/field foreman
   d. Division 26 site superintendent/field foreman

e. Division 27 project manager and site superintendent/field foreman
f. Emergency Responder Radio Reinforcement subcontractor/supplier project manager

2. At minimum, meeting agenda topics shall include:
   a. Confirmation of PSN frequencies and channel loading currently being used by PSEs serving project area
   b. Identification of planned or potential changes in active frequencies and/or channel loading that may be implemented prior to scheduled date of substantial project completion
   c. Identification and discussion of proposed system's functional capabilities and limitations
   d. Step-by-step review of system design and deployment execution plan
   e. Review of survey, design, installation, configuration, programming, and testing schedule and of how those relate to overall construction schedule, including identification of interdependencies, project milestones, and critical dates.
3. Meeting shall be scheduled with minimum of two weeks' notice.
   a. Contractor shall publish meeting agenda and distribute agenda and configuration and programming guide to invited attendees minimum of one week prior to meeting.
4. Contractor shall take detailed notes during meeting and publish meeting minutes within one week after meeting. Minutes shall be distributed to attendees, Architect, and Engineer, and be included in Operation and Maintenance Manual.

3.02 PRE-DESIGN SITE SURVEY

A. After specified coordination meetings and before completion of design, Contractor shall conduct pre-design site survey.
B. Data collection points shall:
   1. Include potential donor antenna locations and elevations
      a. Every effort shall be made to be accurate in locating potential donor antenna locations and elevations on site during survey, to ensure survey measurements are conducted within 10 feet of actual locations, including elevation.
   2. Be sufficient in quantity and location to provide accurate and sufficiently granular data throughout coverage areas
   3. Be sufficient in quantity and location to properly inform Contractor's design
C. Survey measurements shall include:
   1. Baseline RF noise at and adjacent to supported frequencies
   2. Signal strength of each supported PSN's macro signals, at supported frequencies
D. Survey data shall be submitted to Architect and Engineer and be included in Operation and Maintenance Manual.

3.03 DESIGN

A. Where DAS is used in lieu of a two-way in-building wired emergency communications system, DAS design shall be approved by AHJ.
B. Contractor is solely responsible for design of Emergency Responder Radio Reinforcement System.
C. Contractor shall design Emergency Responder Radio Reinforcement System in accordance with manufacturer's instructions and recommendations, industry standard best practices, and requirements of supported PSNs. Where discrepancies arise, more stringent requirement will govern.
D. Contractor shall design Emergency Responder Radio Reinforcement System to provide performance specified herein throughout the coverage areas and to meet approval of all supported PSNs.
E. Refer to Architectural drawings for building occupant information.

3.04 PRE-INSTALLATION SITE SURVEY

A. Contractor shall conduct pre-installation site survey no more than thirty (30) days prior to commencement of installation work on site to acquire updated measurement data.
   1. Pre-installation site survey shall be conducted after walls are built and after glazing is installed.
   2. Where pre-design site survey is conducted within thirty days of commencement of installation work and fulfills all requirements for both pre-design site survey and pre-installation site survey, separate pre-installation site survey is not required.

B. Data collection points shall:
   1. Include potential donor antenna locations and elevations
      a. Every effort shall be made to be accurate in locating potential donor antenna locations and elevations on site during survey, to ensure survey measurements are conducted within 10 feet of actual locations, including elevation.
   2. Be sufficient in quantity and location to provide accurate and sufficiently granular data throughout coverage areas
   3. Be sufficient in quantity and location to properly verify Contractor's design

C. Survey measurements shall include:
   1. Baseline RF noise at and adjacent to supported frequencies
   2. Signal strength of each supported PSN's macro signals, at supported frequencies
   3. Continuous wave (CW) testing to validate propagation modeling

D. Survey data shall be submitted to Architect and Engineer and be included in Operation and Maintenance Manual.

E. Contractor shall update their design as required by updated survey data.

3.05 WORK SEQUENCE

A. Coordinate schedule of Emergency Responder Radio Reinforcement system work to ensure Certificate of Occupancy is obtained in accordance with project schedule.

3.06 EQUIPMENT SUPPORTS

A. Donor Antenna Mounts
   1. Donor antenna assemblies including antenna(s), antenna cable, antenna mount/mast, and associated accessories and hardware shall be designed and installed to withstand sustained winds of ≥ 100 miles per hour from any direction with all devices, equipment, and material installed and with up to 6 inches of radial ice accumulated.
   2. Make donor antenna mounts/masts and associated components, accessories, and hardware electrically continuous and properly ground to lightning protection system. Refer to Section 26 4113 for conductor sizing and termination requirements, and for additional information and requirements.

3.07 INSTALLATION

A. Design and installation shall be performed and overseen by FCC GROL licensed technician employed by installing contractor.

B. Equipment Locations
   1. Install antenna(s) in coverage areas. **[Refer to drawings for additional information.]**
   2. Install **[donor antenna and]** main system head end equipment where indicated on drawings. **[Refer to drawings for additional information.]**
   3. Install system floor-level equipment (splitters, directional couplers / taps, etc.) where indicated on drawings in telecommunications rooms. Refer to drawings for additional information.
   4. Active system components, including transmitter, receiver, signal booster components, external filters and battery system components, shall be contained in NEMA 4 or 4X enclosures.

C. Power Supplies
   1. Primary power source
      a. Emergency Responder Radio Reinforcement system active electronics shall be fed via minimum 20-amp emergency power electrical circuit(s), dedicated to Emergency Responder Radio Reinforcement system head end equipment.
   2. Secondary power source
      a. System shall include battery back-up sufficient to power system at 100 percent system operation for minimum of twenty-four (24) hours.
   3. Power supply system shall be equipped with emergency power off (EPO) switch **[in location approved by fire code official][in Fire Command Center][adjacent to BDA or Signal Booster in an approved location]**. EPO shall disconnect both circuit breaker and secondary power supply simultaneously.
   4. Coordinate power requirements, quantities, connection locations, and schedule for activating power with on-site Division 26 Contractor prior to commencement of work on site.

D. Cabling
   1. Where DAS is used in lieu of two-way in-building wired emergency communications system, DAS shall have pathway survivability of Level 1, Level 2, or Level 3.
   2. http://www.madcad.com/library/213590/613466/Riser cables shall be routed through 2-hour rated enclosure.
   3. Connection between riser and feeder cables shall be made within 2-hour rated enclosure.
      a. Passage of feeder cable in and out of 2-hour rated enclosure shall be fire-stopped to 2-hour ratings.

E. Properly ground system components with minimum 6 AWG bonding conductor terminated with two-hole compression lugs.
   1. Refer to Section 27 0526 for additional information and requirements.

F. Provide and configure filtering to maximize composite power for PSN frequencies being supported.

G. Properly terminate unused RF ports on system devices, including amplifiers, splitters, directional coupler / taps, etc.

H. Donor Antennas
   1. Coordinate donor antenna locations and mounting method with Architect and GC prior to rough-in.
   2. Fasten donor antennas and associated mounting components. with stainless steel fasteners.
   3. Bond donor antenna cables to ground at point where cable connects to antenna and at point where cable transfers off antenna mounting structure.
   4. Provide in-line surge protection on antenna cables, at point where cable enters building.
      a. Properly ground surge protection components with minimum 6 AWG bonding conductor terminated with two-hole compression lugs.
      b. Refer to Section 27 0526 for additional information and requirements.
   5. Weatherproof exterior antenna cable connections with manufacturer-approved assembly.

I. Coverage Antennas shall be installed **[in][above]** accessible ceilings**[, mounted to bottom of structure]**. Coordinate antenna locations with work by other trades to ensure that direct access to antenna is maintained after project completion.

J. System shall provide uniform coverage. Radio coverage shall be provided throughout building as percentage of floor area.
   1. Building shall be considered to have acceptable emergency responder radio coverage when signal strength measurements in 95 percent of all areas on each floor of building meet signal strength requirements.
   2. Minimum signal strength of -95 dBm shall be receivable within the building.

3. Minimum signal strength of -95 dBm shall be received by agency's radio system when transmitted from within building.
4. Critical areas, including fire command centers, fire pump rooms, exit stairs, exit passageways, elevator lobbies, standpipe cabinets, sprinkler sectional valve locations, and other areas deemed critical by AHJ, shall be provided with 99 percent floor area radio coverage.
   a. General building areas shall be provided with 90 percent floor area radio coverage.
5. Minimum inbound signal strength sufficient to provide usable voice communications, as specified by AHJ, shall be provided throughout coverage area. Inbound signal level shall be sufficient to provide minimum of DAQ 3.0 for either analog or digital signals.
6. Minimum outbound signal strength sufficient to provide usable voice communications, as specified by AHJ, shall be provided throughout coverage area. Outbound signal level shall be sufficient to provide minimum DAQ 3.0 for either analog or digital signals.
7. Isolation shall be maintained between donor antenna and inside antennas to minimum of 20 dB under operating conditions.

K. http://www.madcad.com/library/213590/613466/System shall not interfere with operation of other electronic systems.

3.08 SYSTEM MONITORING

A. Fire Alarm System
   1. System shall include automatic supervisory signals for malfunctions of emergency responder radio reinforcement system annunciated by fire alarm system in accordance with NFPA 72.
      a. Monitoring for system integrity shall comply with NFPA 72, Chapter 10.
      b. Provide visual and labeled indications for each supervised system component.
      c. System supervisory signals shall include:
         1) Donor antenna malfunction
         2) Active RF emitting device failure
         3) Low-battery capacity indication when 70 percent of the 24-hour operating capacity has been depleted
         4) System component failure
      d. Power supply supervisory signals shall include the following for each RF emitting device and system component:
         1) Loss of normal AC power
         2) Failure of battery charger
      e. Communications link between fire alarm system and emergency responder radio reinforcement system shall be monitored for integrity.

B. Dedicated Panel
   1. Dedicated monitoring panel shall be provided within fire command center to annunciate status of RF emitting devices and system component locations. Monitoring panel shall provide visual and labeled indications of following for each system component and RF emitting device:
      a. Normal AC power
      b. Loss of normal AC power
      c. Battery charger failure
      d. Low battery capacity (to 70 percent depletion)
      e. Donor antenna malfunction
      f. Active RF emitting device malfunction
      g. System component malfunction
   2. Communications link between dedicated monitoring panel and emergency responder radio reinforcement system must be monitored for integrity.

3.09 INSPECTION AND TESTING

A. Test plan shall include tests necessary to verify that installed system meets specified requirements and requirements of each PSE.
B. Scheduling
   1. Testing shall be scheduled minimum of two weeks prior to scheduled date of final completion.
      a. Contractor shall coordinate with each PSE to arrange for them to observe system testing.
C. Data collection points
   1. Data collection points shall include:
      a. All donor antenna locations
      b. Signal level at each stair landing and elevator lobby
      c. Signal level at locations as required by AHJ
   2. Be sufficient in quantity and location to properly verify that system's performance meets specified requirements and requirements of each PSE.
      a. At a minimum, each floor shall be divided into twenty equal areas and data shall be collected at or as near as is practical to the center of each area.
D. Survey measurements shall include:
   1. Baseline RF noise at and adjacent to supported frequencies
   2. Signal strength of each supported PSN's macro signals, at supported frequencies
   3. Signal strength of each supported PSN's system coverage signals, at all supported frequencies
E. At no additional cost to Owner, Contractor shall adjust, modify, and/or add to system as necessary to achieve performance required by AHJ.

3.010 ATTIC STOCK

A. Contractor shall provide following spare devices and equipment as Owner's attic stock:
   1. Donor Antennas: One (1) of each type provided
   2. Coverage Antennas: Five (5) of each type provided
   3. Surge Suppressors: 100% of the quantity installed of each type provided.
   4. Fuses: 20% of each type provided as part of system devices and equipment, minimum ten (10) of each type provided.

3.011 TRAINING

A. Contractor shall provide to Owner's designated representative(s) a minimum of one (1) 4-hour on-site training session related to work under this section within thirty (30) days of substantial completion.

END OF SECTION

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SECTION 28 0000
GENERAL ELECTRONIC SAFETY AND SECURITY REQUIREMENTS

PART 1 - GENERAL

1.01 SCOPE

A. This section details references, standards, guidelines, requirements and conditions common to all Division 28 work.
B. Work under this Section and related sections is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.
C. Systems constituting the Division 28 scope of work include:
   1. Security Systems Integration
   2. Electronic Access Control
   3. Video Surveillance
D. Fire Detection and Alarm (28 46 00) is not included as part of these general requirements.

1.02 DESCRIPTION

A. Intent of drawings and specifications is to obtain complete systems tested, adjusted, and ready for operation.
B. Except as otherwise defined in greater detail, terms "provide", "furnish" and "install" as used in Division 28 contract documents shall have the following meanings:
   1. "Provide" or "provided" shall mean "furnish and install".
   2. "Furnish" or "furnished" does not include installation.
   3. "Install" or "installed" does not include furnishing.
C. Include incidental details not usually shown or specified, but necessary for proper installation and operation.
D. Check, verify and coordinate work with drawings and specifications prepared for other trades. Include modifications, relocations or adjustments necessary to complete work or to avoid interference with other trades.
E. Included in this contract are connections to equipment provided by others. Refer to Architectural, Electrical, Integrated Automation, Mechanical, Security and final shop drawings for equipment being furnished under other sections for exact locations of outlets and various connections required.
F. Information given herein and on drawings is as exact as could be secured but is not guaranteed. Do not scale drawings for exact dimensions.
G. Where architectural features govern location of work, refer to architectural drawings.
H. Perform work in "neat and workmanlike" manner as defined in ANSI/NECA 1 "Standard Practices for Good Workmanship in Electrical Contracting".

1.03 RELATED WORK

A. Related Division 28 Sections include:
   1. Section 28 0545 - Electronic Safety and Security Systems Integration
   2. Section 28 1000 - Electronic Access Control
   3. Section 28 2000 - Video Surveillance
B. Related sections in other Divisions of Work:
   1. Section 27 0526 - Grounding and Bonding for Communications Systems
   2. Section 27 0528.29 - Hangers and Supports for Communications Systems
   3. Section 27 0528.33 - Raceway and Boxes for Communications Systems
   4. Section 27 0528.36 - Cable Tray for Communications Systems
   5. Section 27 0553 - Communications Systems Identification
   6. Section 27 1000 - Structured Cabling
   7. Section 27 1100 - Communications Equipment Room Fittings

8. Section 27 1300 - Communications Backbone Cabling
9. Section 27 1500 - Communications Horizontal Cabling
10. Also refer to individual technical sections identified above.

C. Temporary Services:
   1. Refer to Division 01 - Temporary Facilities and Controls.
   2. Clean and repair existing materials and equipment that remain or is to be reused.
D. Concrete Work:
   1. Provide cast-in-place concrete as required by contract documents unless otherwise noted.
   2. Concrete shall comply with Division 03 - Concrete.
   3. Provide anchor bolts, metal shapes and templates required to be cast in concrete or used to form concrete for support of equipment.
E. Painting:
   1. Furnish equipment with factory applied prime finish unless otherwise specified.
   2. If factory finish on equipment furnished by Contractor is damaged in shipment or during construction, refinish equipment to satisfaction of Engineer.
   3. Furnish one can of touch up paint for each factory finish, which will be final finished surface of product.
   4. Contractor is responsible for painting of plywood in Security Equipment Rooms. Refer to Drawings.

1.04 REQUIREMENTS OF REGULATORY AGENCIES

A. Rules and regulations of Federal, State and local authorities and utility companies, in force at time of execution of contract shall become part of this specification.
B. Perform work in accordance with laws, codes, regulations, ordinances, etc. of the jurisdiction in which the project site is located and in accordance with Owner's published standards.
C. Perform work in accordance with referenced standards, guidelines, and industry best practices.
D. Perform work in accordance with manufacturer's instructions, guidelines, recommendations, etc.
E. Where a discrepancy exists between laws, codes, regulations, ordinances, guidelines, industry best practices, Owner's published standards, manufacturer's instructions, manufacturer's guidelines, manufacturer's recommendations, etc. and contract documents, the most stringent requirement or direction that complies with laws, codes, regulations, and ordinances shall govern.
F. Changes to work conveyed by contract documents made after letting of contract to comply with applicable laws, codes, regulations, ordinances, Owner's published standards, or contract documents or to comply with requirements of Authority Having Jurisdiction shall be made by Contractor without any cost to Owner.
G. Contractor shall include in their bid costs to procure permits, licenses, approvals, etc. applicable to work performed, including:
   1. Costs to prepare documents for applications, submittals, etc. for review by Authority Having Jurisdiction
   2. Application, submittal, etc. charges, fees, taxes, etc.
   3. Contractor shall include in their bid costs for inspections of work performed related to permits, licenses, approvals, etc. or laws, codes, regulations, ordinances, or Owner's published standards.

1.05 REFERENCES AND STANDARDS

A. Design, cable and component selection, and installation practices shall conform with following:
   1. Local Electrical Code
   2. Country, state and local health, safety and building codes
   3. Americans with Disabilities Act

4. ADA Standards for Accessible Design
5. ASIS PAP.1-2012: Security Management Standard: Physical Asset Protection
6. ASIS SPC.1-2009: Organizational Resilience: Security, Preparedness, and Continuity Management Systems - Requirements with Guidance for Use
7. IEEE 142: Recommended Practice for Grounding of Industrial and Commercial Power Systems
8. IEEE 1100: Recommended Practice for Power and Grounding Sensitive Electronic Equipment in Industrial and Commercial Power Systems
9. IEEE C2: National Electrical Safety Code
10. ICC International Building Code
11. ICC International Fire Code
12. IEEE 81: IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System Part 1: Normal Measurements
13. IEEE 802.3af and 802.3at: Power-over-Ethernet Standards
14. IEEE 837: Standard for Qualifying Permanent Connections Used in Substation Grounding
15. NECA/BICSI 607: Standard for Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings
16. NETA MTS: Standard for Maintenance Testing Specifications for Electrical Power Equipment and Systems
17. NFPA 70: National Electrical Code
18. NFPA 70B: Recommended Practice for Electrical Equipment Maintenance
19. NFPA 101: Life Safety Code
20. NFPA 780: Standard for the Installation of Lightning Protection Systems
21. NFPA 5000: Building Construction Safety Code
22. NIST SP 800-63B: Digital Identity Guidelines
23. TIA-606-C: Administration Standard for Telecommunications Infrastructure
24. TIA-607-D: Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises Standard
25. TIA-5017: Telecommunications Physical Network Security Standard
26. TIA TSB-184: Guidelines for Supporting Power Delivery Over Balanced Twisted-Pair Cabling
27. TIA TSB-185: Environmental Classification (MICE) Tutorial
28. TIA TSB-190: Guidelines on Shared Pathways and Shared Sheaths
29. Underwriters Laboratories Standards applicable to scope of work specified herein
30. UL Fire Resistance Directory Through Penetration Firestop Systems (XHEZ)
31. Standards identified in individual Technical Sections.
32. Standards identified in other Divisions and Sections referenced herein.

B. Agencies or publications referenced herein refer to the following:
1. ANSI American National Standards Institute
2. ASIS American Society of Industrial Security
3. ASME American Society of Mechanical Engineers
4. ASTM American Society for Testing and Materials
5. BICSI Building Industry Consulting Services International
6. FIPS Federal Information Processing Standards
7. FCC Federal Communications Commission
8. ICEA Insulated Cable Engineers Association
9. IEEE Institute of Electrical and Electronics Engineers
10. NEC National Electrical Code
11. NECA National Electrical Contractors Association
12. NEMA National Electrical Manufacturers Association

13. NESC National Electrical Safety Code
14. NETA National Electrical Testing Association
15. NFPA National Fire Protection Association
16. NIST National Institute of Standards and Technology
17. OSHA Occupational Safety and Health Administration
18. TIA Telecommunications Industry Association
19. UL Underwriters Laboratories, Inc.

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

1.06 DEFINITIONS

A. The following definitions are applicable to security environments and shall apply to this document and its companion sections for clarification and direction.

1. Auxiliary Intelligent Controllers (AIX) or Auxiliary I/O Controllers (AIO): Controllers that are located near a served access control door and not in the Master Intelligent Controller location.
2. Cable: Assembly of one or more conductors or optical fiber strands within enveloping sheath, constructed so as to permit use of conductors singly or in groups.
3. Cable ID: Unique alpha-numeric identification used for tagging of backbone or horizontal cabling.
4. Configuration: Initial physical and logical connection and set up of equipment and devices to provide specified features and functionality
5. Contractor: Electronic Safety and Security Contractor or sub-contractor(s) responsible for installation, termination, test and documentation of Electronic Safety and Security equipment, devices, cabling, pathway hardware, equipment room hardware, and related components detailed in technical sections of this Division of work.
6. Controller Location: Location in building having Master or Auxiliary Intelligent Controller. Where this term is presented with an initial capital letter, this definition applies.
7. Credential: Data assigned to an entity and used to identify that entity.
8. Entrance Facility: An entrance to building for both public and private network service cables and/or wireless services including entrance point of building and continuing to Entrance Room.
9. Entrance Room: Room where both public and private network service cables and/or wireless services are terminated. Service provider(s) point-of-demarcation (DEMARC) is typically located here.
10. Equipment Room (Electronic Safety and Security): An environmentally controlled centralized space for Electronic Safety and Security equipment that usually houses head end equipment, servers, control panels, power supplies, and systems wiring and cabling terminations.
11. F/UTP: Foiled Unshielded Twisted Pair. No shielding around individual pairs and an overall foil shield under the cable jacket.
12. Guarantee: Promise or an assurance that attests to quality or durability of product or service or that task will be performed in specified manner. Used interchangeably with "Warranty" in these documents.
13. Identifier: Credential card, keypad personal identification number, or code, biometric characteristic, or other unique identification entered as data into entry-control database for purpose of identifying an individual. Where this term is presented with an initial capital letter, this definition applies.
14. Intelligent Controller: Access control controller containing a database of credential holders and system operation parameters that allow it to operate independently from system Server when communications between Server and the Intelligent Controller is not available.

15. Intra-building: Within single building.
16. Inter-building: Between 2 or more buildings.
17. I/O controllers: Input/Output controllers that provide a wiring interface to field devices,
18. IP Telephony: Use of Internet Protocol (IP) for two-way transmission of conversations. Also referred to as “Voice over Internet Protocol (VoIP)”.
19. Lightning Protection Zone (LPZ): IEC standard (62305-4) for lightning protection. The Lightning Protection Zone concept is based on the idea of gradually reducing lightning energy to a safe level so that it won’t cause damage to terminal device.
20. Master Intelligent Controller (MIC): Intelligent controller that connects to Auxiliary Intelligent Controllers or Auxiliary I/O controllers over TCP/IP or RS-232 / RS-422 / RS-485 communications networks.
21. PC: Personal computer. Applies to main and auxiliary workstations.
22. Programming – Implementation of owner-, customer-, user-, project- or site-specific system settings to complete system functionality.
23. Proximity: Credential technology that is based on electro-magnetic principles and incorporates specially treated wires embedded in the credential.
24. Rack Unit: Standard measurement of vertical mounting space on an equipment rack. Each Rack Unit is 1-3/4” high.
25. Server: Computer configured as access control system application and file server.
26. Service Loop: Surplus cable, typically located at or near point of termination, to enable future changes.
27. S/FTP: Screened Foiled Twisted Pair. Individual foil shield around each individual pair and an overall braided shield under the cable jacket.
28. SF/UTP: Screened Foiled Unshielded Twisted Pair. No shielding around individual pairs and overall foil and braided shields under the cable jacket.
29. S/UTP: Screened Unshielded Twisted Pair. No shielding around individual pairs and an overall braided shield under the cable jacket.
30. U/FTP: Unshielded Foiled Twisted Pair. Individual foil shield around each individual pair and no overall braided shield under the cable jacket.
31. UTP: Unshielded Twisted Pair. No shielding around pairs nor overall under cable jacket.
32. Voice over Internet Protocol: Refer to IP Telephony.
33. WAV: Usually uncompressed lossless computer file format used for storage of digital audio data.
34. Wiegand: Cable and signal protocol
35. Windows: Operating system by Microsoft Corporation.
36. Workstation: PC with software that is configured for specific, limited security-system functions.
37. Workstation, Auxiliary: Workstation that provides an auxiliary location for system management more geographically convenient for some staff than the Main Workstation
38. Workstation, Main: Workstation that is primarily used for system management

B. Typical NEMA Enclosures and Usage
   1. Refer to Section 26 0000 – General Electrical Requirements.

1.07 ABBREVIATIONS AND ACRONYMS

A. The following abbreviations and acronyms shall apply to this document and its companion sections for clarification and direction.
   1. 8P8C Eight-Position, Eight-Conductor. Used in clarifying jack type; a.k.a. "RJ-45".
   2. ACMS Access Control **[and Alarm]** Monitoring System
   3. AFF Above Finished Floor
   4. ATM Asynchronous Transfer Mode
   5. AWG American Wire Gauge

6. BAS Building Automation Systems
7. BTU British Thermal Unit
8. CDDI Copper Distributed Data Interface (Cisco Systems trade name for TP-PMD)
9. cm centimeters
10. CM Communications cable rated for General Purpose use
11. CMP Communications cable rated for use in Plenum areas
12. CMR Communications cable rated for use in Risers and vertical runs
13. CP Consolidation Point
14. CPU Central processing unit.
15. °C degrees Celsius
16. °F degrees Fahrenheit
17. DTMF Dual Tone Multi Frequency
18. EAC Electronic Access Control
19. EIA Electronic Industries Alliance
20. EF Entrance Facility
21. ELFEXT Equal-Level Far-End Cross Talk (pair-to-pair)
22. ER Entrance Room
23. EIDF Equipment Intermediate Distribution Facility
24. FDDI Fiber Distributed Data Interface
25. FEXT Far-End Cross Talk
26. ft feet
27. GbE Gigabit Ethernet
28. HC Horizontal Cross-connect
29. HCP Horizontal Connection Point (e.g. for TIA-862)
30. Hz Frequency in Hertz (k = kilo, M = Mega, G = Giga)
31. ID Inside Diameter
32. IDF Intermediate Distribution Frame
33. in inch
34. IPT IP Telephony
35. kg kilogram
36. lbs pounds
37. LAN Local Area Network
38. MATV Master Antenna Television
39. MC Main Cross-connect
40. MDF Main Distribution Frame
41. MTR Main Telecommunications Room
42. m meters
43. mm millimeters
44. Mbps Megabits per second
45. µm micrometer (10^{-6} meter)
46. N Newton
47. NEXT Near End Cross Talk
48. OD Outside Diameter
49. OFNP Optical Fiber Nonconductive Plenum
50. OFNR Optical Fiber Nonconductive Riser
51. OTDR Optical Time Domain Reflectometer
52. PBX Private Branch Exchange (Telephone Switch)
53. pF pico-Farad (10^{-12} Farad)
54. PoE Power-over-Ethernet
55. PSNEXT Power Sum Near End Cross Talk
56. PVC Polyvinyl Chloride

57. RF Radio Frequency.
58. ROM Read-Only Memory. ROM retains data through power losses.
59. RU Rack Unit
60. sq ft square feet (area)
61. TCP/IP Transport Control Protocol / Internet Protocol
62. TO Telecommunications Outlet
63. TP-PMD Twisted Pair Physical Medium Dependent
64. TR Telecommunications Room
65. UPS Uninterruptible Power Supply
66. USB Universal Serial Bus
67. USOC Universal Service Ordering Code
68. VoIP Voice over Internet Protocol
69. WAN Wide Area Network
70. WLAN Wireless Local Area Network
71. WMP Windows Media Player

B. Refer also to technical sections for additional terminology.

1.08 LISTING

A. Refer to technical sections of this Division of work for listing requirements.

1.09 SUBMITTALS

A. Submit shop drawings for equipment provided under this Section:
   1. Refer to Division 01 - Submittal Procedures.
   2. Provide documentation demonstrating compliance with requirements specified in 280000 - 1.13 - Quality Assurance below.
   3. Note that for satisfying submittal requirements for Division 28, "Product Data" is usually more appropriate than true "Shop Drawings" as defined in Division 01. However, expression "Shop Drawings" is generally used throughout specification.
   4. Mark catalog sheets and drawings to indicate specific items submitted.
      a. Markings shall be reproducible (arrow, boxed, encircled, checkmark, etc.).
      b. Where sheet includes multiple product options, mark proposed option(s).
   5. Include proper identification of equipment by name and/or number, as indicated in specification and shown on drawings.
   6. When manufacturer's reference numbers are different from those specified, provide correct cross-reference number for each item. Mark and annotate submittals accordingly.
   7. Group submittals by Section to include complete documentation of related systems, products and accessories. Where applicable, dimensions shall be marked in units to match those specified.
   8. Submittals shall be in electronic form or on paper per Division 01.
      a. Documents in electronic form shall be ADOBE *Acrobat* PDF.
      b. Paper documents shall be original catalog sheets or photocopies thereof.
      c. Facsimile (fax) sheets will not be accepted.
   9. Engineer’s Review is to confirm compliance with performance, interoperability, physical, and other pertinent requirements of project. Review is not to confirm quantities nor that all required items have been submitted.
   10. When equipment and items specified include accessories, parts and additional items under one designation, submittals shall be complete and include required components.
   11. Include wiring diagrams for electrically powered or controlled equipment.
   12. Submit equipment room layouts drawn to scale, including equipment, raceways, accessories and clearance for maintenance.

13. Where submittals cover products containing potentially hazardous non-metallic materials, include "Material Safety Data Sheet" (MSDS) from manufacturer stating physical and chemical properties of components and precautionary considerations required.
14. Submit shop drawings or product data as soon as practicable after signing contracts. Submittals must be approved before installation of materials and equipment.
15. Submittals, which are not complete, not permanent, or not properly checked by Contractor, will be returned without review.
16. "Coordination Drawings", which are normally prepared by Contractor to coordinate work among various trades and to facilitate installation, shall not be submitted for Division 28 work unless specifically requested in technical sections. These types of drawings typically include dimensioned piping, ductwork, communications and/or electrical raceway layouts.
    a. Unless specifically requested in Division 28 technical sections, submittals of coordination drawings will be returned without review.

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

C. Operation and Maintenance Manuals:
1. Refer to Division 01 - Operation and Maintenance Data.
2. Upon completion of work but before final acceptance of system, submit to Architect for approval, 3 copies of operation and maintenance manuals in loose-leaf binders. If "one copy" is larger than 2” thick or consists of multiple volumes, submit only one set initially for review. After securing approval, submit 3 copies to Owner.
3. Manuals shall be organized by specification section number and shall have table of contents and tabs for each piece of equipment or system.
4. Manuals shall include the following:
    a. Copies of shop drawings
    b. Manufacturer's operating and maintenance instructions. Include parts lists of items or equipment. Where manufacturer's data includes several types or models, applicable type or model shall be designated.
    c. CD ROM's of O&M data with exploded parts lists where available
    d. Phone numbers and addresses of local parts suppliers and service companies
    e. Internet/WEB page addresses where applicable
    f. Wiring diagrams
    g. Start up and shut down procedure
    h. Factory and field test records
    i. Additional information, diagrams or explanations as designated under respective equipment or systems specification section
5. Instruct Owner's representative in operation and maintenance of equipment. Instruction shall include complete operating cycle on all apparatus.
6. O&M manuals and instructions to Owner shall be provided prior to request for final payment.

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

1.010 JOB CONDITIONS

A. Building Access:
1. Arrange for necessary openings in building to allow for admittance of all apparatus.

B. Cutting and Patching:

1. Refer to General Conditions of Contract, and Division 01 - Cutting and Patching.
2. Perform cutting and patching required for complete installation of systems unless otherwise noted. Patch and restore work cut or damaged to original condition. This includes openings remaining from removal or relocation of existing system components.
3. Provide materials required for patching unless otherwise noted.
4. Do not pierce beams or columns without permission of Architect and then only as directed. If openings are required through walls or floors where no sleeve has been provided, hole shall be core drilled to avoid unnecessary damage and structural weakening.
5. Where alterations disturb lawns, paving, walks, etc., replace, repair or refinish surfaces to condition existing prior to commencement of work. This may include areas beyond construction limits.

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

1.011 WORK BY OWNER

A. Owner will provide:
1. Telecommunications service, including voice and data / internet
2. Active telephone electronics, including analog/digital/VoIP private branch exchange (PBX), telephones, fax machines, and modems, for interface with building structured cabling systems
3. Active Ethernet networking electronics, including modems, routers, firewalls, switches, wireless Ethernet access points, for interface with building structured cabling systems
4. Active office electronics, including server computers, data storage appliances, workstation computers, scanners, and printers
5. Connections from active telephone and Ethernet networking electronics to Contractor provided structured cabling.

1.012 QUALITY ASSURANCE

A. Refer to the individual technical sections for general product quality requirements, manufacturer qualifications, and contractor qualifications and certification requirements.

B. Products
1. Only products of reputable manufacturers, as determined by Architect/Engineer, will be acceptable. Manufacturers shall have minimum of five (5) years of documented experience in designing, manufacturing, delivering, and supporting specified material.
2. Where contract documents require a product, material, or assembly that hasn't been specified by brand or trade name, provide product, material, or assembly meeting specified requirements, as supplied and warranted by system vendor. If system vendor does not offer product, material, or assembly, provide product, material, or assembly per system vendor's recommendation.

C. Contractor
1. Contractor shall have minimum of five (5) years' documented experience providing and servicing specified equipment, devices, components, materials, and systems.
2. Contractor shall have documented history of successfully completing minimum of three (3) projects of scope and magnitude equal to or greater than that specified in Contract Documents.
3. Contractor shall have a minimum of five (5) years' documented history of being continuously current on manufacturer's training and certifications applicable to specified equipment, devices, components, materials, and systems they propose for use on project.

4. Contractor shall have a minimum of five (5) years' documented history of being certified by manufacturer to offer and support manufacturer warranties applicable to specified equipment, devices, components, materials, and systems they propose for use on project.
5. Contractor's staff assigned as project manager, site superintendent, and foreman shall each have documented history of successfully completing minimum of three (3) projects of scope and magnitude equal to or greater than that specified in Contract Documents.
6. Contractor's staff assigned as site superintendent and foreman and Contractor's staff assigned to perform installation, termination, configuration, programming, and testing shall have minimum of three (3) years' documented experience of being continuously, individually certified by manufacturer on specified equipment, devices, components, materials, and systems proposed and approved for use on project.
7. Contractor shall have in-house service department staffed with technicians who are individually manufacturer-certified to install and service specified equipment, devices, components, materials, and systems proposed and approved for use on project, and who are equipped with tools, equipment, materials, etc. necessary to install and service specified equipment, devices, components, materials, and systems proposed and approved for use on project.
    a. Contractor's in-house service department shall offer maximum 8-hour] on-site service call response time 24 hours a day, 7 days a week, 365(6) days a year.
8. Contractor and subcontractor(s) shall only employ workers who are properly trained to execute work being performed and are skilled in their trade.
9. Contractor and subcontractor(s) shall own and maintain equipment, tools, etc. to execute work performed in manner consistent with laws, codes, regulations, ordinances, standards, guidelines, industry best practices, manufacturer's instructions, etc.. Workers shall be properly trained in use of equipment, tools, etc. necessary for them to complete work performed.
10. Inability to demonstrate compliance with requirements listed above shall disqualify Contractor from self-performing work conveyed by contract documents, and Contractor shall then, at no additional cost to Owner, subcontract with another firm qualified to perform work.

D. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): "The articles listed in FAR 25.104(a) that are acquired as construction materials."

1.013 GUARANTEE

A. Refer to Division 01 for general Guarantee (Warranty) requirements.
B. Refer to technical sections for Guarantee requirement for each system.
    1. Where no guarantee requirements are called out, guarantee as called out in Division 01 for equipment, materials, and workmanship to be free from defect.
C. Repair, replace or alter systems or parts of systems found defective at no extra cost to Owner.
D. Wherein fulfilling requirements of any guarantee, if Contractor disturbs any work guaranteed under another contract, restore such disturbed work to condition satisfactory to Architect and guarantee such restored work to same extent as it was guaranteed under such other contract.
E. Guarantees shall include labor, material and travel time.

1.014 ANNUAL SERVICE CONTRACT

A. Provide annual cost and complete terms and conditions for extended service and maintenance warranty after the first year for the Electronic Access Control Video Surveillance systems in accordance with the following terms:
    1. Project warranty term shall begin on the date of system acceptance and shall continue for one (1) year.

2. If accepted by Owner, extended service and maintenance warranty term shall begin upon expiration of project warranty. At the Owner's option, the term may be automatically renewed for successive one-year periods unless cancelled by the Owner.
3. Annual cost quoted for extended service and maintenance warranty shall include in the base cost each item and service listed herein, including equipment, devices, materials, parts, firmware, software, labor, travel, etc.
4. Service and maintenance provided under the base annual cost for extended service and maintenance warranty shall include:
    a. Repair or replace any system equipment item that fails to perform as initially installed, as specified, or as determined per the manufacturer's performance criteria.
    b. Perform semi-annual preventive maintenance on the system equipment. This preventive maintenance shall include, but is not limited to, cleaning, realignment, inspection, and testing. The Owner shall receive a written report of these inspections that documents system equipment and device status and, if required, a list of all necessary repairs or replacements.
    c. Provide software maintenance on the system. Install and configure each manufacturer-provided firmware and software update. Any additional software options, updates, or enhancements purchased by the Owner shall be installed. The Contractor shall not be responsible for the purchase of additional software packages or the maintenance of Owner data.
5. Owner shall compensate Contractor for repairs or maintenance required as a result of Owner abuse, misuse, intentional damage, accidental damage, or power fluctuations exceeding specified equipment tolerances.
6. System defects or failures shall be corrected within four (4) hours on the same business day if the Owner makes a service request before 11:00 a.m., or before 12:00 noon the next business day if the Owner makes the request after 11:00 a.m. If requested by the Owner, the Contractor shall respond or remain at the site after normal business hours, and the Owner shall reimburse the Contractor for the incremental cost difference between premium labor rates and standard labor rates. This reimbursement applies to premium labor rates that do not exceed time-and-one-half rates after normal business hours and double-time rates for Sundays and holidays. The Contractor's services shall be performed in a good and workmanlike manner and remain free from defects for a period of one (1) year following completion of service.

B. The Owner will enter into a contract directly with the vendor. This specification is not a contract between the Owner and the vendor to perform these services.

PART 2 - PRODUCTS

2.01 GENERAL

A. Provide new materials, unless specifically noted otherwise in the contract documents.
B. Where manufacturer has replaced part number with newer part number, provide material version that is manufacturer's most current offering available at time of installation.
C. Where manufacturer has published end of life or similar notice for part number, notify Architect/Engineer of notice and manufacturer's recommended substitution. Where manufacturer offers no substitution, provide Architect/Engineer three (3) options for acceptable alternates.
D. Where multiple manufacturers' names or manufacturers' names and part numbers are listed, basis of design listed shall be considered benchmark for quality, features, and functionality for that material.
E. Include hardware, details, options, modules, accessories, subassemblies, etc. not shown or specified, but necessary for proper installation and operation.

F. Where one or more of same item of material is required, all such units shall be provided as same manufacturer and part number.
G. Refer to technical sections for additional information and requirements.

2.02 PRODUCT SUBSTITUTIONS

A. Refer to Division 01 - Product Requirements.
B. Unless noted otherwise and in accordance with Division 01, prior to submittal submission Contractor may choose to propose equivalent material from another manufacturer not listed herein.
   1. Refer to Division 01 for product substitution request requirements.
   2. Where Contractor chooses to propose other material they believe to be equivalent, Contractor is solely responsible for demonstrating that alternate material being proposed meets requirements specified in project documents for that material, is demonstrably equivalent to listed basis of design, and fits in the allocated space.
   3. Architect/Engineer shall make final determination as to whether the proposed alternate material is equivalent and acceptable for use on the project.

PART 3 - EXECUTION

3.01 GENERAL

A. Verify elevations and measurements prior to installation of materials.
B. Refer to Division 01 for additional information and requirements.

3.02 DELIVERY, STORAGE, AND HANDLING

A. Refer to Division 01 for additional information and requirements.
B. Transport, handle, and store materials in manner that avoids damage, preserves their original condition as delivered from manufacturer, is consistent with manufacturer's guidelines and instructions, and maintains applicable manufacturer warranties.
   1. Protect material from deleterious substances, agents, contaminants, and conditions, including dust, dirt, debris, moisture, chemicals, chemical compounds, corrosion, temperatures outside material's published tolerance range.
   2. Protect material from damage due to intentional or incidental contact, vandalism, neglect, etc.
C. Handle materials in accordance with recommended procedures, precautions, and remedies described in material safety data sheets, where applicable.
   1. Where applicable, lift only with lugs provided for purpose.
D. Store materials in clean, dry, secure, temperature-controlled location.
E. Maintain manufacturer's original material packaging and shipping packaging until material is installed.
F. Contractor shall include in their bid costs to deliver, store, and handle materials.

3.03 WORK LOCATIONS

A. Field-verify locations, elevations, measurements, etc. prior to material installation.
B. Electronic Safety and Security equipment and device locations shown on drawings are diagrammatic and shall not be used for dimensioning of final locations. Field-coordinate locations, elevations, measurements, etc. with Owner and with other trades prior to material installation.
   1. Where architectural features govern work location and where areas are dense with work of multiple trades, refer to Architectural contract documents.
   2. Where work by other trades governs work location, refer to the contract documents of other trade.

3. Check, verify, and coordinate work with other trades' contract documents and include modifications, relocations, adjustments, etc. necessary to complete work and prevent interference with other trades.
4. Contract includes connections to equipment provided by others. Refer to other trades' contract documents and to final shop drawings for exact equipment, device and connection locations.

C. Locate equipment and devices to fit space conditions. Owner and Architect reserve right to make minor position changes of equipment and device locations before work has been installed.
D. Contractor shall survey site and include in their bid costs to perform work as specified in contract documents.
E. Where conditions on site require adjustments to indicated locations and/or arrangements of equipment and devices, Contractor shall make required changes at no additional cost to Owner.

3.04 FLOOR, WALL, ROOF AND CEILING OPENINGS

A. Coordinate location of openings, chases, furred spaces, etc. with appropriate Contractors. Provide during progress of construction sleeves and inserts that are to be built into structure.
B. Temporary sleeves, if used to form wall openings, shall be removed prior to installation of permanent materials. Permanent sleeves for wall penetrations shall be minimum 24 ga galvanized sheet metal unless otherwise noted.
C. Steel sleeves, when required, shall be Schedule 40 carbon steel pipe with integral water stop.
D. For core drilled holes, size and location shall be reviewed and approved by Structural Engineer prior to execution.
E. Submit product data and installation details for penetrations of building structure. Submittal shall include schedule indicating penetrating materials, (including steel conduit, PVC conduit, cables, cable tray), sizes of each, opening sizes and sealant products intended for use.
F. Where penetrations of fire-rated assemblies are involved, seal penetrations with appropriate firestopping systems as specified in Division 26.
G. Openings for penetrations shall be minimum 1/2" larger on all sides than outside dimensions of raceways or cables. However, where fire resistant penetrations are required, size openings in accordance with recommendations of firestopping systems manufacturer.
H. Seal non fire-rated floor penetrations with non-shrink grout equal to Embeco by Master Builders, or urethane caulk, as appropriate.
I. Seal non-rated wall openings with urethane caulk.
J. Where penetrations occur through exterior walls into building spaces, use steel sleeves with integral water stop, similar to type "WS" wall sleeves by Thunderline Corporation. Seal annular space between sleeves and pipe with "Link-Seal" modular wall and casing seals by Thunderline Corporation, or sealing system by another manufacturer approved as equal by Architect. Sealing system shall utilize Type 316 stainless steel bolts, washers and nuts.
K. Finish and trim penetrations as shown on details and as specified hereinafter.
L. Provide chrome or nickel plated escutcheons where raceways pass through walls, floors or ceilings and are exposed in finished areas. Size escutcheons to fit raceways for finished appearance. Finished areas shall not include mechanical/electrical rooms, janitor's closets, storage rooms, etc., unless suspended ceilings are specified.

3.05 EQUIPMENT ACCESS

A. Install raceways, junction and pull boxes, and accessories to permit access to equipment for maintenance. Relocation of raceways, or accessories as required to provide access, shall be provided at no additional cost to Owner.

B. Install equipment with ample space allowed for removal, repair or changes to equipment. Provide ready accessibility to equipment and wiring without moving other equipment, which is to be installed or which is already in place.
C. Access doors in walls, chases, or inaccessible ceilings will be provided under Division 08 - Access Doors and Frames, unless otherwise indicated. Access doors shall be for purpose of providing access where equipment requiring servicing, repairs or maintenance is located in walls, chases or above inaccessible ceilings.
D. Provide necessary coordination and information to Trade Contractor under Division 08 - Access Doors and Frames. This information shall include required locations, sizes and rough-in dimensions, without limitations.
E. Locate communications outlets and equipment to fit details, panels, decorating or finish at space. Architect reserves right to make minor position changes of outlet locations before work has been installed.
F. Verify room door swings before installing wall-mounted communications outlets and install boxes on latch side of door unless otherwise noted.

3.06 EQUIPMENT SUPPORTS

A. Provide supporting steel not indicated on drawings as required for installation of equipment and materials including angles, channels, beams, hangers.
B. Concrete anchors, used for attachment to concrete, shall be steel shell with plug type. Plastic, rawhide or anchors utilizing lead are not allowed.
C. Do not support equipment or cable pathways from metal roof decking.

3.07 SUPPORT PROTECTION

A. In occupied areas, mechanical rooms and areas requiring normal maintenance access, certain equipment must be guarded to protect personnel from injury.
B. Provide minimum 1/2” thick Armstrong Armaflex insulation or similar product applied with Armstrong 520 adhesive on lower edges of equipment, including bus duct, cable tray, pull boxes and electrical supporting devices suspended less than 7 ft above floors, platforms or catwalks in these areas.
C. Threaded rod or bolts shall not extend beyond supporting element and shall be protected as described above.

3.08 CABLE AND CONDUCTOR PROTECTION

A. Protect cabling and termination components from contact with, and potential application of, foreign materials.
    1. Foreign material is defined as material that is not part of cabling assembly and termination components when delivered from manufacturer.
    2. Examples include paint overspray and drywall compound.
B. Cabling and components that come into contact with foreign materials shall be replaced at no cost to project.
    1. Solvents and other cleaning agents shall not be used to remove foreign materials that have already accumulated on cabling and components.

3.09 HOUSEKEEPING PADS

A. Not applicable to this Division of work.

3.010 INSTALLATION

A. Pre-Installation Inspection
    1. Prior to commencement of work on site, Contractor shall inspect site to evaluate whether site conditions are sufficiently consistent with Contract Documents to support and facilitate execution of specified work and specified system performance.
    2. Contractor shall prepare and submit to Architect/Engineer and Owner report documenting observed inconsistencies that may impact execution of specified work or specified system

performance. Report shall include photographs, annotated drawings, and written descriptions to clearly and completely document observed inconsistencies, and itemized recommendations and cost estimates for remediation of each observed inconsistency.
   a. Contractor shall not take steps to remediate observed inconsistencies without written direction from Architect/Engineer and Owner.
3. Commencement of work on site indicates Contractor's confirmation that existing conditions support and facilitate execution of specified work and specified system performance. Contractor shall be solely responsible for costs to remediate inconsistencies that went unreported prior to the Contractor's commencement of work on site.

B. General
1. Refer to manufacturer's product installation instructions, recommendations, and guidelines for additional information and requirements. If discrepancy is identified between Contract Documents and manufacturer's product installation instructions, more stringent requirement shall govern.
2. Cable, devices, equipment, etc. shall not be installed until building is enclosed and weather tight, and temperature and humidity conditions are controlled continuously at levels approximately equivalent to final conditions expected after occupancy.
3. Cable, devices, equipment, etc. shall not be installed in areas where installed materials would be exposed to moisture, dust, overspray, or other deleterious conditions.
4. No equipment, devices, cable, etc. shall be installed in Communications Equipment Rooms until room is broom clean and free of debris, dirt, dust, moisture, foreign materials, etc. and room is equipped with operable door that can be closed and latched to prevent ingress of deleterious conditions.
5. Protect installed cable, devices, equipment, etc. from damage through completion of construction and date of Owner's final acceptance.

C. Rough-In
1. Coordinate pathway requirements with Division 26 prior to commencement of work on site.
2. Where Division 28 equipment or device is provided with equipment- or device-specific back box, Contractor shall provide back box to Division 26 prior to commencement of rough-in work on site.
3. Unless noted otherwise, install conduit concealed in walls and ceilings. Exposed conduit in utility spaces and unfinished spaces is acceptable.
4. Unless noted otherwise, install pathways and raceways parallel and perpendicular to major building orientation.
5. Provide pathways and raceways complete with cable bend radius control fittings and accessories to maintain minimum bend radius of installed cables where cables transition into or out of and between sections of pathway or raceway.
6. Unless noted otherwise, no flexible conduit of any type shall be used.

D. Cable and Conductors
1. Cable shall be listed for installation in environment in which it is installed.
   a. Cable installed in buried conduit, in-slab conduit where slab is poured on grade, or exterior or outdoor conduit or raceway shall be rated for outdoor installation.
2. No cable or conductor shall be fished bare through interior of any enclosed, inaccessible ceiling, wall, or floor structures. Where such installation is required, fish flexible metallic conduit through structure, secure flexible metallic conduit at both ends, provide protective bushings at both ends, and install cable inside flexible metallic conduit.
3. Install cabling in pathways provided, or as designated on floor plans, and support from building structure.
4. Provide pull cord **(**200 lb minimum) with cable installed in conduit or innerduct.

5. Cable and conductors installed shall be free of defects and damage. Provide required installation tools to facilitate cable and conductor installation without damaging cable and protect cable and conductors from damage. Visually inspect cable during installation for damage or defects, including cuts, blisters, and abrasions. Provide permanent abrasion protection at points where cable or conductors contact surface that could damage cable or conductors.
6. Pull cable by hand unless installation conditions require mechanical assistance.
7. Do not exceed recommended pulling tensions or bending radii during cable installation.
    a. Where mechanical assistance is used, ensure that maximum tensile load for cable is not exceeded.
        1) This may be in form of continuous monitoring of pulling tension, use of "break-away" fitting, or other approved method.
    b. Replace cables bent or kinked to radius less than recommended dimension.
        1) This shall be at no expense to Owner.
8. Pulling lubricant may be used and shall:
    a. Be non-injurious to cable jacket and other materials used.
    b. Not harden or become adhesive with age.
9. Provide an adequate number of workers during cable and conductor pulling operations to observe cable or conductors at points of entry into and exit out of pathways, to feed cable and conductors, and to operate pulling machinery.
10. Cable and conductors shall be installed continuous and splice-free.
11. Installed cable and conductors shall be free of tension.
    a. In cases where cable must bear stress, provide Kellems-type grips to distribute stress over greater length of cable.
12. Maintain manufacturer’s published minimum bend radius on installed cable and conductors. Provide permanent bend radius protection at points where cable and conductors change direction.
13. Unless noted otherwise, install cable and conductors parallel and perpendicular to major building orientation.
14. Cable and conductors shall be kept clear of and protected from work by other trades.
15. No cable or conductor shall be attached to or supported in any manner by work by other trades.
16. No cable or conductor shall be laid on accessible ceiling grid or tiles, or attached or supported in any manner by accessible ceiling tiles, grid, or support wires.
17. In vertical pathway, support cables on each floor using industry recognized support methods designed specifically for that purpose.
    a. Strap vertical runs as required to prevent sagging of cables.
18. Route and support cable in Equipment Rooms utilizing horizontal overhead cable runway, wall-mounted vertical cable runway, and wall-mounted "D-type" mounting rings.
19. Neatly lace, dress, and support cabling and conductors.
20. To reduce effects of EMI, adhere to the minimum cable separation distances defined in TIA-569-E.
21. Provide 6 feet of cable slack at each device, coiled and stored neatly on cable tray or last J-hook in the nearest accessible ceiling above the device.]
22. Coordinate surge suppression of devices mounted to the building and/or outside the building’s lightning protection zone with the electrical engineer during the design phase, understanding that different device locations may require different surge suppression strategies.
23. Where cable serves exterior or outdoor equipment and devices located outside of the Lightning Protection Zone, provide surge suppression for each signal conductor in cable.

Surge suppression device shall be bonded to an appropriate ground source in accordance with manufacturer's recommendations.

E. Equipment and Device Termination
   1. Install and tighten connectors per manufacturer's instructions, using appropriate tools recommended by manufacturer for that purpose. Do not strip or damage connectors, terminals, equipment or devices by over-tightening terminations.
   2. Unless noted otherwise, terminations for devices equipped with wire pigtail style connections shall be made only by irreversible means.
   3. Cable and conductor color coding shall be maintained consistent throughout the installation for each equipment and device type.
   4. Provide minimum of 12 inches of slack at cable and conductor termination points.
   5. At exterior and outdoor equipment and devices not attached directly to the exterior of the building, provide surge suppression for each signal conductor.

F. Equipment
   1. Prior to ordering materials, coordinate final power requirements with Electrical Contractor for equipment and devices requiring power. Coordination shall include:
      a. Voltage
      b. Amperage
      c. Connection type and plug configuration
      d. Minimum and maximum allowable conductor sizes
   2. Prior to commencement of work on site, coordinate with General Contractor for structural, backing material, concrete embedments, etc. to support work under this Section.
   3. Unless noted otherwise, install wall mounted equipment in Equipment Rooms between +18" AFF and +72" AFF.

G. Configuration and Programming
   1. Coordinate configuration and programming with Owner prior to commencement of configuration and programming work.
   2. Coordinate Ethernet network requirements with Owner minimum of six weeks prior to commencement of programming work. Coordination shall include:
      a. IP address
      b. Subnet mask
      c. Default gateway
      d. TCP port numbers for active inbound and outbound connections
      e. UDP port numbers for active inbound and outbound connections
      f. VPN assignment
      g. VLAN assignment
      h. IP multicast functionality (yes/no)
   3. Change logins and passwords from manufacturer defaults upon first system startup, prior to commencement of configuration or programming work, and delete default accounts, logins, etc. that exist within manufacturer's standard software, firmware, configuration, programming, etc. Coordinate logins with Owner prior to commencement of configuration or programming work. At minimum, passwords used during execution of installation, configuration, programming, testing, commissioning, etc. work shall conform to Owner's in-house password requirements, conform to NIST SP 800-63B recommendations, and:
      a. Shall consist of minimum of eight (8) printable ASCII characters
      b. Shall not include repetitive or sequential characters, e.g. 'aaaaaa', '1234abcd', etc.
      c. Shall not include context-specific words, e.g. name of service, username, derivatives thereof, etc.

4. Configure servers, computers, IP-enabled equipment and devices, etc. to conform to Owner's in-house configuration, access, and security standards and requirements. Unless noted otherwise, configure servers, computers, IP-enabled equipment and devices, etc. to:
    a. Use a VLAN dedicated solely to equipment and devices of system being supported and inaccessible from rest of Owner's Ethernet network.
    b. Disable Universal Plug and Play (UPnP).
    c. Be inaccessible from outside Owner's Ethernet network.
        1) Where connections to/from outside Owner's Ethernet network are specified, such connections shall use data protection, data validation, and endpoint verification.
            a) Digital Certificates shall be obtained from Certificate Authority recognized as valid in default internet browser software available from Microsoft, Google, Apple, and Mozilla.
            b) Self-signed Digital Certificates shall not be accepted.
    d. Be inaccessible from endpoints on Owner's Ethernet network not essential to system operation.
        1) Where connections to/from endpoints on Owner's Ethernet network not essential for system operation are specified, such connections shall use data protection, data validation, and endpoint verification.
            a) Digital Certificates shall be obtained from Certificate Authority recognized as valid in default internet browser software available from Microsoft, Google, Apple, and Mozilla.
            b) Self-signed Digital Certificates shall not be accepted.
    e. Provide only minimal services required to support intended functions.
    f. Close virtual ports not required to support intended functions.
    g. Use IP address filtering to allow connections only to known devices that are part of same system.
    h. Where devices are IEEE 802.1X capable, enable IEEE 802.1X port-based network access control.
    i. Where devices are IPsec capable, enable IPsec packet encryption.
5. At no additional cost to Owner, apply manufacturer-issued operating system, software, firmware, etc. updates, patches, hotfixes, configuration updates, etc. to ensure operating system, software, firmware, configuration, etc. is current upon system turnover to Owner.
    a. Prior to application, coordinate operating system updates, patches, hotfixes, etc. with Owner to ensure conformance to Owner's internal version standards.
6. Upon system turnover to Owner, change passwords to Owner-defined passwords. Coordinate passwords with Owner prior to system turnover.

3.011 INSPECTION AND TESTING

A. General
    1. Submit with shop drawings documentation of proposed inspection and test procedures.
        a. Inspection and testing shall not commence without Architect/Engineer's approval of proposed procedures. Commencement of inspection and testing without Architect/Engineer's approval of proposed procedures shall be grounds for Architect/Engineer and Owner to reject documentation of related inspection and testing and require repeat of related inspection and tests at no additional cost to Owner.
    2. Prior to testing, visually inspect work to verify completion and compliance with applicable requirements.
    3. Coordinate and schedule testing to be complete minimum of fifteen (15) working days prior to scheduled occupancy, such that Architect/Engineer and Owner have minimum of ten

(10) working days to review draft test results and Owner has minimum of five (5) working days to prepare phase area for occupancy.

4. Conduct tests during course of construction when identifiable portion(s) of installation is complete.
    a. Alternatively, testing may be conducted after entire installation is complete, where doing so does not delay project schedule.
5. Coordinate testing of work under this Division connected to or integrated with work under other sections with contractors of other trade(s) involved.
6. Owner and/or Architect/Engineer may, at their option, be in attendance to witness testing. Submit proposed schedule for acceptance testing to Owner and Engineer minimum of ten (10) working days in advance to facilitate their participation.
7. Provide equipment and personnel to conduct acceptance tests.
8. Work shall be 100% fault free, unless otherwise noted. Where systems, equipment, devices, cable, etc. fail to meet required performance on criteria under test, replace or repair defective work and/or materials at no additional cost to Owner and repeat inspection and test. Replacement materials shall be new.

B. Testing Cable
1. Test installed cable in accordance with applicable standards and cable manufacturer's and equipment manufacturer's published requirements, guidelines, and best practices.
2. At minimum, testing of installed cable shall include:
    a. Test for opens on each conductor
    b. Test for conductor to conductor shorts, among all conductors
    c. Test for conductor to ground shorts, for each conductor (where applicable)
    d. Test for compliance with applicable cable performance standards (e.g., Category 3, Category 5e, Category 6, Category 6A, OS2, OM3, OM4, etc.)
        1) Refer to Section 27 1000 for additional information on and requirements for testing structured cabling.
    e. Tests recommended by manufacturer of associated equipment or devices.

C. Testing Devices
1. Verify proper operation of each feature and function of each device.
2. Verify that each device has been configured and programmed in accordance with requirements of project documents and Owner's direction.

D. Test Documentation
1. Document and certify test results in writing.
2. Maintain copies of certified test results, including those for failed tests, at project site through completion of project.

E. Re-Testing
1. Architect/Engineer or Owner may, at their option, request that a random 10% re-test be conducted by this Contractor at no additional cost to Owner to verify documented findings. Re-testing conducted shall be an exact repeat of those conducted and documented previously.
2. Owner may, at their option, also perform independent re-testing to verify documented findings.
3. If re-test findings contradict previous test documentation submitted by Contractor, additional re-testing shall be performed by this Contractor at no additional cost to Owner. The extent of such additional re-testing, including a 100% re-test, shall be determined solely by Architect/Engineer and Owner.

3.012 START-UP

A. Systems and equipment shall be started, adjusted, tested, etc. and turned over to Owner ready for operation.

1. This includes "Owner-Furnished, Contractor-Installed" (OFCI) and "Contractor-Furnished, Contractor-Installed" (CFCI) systems and equipment.

B. Provide services of manufacturer-trained and -certified technician who is knowledgeable in start-up, adjustment, and checkout of systems and equipment provided and is experienced with specific materials provided.
   1. Where Contractor does not employ such a technician directly on their own staff, Contractor shall provide at no additional cost to Owner such services from manufacturer's personnel.

C. Where specified, provide at no additional cost to Owner, services of manufacturer's personnel for start-up, adjustment, and checkout of systems and equipment provided.

D. Follow manufacturer's pre-start-up checkout, start-up, trouble shooting and adjustment procedures.

E. Coordinate start-up with Owner and other trades.

3.013 DOCUMENTATION

A. Upon completion of installation, Contractor shall provide System Documentation. Documentation shall include:
   1. Acceptance Test Results
   2. Record Drawings
   3. All Approved Submittals
   4. Manufacturer's Warranty Documents

B. Submit System Documentation in accordance with Division 01 "Project Record Documents".
   1. Documents shall be submitted in same electronic format in which they were received from Architect and Engineer.
   2. Document updates shall be performed in native software format matching original design team documents.
      a. Scans of hand marked documents shall not be allowed.
   3. Update documents to reflect installed conditions for equipment shown on documents.

C. Submit documentation within ten (10) working days of the completion of testing of each testing phase (e.g. subsystem, cable type, area, floor, etc.) or 3 weeks prior to scheduled occupancy of subject area, whichever is sooner. This is inclusive of Test Result and draft Record Drawings.
   1. Draft drawings may include mark-ups done by hand.
   2. Machine generated (final) copies of Record Drawings shall be submitted within 30 working days of completion of each testing phase.
   3. Documentation will include all aspects of systems covered by these specifications that are required for systems to be fully functional.
   4. For structured cabling this includes the horizontal link from the TO to the HC, backbone cabling from the HC to the MC, cross-connections, interconnections and/or patch cords that are the responsibility of the contractor.

D. Submit Acceptance Test Results in electronic form for review and distribution.
   1. Interim documentation of Test Results (if applicable) may be submitted via email or on CD-ROM.
   2. Final documentation of Test Results shall be submitted on CD-ROM.
   3. Test results shall be submitted in format(s) native to test instrument(s) used in performing testing.
   4. Where unique software (other than an MS-Word™ compatible Word Processor or MS-Excel™ spreadsheet) is required for viewing of test results, Contractor shall provide along with above documentation, (1) licensed copy of such software. Software shall run on MICROSOFT Windows-based personal computer.

E. Acceptance Test results shall include description of sub-system tested, equipment/cable/outlet I.D., reference and test setup, test equipment type/model and serial number(s), equipment

location and direction of test (if applicable), test frequencies/wavelengths, date and operator name(s).

F. Engineer or Owner may request that 10% random re-test be conducted on cable system - at no additional cost - to verify documented findings. Tests shall be a repeat of those defined above and in technical sections.
   1. Owner may also perform independent testing to verify results.
   2. If findings contradict documentation submitted by Contractor, additional testing can be requested to extent determined necessary by Engineer or Owner, including 100% re-test. This re-test shall be at no additional cost to Owner.

G. Documentation - including hard copy and electronic forms of Test Data and Record Drawings - shall become property of Owner.

H. Refer also to Technical Sections for requirements specific to covered subsystems.

3.014 CLEANING

A. Refer to Division 01 for additional information and requirements.

B. Refer to individual technical sections for additional information and requirements specific to work under that section.

C. Contractor shall, periodically, throughout execution of work under this section and/or as directed by Architect/Engineer, Owner, Construction Manager, or General Contractor, remove waste materials, trash, rubbish, debris, etc. generated by execution of work under this section from building and leave work areas broom clean.
   1. Construction waste shall be managed in accordance with provisions of Division 01 Section Construction Waste Management.

D. After installation is complete and prior to Owner's final acceptance, Contractor shall clean work provided under this section.
   1. Remove unused materials, tools, installation equipment, etc. from site.
   2. Faceplates, devices, components, equipment, enclosures, junction boxes, pull boxes, etc. shall be clean and free of stains, dust, dirt, debris, oil, grease, paint, and other foreign material.
   3. Interiors of equipment enclosures, junction boxes, pull boxes, etc. shall be clean and free of wire/cable scraps, pieces of wire/cable insulation, stains, dust, dirt, debris, oil, grease, paint, and other foreign material.
   4. Remove temporary labels not used for instruction or operation.
   5. Walls and floors of Electronic Safety and Security spaces and equipment rooms shall be clean and free of dust, dirt, debris, oil, grease, paint, and other foreign material.
   6. Remove and properly dispose of waste materials, trash, rubbish, debris, etc. generated by execution of work under this section.
   7. Contractor's cleaning protocol shall not damage provided materials or invalidate manufacturer's warranty on provided materials.
      a. Contractor's cleaning protocol shall only include methods and use of solvents, chemicals, compounds, and agents approved by material manufacturer for use on their product.

3.015 TRAINING

A. Refer to Division 01 for additional information and requirements.

B. Refer to technical sections for additional information and requirements specific to work under each section.

C. Contractor shall train Owner's designated representative(s) on systems provided as part of work under this Division. Training shall include:
   1. System topology
   2. Equipment, devices, cable, etc. that constitute installed system
   3. Equipment Room layouts

4. Location of equipment, devices, etc.
5. Labeling scheme logic and label formats
6. Core operating principles (“how it works”)
7. Features and functionality
8. Startup process
9. Operation
10. Execution of tasks
11. Commands
12. Shut down process
13. Restart and recovery process
14. Care and maintenance, including:
    a. Recommended tasks
    b. Recommended schedule / intervals for each task
    c. Step-by-step instructions for execution of each task
    d. Items required to perform each task, including:
        1) Tools
        2) Parts
        3) Consumable materials (cleaners, lubricants, etc.)
15. Troubleshooting, fault diagnosis, and remediation, including:
    a. Common issues and malfunctions
    b. Methods and execution of troubleshooting and fault diagnosis
    c. Step-by-step instructions for execution of remediation:
    d. Items required to perform remediation, including:
        1) Tools
        2) Parts
        3) Consumable materials (cleaners, lubricants, etc.)
16. Contents of Operation and Maintenance Documents and Record Drawings

D. Provide comprehensive manuals prepared to provide written version of specified instruction, and use these written manuals as reference materials during in-person verbal training sessions. Provide manuals in .pdf electronic form, and provide one (1) printed, bound copy of manuals for each Owner’s designated representative attending in-person verbal training sessions, in addition to quantity specified to be provided as part of Operation and Maintenance Documents.
E. In-person verbal training sessions shall include a walking tour component to observe actual work in facility and a “classroom” component based on written manuals.
F. Coordinate training schedules with Owner and Architect/Engineer. No training session shall be scheduled with less than ten (10) business days’ advance notification for attendees.
G. Attendees shall include minimum of six (6) Owner’s designated representatives.
H. Training shall be held at Project Site and shall be conducted on Owner’s standard days of operation during Owner’s standard working hours.
I. Owner may, at their option, videotape training session(s) for use as future refresher materials for Owner’s staff.
J. Refer to technical sections for minimum duration of in-person verbal training sessions specific to work under each section.

END OF SECTION

SECTION 280545
ELECTRONIC SAFETY AND SECURITY SYSTEMS INTEGRATION

PART 1 - GENERAL

1.01 SCOPE

A. This section includes product and execution requirements for Electronic Safety and Security Systems Integration. Unless noted otherwise, work under this section is subject to requirements of Section 28 0000.

1.02 DESCRIPTION

A. Refer to Section 280000 for additional information and requirements.
B. Complete, turnkey Electronic Safety and Security Systems Integration compliant with applicable codes and standards referenced herein and as indicated on drawings.
C. Electronic Safety and Security Systems Integration shall include the following major components:

1.03 RELATED WORK

A. Refer to Section 28 0000 for additional information and requirements.

1.04 REQUIREMENTS OF REGULATORY AGENCIES

A. Refer to Section 28 0000 for additional information and requirements.

1.05 REFERENCES AND STANDARDS

B. Refer to Section 28 0000 for additional information and requirements.

1.06 DEFINITIONS

A. Refer to Section 28 0000 for additional information and requirements.

1.07 ABBREVIATIONS AND ACRONYMS

A. Refer to Section 28 0000 for additional information and requirements.

1.08 LISTING

A. Refer to Section 28 0000 for additional information and requirements.

1.09 SUBMITTALS

A. Shop Drawings:
    1. Refer to Section 28 0000 for additional information and requirements.
    2. Submit an Electronic Safety and Security Systems Integration Schedule that documents details of each integration being provided, including:
        a. Feature or function the integration provides
        b. Systems being integrated
        c. Power requirements
        d. Communication requirements, including:
            1) Nature of physical connection(s) between systems being integrated
            2) Converter and/or adapter hardware required to facilitate physical connections between systems being integrated
            3) Nature of logical connection(s) between systems being integrated
            4) Converter and/or adapter software required to facilitate logical connections between systems being integrated
            5) Custom software required to facilitate logical connections between systems being integrated, including the party in charge of developing the software
    3. Submit sequence of operation for each integration being provided
B. Certificates and Inspections
    1. Refer to Section 28 0000 for additional information and requirements.
C. Operation and Maintenance Manuals
    1. Refer to Section 28 0000 for additional information and requirements.

D. Record Documents
   1. Refer to Section 28 0000 for additional information and requirements.

1.010 JOB CONDITIONS

A. Refer to Section 28 0000 for additional information and requirements.

1.011 WORK BY OWNER

A. Refer to Section 28 0000 for additional information.
B. Owner will provide:
   1. Ethernet Networking Electronics

1.012 QUALITY ASSURANCE

A. Refer to Section 28 0000 for additional information and requirements.

1.013 GUARANTEE

A. Refer to Section 28 0000 for additional information and requirements.

PART 2 - PRODUCTS

2.01 GENERAL

A. Refer to Section 28 0000 for additional information and requirements.

2.02 ELECTRONIC SAFETY AND SECURITY SYSTEMS INTEGRATION CABLE

A. Refer to referenced technical Sections for requirements.

2.03 ELECTRONIC SAFETY AND SECURITY SYSTEMS INTEGRATION HANGERS AND SUPPORTS

A. Refer to referenced technical Sections for requirements.

2.04 ELECTRONIC SAFETY AND SECURITY SYSTEMS INTEGRATION RACEWAYS AND BOXES

A. Refer to referenced technical Sections for requirements.

2.05 ELECTRONIC SAFETY AND SECURITY SYSTEMS INTEGRATION SURFACE RACEWAYS

A. Refer to referenced technical Sections for requirements.

PART 3 - EXECUTION

3.01 PRE-CONSTRUCTION COORDINATION MEETING

A. Prior to preparing and submitting shop drawings, Contractor shall arrange and conduct a pre-construction coordination meeting to review and coordinate Electronic Safety and Security Systems Integration requirements.
   1. Attendees shall include:
      a. Owner’s project manager, security representative, and facilities / buildings and grounds / maintenance representative
      b. Division 28 Engineer
      c. Construction Manager / General Contractor project manager and site superintendent / field foreman
      d. Division 28 project manager and site superintendent / field foreman
      e. Electronic Access Control subcontractor/supplier project manager and system programmer
      f. Video Surveillance subcontractor/supplier project manager and system programmer
      g. Intercom subcontractor/supplier project manager and system programmer
      h. Intrusion Detection subcontractor/supplier project manager and system programmer
   2. Meeting agenda topics shall include:
      a. Review and coordinate details of each integration being provided, including:

1) Feature or function the integration provides
2) Systems being integrated
3) Nature of physical connection(s) between systems being integrated
4) Converter and/or adapter hardware required to facilitate physical connections between systems being integrated
5) Nature of logical connection(s) between systems being integrated
6) Converter and/or adapter software required to facilitate logical connections between systems being integrated
7) Custom software required to facilitate logical connections between systems being integrated, including the party in charge of developing the software
8) Intended operation

b. Coordinate division of work among trades.
c. Review construction schedule and identify milestones related to Electronic Safety and Security Systems Integration

3. Schedule meeting with minimum two weeks' notice.
   a. Publish agenda for meeting and distribute to invited attendees when meeting is scheduled.
4. Take detailed notes during meeting and publish meeting minutes within one week after meeting. Distribute minutes to invited attendees and Architect.

3.02 PRE-INSTALLATION COORDINATION MEETING

A. After Section 28 0545 shop drawings have been approved, Contractor shall arrange and conduct a pre-installation coordination meeting to review and coordinate furnishing and installation of equipment and devices related to Electronic Safety and Security Systems Integration.
   1. Attendees shall include:
      a. Construction Manager / General Contractor project manager and site superintendent / field foreman
      b. Division 26 project manager and site superintendent / field foreman
      c. Division 27 project manager and site superintendent / field foreman
      d. Division 28 project manager and site superintendent / field foreman
      e. Electronic Access Control subcontractor/supplier project manager and system programmer
      f. Video Surveillance subcontractor/supplier project manager and system programmer
      g. Intercom subcontractor/supplier project manager and system programmer
      h. Intrusion Detection subcontractor/supplier project manager and system programmer
   2. Meeting agenda topics shall include:
      a. Review and coordinate details of furnishing and installing equipment and devices related to each integration, including:
         1) Systems being integrated
         2) Requirements for each item of equipment or device involved in the integration:
            a) Location
            b) Power
            c) Communication, including:
               a Nature of physical connection(s) between systems being integrated
               b Converter and/or adapter hardware required to facilitate physical connections between systems being integrated
               c Nature of logical connection(s) between systems being integrated

d Converter and/or adapter software required to facilitate logical connections between systems being integrated
e Custom software required to facilitate logical connections between systems being integrated, including the party in charge of developing the software

d) Mounting
e) Box and conduit rough-in

b. Coordinate testing and adjustment of each integration and related equipment and devices.
c. Coordinate division of work among trades.
d. Review overall construction schedule and installation, configuration, programming, and testing schedule, and coordinate inter-trade schedule interdependencies.

3. Hold meeting minimum two weeks prior to commencement of rough-in work on site.
4. Schedule meeting with minimum two weeks' notice.
   a. Publish agenda for meeting and distribute to invited attendees when meeting is scheduled.
5. Take detailed notes during meeting and publish meeting minutes within one week after meeting. Distribute minutes to invited attendees, Architect, and Engineer.

3.03 CONFIGURATION AND PROGRAMMING COORDINATION MEETING

A. After Section 28 0545 shop drawings have been approved, Contractor shall arrange and conduct a configuration and programming coordination meeting to review and coordinate Electronic Safety and Security Systems Integration device and equipment configuration and programming.
   1. Attendees shall include:
      a. Owner's project manager, security representative, and facilities / buildings and grounds / maintenance representative
      b. Construction Manager / General Contractor project manager and site superintendent / field foreman
      c. Division 28 project manager and site superintendent / field foreman
      d. Electronic Access Control subcontractor/supplier project manager and system programmer
      e. Video Surveillance subcontractor/supplier project manager and system programmer
      f. Intercom subcontractor/supplier project manager and system programmer
      g. Intrusion Detection subcontractor/supplier project manager and system programmer
      h. **[LIST OTHER REQUIRED ATTENDEES PER INTEGRATIONS SPECIFIED]**
   2. Meeting agenda topics shall include:
      a. Review and coordinate details of each integration being provided, including:
         1) Feature or function the integration provides
         2) Systems being integrated
         3) Sequence of operation
         4) Review of product-specific configuration and programming guide detailing configuration and programming options applicable to system software, hardware, equipment, and devices being integrated
         5) Configuration and programming of system server(s) and workstations and of server/workstation graphical user interface screens related to the integration
      b. Coordinate division of work among trades.
      c. Review overall construction schedule and installation, configuration, programming, and testing schedule, and coordinate inter-trade schedule interdependencies.

3. Hold meeting minimum four weeks prior to commencement of configuration and programming work.
4. Schedule meeting with minimum two weeks' notice.
   a. Publish agenda for meeting and distribute to invited attendees when meeting is scheduled.
5. Take detailed notes during meeting and publish meeting minutes within one week after meeting. Distribute minutes to invited attendees, Architect, and Engineer.

3.04 GENERAL

A. Refer to Section 28 0000 for additional information and requirements.

3.05 INSTALLATION

A. Integrations
   1. Elevator
      a. Contractor shall provide required cabling for security peripherals shown on project documents. Contractor shall also provide additional material and labor necessary to facilitate system operation.
      b. Contractor shall provide elevator interface as shown on drawings. Interface shall include provisions to support alarm monitoring and authorize access to select floors.
      c. Contractor shall furnish security peripherals to Elevator Contractor for installation within elevator systems or cab. Only Elevator Contractor shall alter, install, or make modification to elevator return panel or interior finished areas within elevator cab.
         1) Elevator Contractor shall provide elevator control equipment and required elevator system programming and wiring from card readers in elevator cab and at elevator lobbies to elevator machine room.
      d. Contractor shall extend security peripheral cabling located in redirect panel for final connection by Elevator Contractor.
         1) Contractor shall provide redirect panel in break out box in elevator machine room.
         2) Contractor shall provide connection to provide access control functionality in select elevator cabs within this break out box.
         3) Breakout box shall be alarmed and key lockable.
         4) Contractor shall coordinate elevator recall. If allowed by code, elevator recall for a non-fire event shall recall elevator off accessible public floors to secure floor.
      e. Operation
         1) ACMS operation shall be coordinated with Owner. Contractor shall configure manual or automatic initiation of secure and non-secure operation modes for elevator cabs equipped with access control readers.
         2) Interface between elevator system and ACMS shall be disengaged upon activation of elevator service mode, allowing access to any floor without authorized credential presentation.
            a) Contractor shall provide output to ACMS system to denote when elevator service mode has been activated. This input shall annunciate on the ACMS host server as an alarm input.
         3) If no floor button is selected after authorized credential presentation, security system shall reset and deactivate all buttons until next authorized credential is presented.
            a) Acceptable button selection time period will be defined by Owner.

4) Upon valid credential presentation and after desired floor has been selected, elevator system shall illuminate only the floor selected.
a) ACMS and elevator system shall not allow more than one button selection per valid credential presentation to reader inside cab.

2. Fire Alarm Interface
a. Door hardware power supplies shall be capable of receiving relay input from fire alarm system, as required by code.
1) Relay input shall be solely utilized for deactivation (unlocking) of access-controlled doors within a path of egress upon initiating signal from the fire alarm system.
b. Refer to Division 26 drawings for fire alarm panel locations and UL-listed fire interface connection points.
1) Contractor shall provide required cable and conduit for connection to fire interfaces for egress path doors.

3. Operator
a. Roll-Up/Sliding Doors/Gate Operators
1) Contractor shall provide interface with roll-up door operators.
2) Door control shall provide direct interface with ACMS credential holder database, allowing authorized credential holders to activate roll-up doors through use of a credential reader or remote operation.
3) ACMS shall also have capability of opening, holding, and closing roll-up doors though on-screen icons and commands generated from ACMS GUI.
4) Roll-up door operator safety features shall be preserved and ACMS shall not interfere with safety or operation of roll-up door.
b. Optical beam/Passive Infra-Red (PIR)
1) Provide optical beam devices/reflectors as shown on details to facilitate select operation of doors equipped with extended range reader.
c. Accessible Door Operators
1) Contractor shall provide interface for controlling doors equipped with accessible door operators. Following conditions shall be met and shall be provided by Contractor:
a) Accessible door operators shall not be functional until presentation of approved credential. Credential shall enable accessible door operator push pad, which shall energize door operator.
2) Following pre-set time period coordinated with Contractor, automatic door opening device shall release and door shall close and re-lock.
3) Contractor shall provide interfaces to allow exiting from doors equipped with door operators and electrified hardware controlled by ACMS.
a) Contractor shall provide connection to door operator or third-party request-to-exit sensor to de-energize or energize associated door hardware prior to activation of door operator.

4. Operable Revolving Doors
a. Provide relay inputs and outputs to grant access, lock, and obtain generated alarms from revolving doors (e.g. Piggy-backing, door collapse, door monitoring).

5. Magnetic hold-open(s)
a. Contractor, at select doors, shall provide relay to remotely de-energize magnetic hold-open devices to allow doors to close. Refer to drawings for locations.

B. System Servers and Application Software
1. Coordinate exact location with Owner and work by other trades prior to installation.

2. Coordinate schedule for activating power with on-site Division 26 Contractor prior to the commencement of work on site.
3. Properly ground system servers with minimum 6 AWG bonding conductor terminated with two-hole compression lugs. Refer to Section 270526 for additional information and requirements.
4. Provide surge protective device in-line just before connection to electrical receptacle.
5. Provide surge protective device in-line just before connection to Ethernet jack.
6. Coordinate configuration of server operating system software with Owner and with system application software manufacturer prior to installation and configuration.
7. Cable, terminate, configure, program, test, adjust, and make completely ready for use.

C. System Workstations and Application Software
1. Coordinate exact location with Owner and work by other trades prior to rough-in.
2. Coordinate power requirements, connection locations, and schedule for activating power with on-site Division 26 Contractor prior to the commencement of work on site.
3. Provide surge protective device in-line just before connection to electrical receptacle.
4. Provide surge protective device in-line just before connection to Ethernet jack.
5. Coordinate configuration of workstation operating system software with Owner and with system application software manufacturer prior to installation and configuration.
6. Cable, terminate, configure, program, test, adjust, and make completely ready for use.

D. Electronic Safety and Security Systems Integration Cable
1. Refer to referenced technical Sections for requirements.

E. Electronic Safety and Security Systems Integration Hangers and Supports
1. Refer to referenced technical Sections for requirements.

F. Electronic Safety and Security Systems Integration Raceways and Boxes
1. Refer to referenced technical Sections for requirements.

G. Electronic Safety and Security Systems Integration Surface Raceways
1. Refer to referenced technical Sections for requirements.

H. Configuration and Programming
1. Coordinate IP address requirements with Owner a minimum of six weeks prior to commencement of programming work.

3.06 INSPECTION AND TESTING

A. After successful completion of testing and prior to final acceptance, verify final operation of each integration on site with Owner.

B. Verification Follow-Up Visits
1. Contractor shall include in their bid a minimum of two (2) unique visits to site to review operation of each integration on site with Owner.
2. Schedule:
   a. First visit will occur within six (6) months of substantial completion or at Owner's request, whichever comes first.
   b. Second visit will occur within twelve (12) months of substantial completion or at Owner's request, whichever comes first.
   c. Tentatively coordinate schedule for both visits upon substantial completion of work on site, but before final acceptance of the project.
3. Provide for average of fifteen (15) minutes per instance of each integration provided under this project or total of eight (8) hours on site for each visit, whichever is greater.
4. After each visit, prepare a report detailing observation of operation of each instance of each integration provided, discussion with Owner about each instance of each integration provided, and adjustments made.
5. Contractor's bid shall include all labor costs associated with visits, including:
   a. Off-site pre-preparation time

b. On-site time
c. Travel time
d. Off-site report preparation time

3.07 START-UP

A. Refer to Section 28 0000 for additional information and requirements.

3.08 DOCUMENTATION

A. Refer to Section 28 0000 for additional information and requirements.

3.09 CLEANING

A. Refer to Section 28 0000 for additional information and requirements.

3.010 TRAINING

A. Refer to Section 28 0000 for additional information and requirements.
B. Contractor shall provide to Owner's designated representative(s) a minimum of one (1) 4-**hour**on-site training session related to work under this section within fifteen (15) days of substantial completion.

END OF SECTION

SECTION 281000
ELECTRONIC ACCESS CONTROL

PART 1 - GENERAL

1.01 SCOPE

A. This section includes product and execution requirements for Electronic Access Control. Unless noted otherwise, work under this section is subject to requirements of Section 28 0000.

1.02 DESCRIPTION

A. Refer to Section 280000 for additional information and requirements.
B. Complete, turnkey Electronic Access Control system compliant with applicable codes and standards referenced herein and as indicated on drawings.
C. The Electronic Access Control system shall include the following major components:
   1. Electronic Access Control System Application Software
   2. Electronic Access Control System Server(s)
   3. Intelligent System Controllers
   4. Credential Reader Interface Modules
   5. Input Control Modules
   6. Output Control Modules
   7. Electronic Access Control Panel Enclosure
   8. Electronic Access Control Power Supply
   9. Credential Readers
   10. Credentials
   11. Electrified Door Locking Hardware
   12. Latch Bolt Monitors
   13. Door Position Monitors
   14. Request to Exit Devices
   15. Remote Door Release Button
   16. Local Annunciators
   17. Electronic Access Control Cable

1.03 RELATED WORK

A. Refer to Section 28 0000 for additional information and requirements.

1.04 REQUIREMENTS OF REGULATORY AGENCIES

A. Refer to Section 28 0000 for additional information and requirements.

1.05 REFERENCES AND STANDARDS

B. Refer to Section 28 0000 for additional information and requirements.

1.06 DEFINITIONS

A. Refer to Section 28 0000 for additional information and requirements.

1.07 ABBREVIATIONS AND ACRONYMS

A. Refer to Section 28 0000 for additional information and requirements.

1.08 LISTING

A. Refer to Section 28 0000 for additional information and requirements.

1.09 SUBMITTALS

A. Shop Drawings:
   1. Refer to Section 28 0000 for additional information and requirements.
   2. Submit Contractor-prepared Electronic Access Control Schedule that documents for each controlled and/or monitored portal each Electronic Access Control device, connection, function, and integration listed in Division 08 Door Schedule and Division 08

Door Hardware Group, specified herein and on drawings, and per Contractor coordination with Owner, to include:
a. Door Number
b. Room Name
c. Plan Reference
d. Door Hardware Group
e. Electronic Access Control devices and connections
f. Functionality features
g. Integrations

B. Certificates and Inspections
1. Refer to Section 28 0000 for additional information and requirements.
C. Operation and Maintenance Manuals
1. Refer to Section 28 0000 for additional information and requirements.
D. Record Documents
1. Refer to Section 28 0000 for additional information and requirements.

1.010 JOB CONDITIONS

A. Refer to Section 28 0000 for additional information and requirements.

1.011 WORK BY OWNER

A. Refer to Section 28 0000 for additional information.
B. Owner will provide:
1. Electronic Access Control System Application Software
2. Electronic Access Control system Workstation(s) and workstation Application Software
3. Electronic Access Control System Server Hardware
4. Electronic Access Control System Badging Station Hardware
5. Intelligent System Controllers
6. Credential Reader Interface Modules
7. Input Control Modules
8. Output Control Modules
9. Electronic Access Control Panel Enclosure
10. Electrified Door Locking Hardware Power Supply
~~1.~~ 11. Credential Readers
~~2.~~ 12. Ethernet Networking Electronics

1.012 QUALITY ASSURANCE

A. Refer to Section 28 0000 for additional information and requirements.

1.013 GUARANTEE

A. Refer to Section 28 0000 for additional information and requirements.

PART 2 - PRODUCTS

2.01 GENERAL

A. Refer to Section 28 0000 for additional information and requirements.
B. Unless noted otherwise, the following equipment and devices shall be the products of a single manufacturer and designed, manufactured, marketed, sold, and supported as an integrated system:
1. Electronic Access Control System Application Software
2. Intelligent System Controllers
3. Credential Reader Interface Modules
4. Input Control Modules
5. Output Control Modules

2.02 ELECTRONIC ACCESS CONTROL SYSTEM APPLICATION SOFTWARE

~~A. Features~~

~~1. Certified for use with Windows 10 and Windows Server 2019~~

~~2. Communicates with Intelligent System Controllers via TCP/IP Ethernet~~

~~3. Application Module~~

~~a. Interfaces with Electronic Access Control System Workstations, Electronic Access Control System Badging Stations, Intelligent System Controllers, and other Electronic Access Control System equipment and devices~~

~~b. Interfaces with Video Surveillance Network Video Management Systems and other building systems at the software level~~

~~c. Organizes, stores, and manages Electronic Access Control System data on a single SQL database~~

~~d. Supports Microsoft Windows Clustering, Hot Standby, Fault Tolerant Servers, and Fault Tolerant Hot Standby Servers~~

~~e. Interfaces bi-directionally with external data sources using:~~

~~1) ASCII with support for manual and automatic XML formatted text exchange of data~~

~~2) ASCII with support for manual and automatic XML formatted text exchange of data, via direct table interface~~

~~3) API based real-time exchange of data via Active Directory/LDAP. The live exchange of data shall permit exposure of SMS events and transactions to other data sources in real time and allow for receipt of data into the SMS permitting this data to be acted upon and trigger linked events in the SMS in real time.~~

~~4) IBM WebSphere adapter based real-time exchange of information.~~

~~B. Basis of Design:~~

~~1. Lenel OnGuard~~

~~C. Acceptable Alternates:~~

~~1. AMAG Symmetry~~

~~2. Andover Continuum~~

~~3. Genetec Synergis~~

~~4. Identiv Hirsch Velocity~~

~~5. Open Options DNA Fusion~~

~~6. RS2 Access It~~

~~7. TYCO Software House C-Cure~~

~~D.~~A. ~~Provide complete with licenses for new work specified in Contract Documents and to provide functionality and integrations specified in Contract Documents.~~Provided by Owner.

2.03 ELECTRONIC ACCESS CONTROL SYSTEM SERVER HARDWARE

~~A. Features~~

~~1. Rack mount configuration~~

~~2. Dual redundant hot-swappable power supplies~~

~~3. Windows 10 operating system~~

~~B. Basis of Design:~~

~~1. Lenovo~~

~~C. Acceptable Alternates:~~

~~1. Dell~~

~~2. Hewlett-Packard~~

~~D. Provide complete with:~~

1. Software applications and licenses for new work specified in Contract Documents and to provide functionality and integrations specified in Contract Documents.
1. Rack Mount Console Drawer:
a. Configuration: Rack mount, 1 RU
a. Video Display Monitor:
1). Nominal Size: 17" diagonal
1). Resolution: 3840x2160
1). Input: HDMI

a.A.Wired USB Keyboard with touch padProvided by Owner.

2.04 ELECTRONIC ACCESS CONTROL SYSTEM BADGING STATION HARDWARE

A. Badging Station Workstation Hardware
1. Features
a. Desktop tower configuration
b. Windows 10 operating system
2. Basis of Design:
a. Lenovo
3. Acceptable Alternates:
a. Dell
b. Hewlett-Packard
4. Provide complete with:
a. Software applications and licenses for new work specified in Contract Documents and to provide functionality and integrations specified in Contract Documents.
b. Video Display Monitor:
1) Configuration: Free-standing desktop
2) Nominal Size: 24" diagonal
3) Resolution: 3840x2160
4) Input: HDMI
c. Wired USB Keyboard
d. Wired USB optical mouse
5. Uninterruptible Power Supply
a. Configuration: Tower
b. Type: Line Interactive
c. Input Voltage: 120 Volts AC
d. Output Voltage: 120 Volts AC
e. Capacity: 1500 VA
f. Efficiency: ≥ 90%
g. Transfer Time, Typical: 6 milliseconds

h.A.Surge Energy Rating: ≥ 300 JoulesProvided by Owner.

2.05 INTELLIGENT SYSTEM CONTROLLERS

2.05A. Provided by Owner.

A. Features:
1. Compatible with Electronic Access Control System Application Software
2. Supports up to 16 credential readers, 160 input points, and 144 output points
3. Supports Wiegand credential reader communication
4. Supports proximity and SMART credential technology
5. Onboard configuration backup
6. Nonvolatile memory for operating system, configuration data, and operations data storage and backup
7. Programmable via Ethernet or RS-232

~~8. UL listed~~

~~B. Specifications:~~

~~1. Host Communications: Ethernet via RJ-45 connector~~

~~2. Accessory Module Communications: RS-485 via terminal strip connector~~

~~3. Input Power Requirements: 1 amp at 12 volts DC~~

~~4. Operating Temperature (Environmental): 32°F - 122°F~~

~~C. Basis of Design:~~

~~1. Mercury LP2500~~

~~D. Acceptable Alternates:~~

~~1. AMAG Symmetry M4000~~

~~2. Andover Continuum ACX 57 series~~

~~3. Identiv Hirsch Mx series~~

~~4. Lenel OnGuard LNL-X3300~~

~~5. Open Options SSP-EP~~

~~6. RS2 SCP~~

~~7. TYCO Software House iStar Pro~~

2.06 CREDENTIAL READER INTERFACE MODULES

~~A. Features:~~

~~1. Supports one electronic access control door, each with:~~

~~a. Up to two credential readers~~

~~1) Includes connections for reader power, reader data, red lamp, green lamp~~

~~b. Two supervised inputs per leaf~~

~~c. Two outputs~~

~~2. Supports Wiegand credential reader communication~~

~~3. Supports proximity and SMART credential technology~~

~~4. UL listed~~

~~B. Specifications:~~

~~1. Controller Communications: RS-485 via terminal strip connector~~

~~2. Input Power Requirements: 2 amps at 12 volts DC~~

~~3. Reader Power Output: ≤ 250 milliamps at 12 volts DC~~

~~4. Reader LED Power Output: ≤ 100 milliamps at 12 volts DC~~

~~5. Relay Output Rating: ≤ 1 amp at 12-24 volts DC~~

~~6. Connections: Terminal strip~~

~~7. Operating Temperature (Environmental): 32°F - 122°F~~

~~C. Basis of Design:~~

~~1. Mercury MR50 / MR52~~

~~D. Acceptable Alternates:~~

~~1. AMAG DEC4~~

~~2. Andover xPBD4~~

~~3. Identiv Hirsch RREB~~

~~4. Lenel OnGuard LNL-1300 / LNL-1320~~

~~5. Open Options RSC-1 / RSC-2~~

~~6. RS2 MR-50 / MR-52~~

~~7.~~A. ~~TYCO Software House iStar RM-4~~Provided by Owner.

2.07 INPUT CONTROL MODULES

~~A. Features:~~

~~1. Supports eight Class A supervised inputs~~

~~2. UL listed~~

~~B. Specifications:~~

1. Controller Communications: RS-485 via terminal strip connector
2. Input Power Requirements: 180 milliamps at 12 volts DC
3. Connections: Terminal strip
4. Operating Temperature (Environmental): 32°F - 122°F

C. Basis of Design:
1. Mercury MR16IN

D. Acceptable Alternates:
1. AMAG IOC20/16
2. Andover xPBD4
3. Identiv Hirsch AEB8
4. Lenel OnGuard LNL-1100
5. Open Options ISC-16
6. RS2 MR-16IN
7. A. TYCO Software House iStar I8-CSI Provided by Owner.

2.08 OUTPUT CONTROL MODULES

A. Features:
1. Supports eight Form C dry contact relay outputs
2. UL listed

B. Specifications:
1. Controller Communications: RS-485 via terminal strip connector
2. Input Power Requirements: 300 milliamps at 12 volts DC
3. Relay Output Rating: ≤ 2 amps at 30 volts DC resistive, ≤ 1 amps at 30 volts DC inductive, ≤ 400 milliamps at 125 volts AC
4. Connections: Terminal strip
5. Operating Temperature (Environmental): 32°F - 122°F

C. Basis of Design:
1. Mercury MR16OUT

D. Acceptable Alternates:
1. AMAG IOC20/16
2. Andover xPBD4
3. Identiv Hirsch REB8
4. Lenel OnGuard LNL-1200
5. Open Options OSC-16
6. RS2 MR-16OUT
7. A. TYCO Software House iStar R8 Provided by Owner.

2.09 ELECTRONIC ACCESS CONTROL PANEL ENCLOSURE

A. Features:
1. Wall mount
2. Steel enclosure with powder coat finish and lockable hinged door
3. Internal backplane for mounting system modules
4. Door tamper switch
5. Optional integral power supply with battery charging capability and Integral mounting brackets for housing backup batteries
6. UL listed

B. Specifications:
1. Dimensions: ≥ 14.5”w x 18”h x 4”d
2. Optional Power Supply:
   a. Input: ≥ 0.5 Amp at 120 Volts AC
   b. Output: ≥ 4 Amps at 12 Volts DC

C. Basis of Design:
1. Altronix Trove1 / Trove 2
D. Acceptable Alternates:
1. AMAG
2. Andover
3. Identiv Hirsch
4. Lenel
5. Open Options
6. RS2
7. TYCO Software House
E. Provide complete with:
1. Minimum 1"x1" slotted finger duct as required for internal routing of cabling from where it enters the panel enclosure to termination points on system components and modules.
a. Provide in larger dimensions as required to maintain maximum 40% fill.
1) Fill calculation shall be based on anticipated amount of cable in a fully-populated panel enclosure.
2. Minimum 3"x3" slotted finger duct around perimeter of each panel enclosure, with section of same duct product extended from perimeter of each panel enclosure to horizontal ladder rack above panel enclosure.
a. Provide in larger dimensions as required to maintain maximum 40% fill.
1) Fill calculation shall be based on anticipated amount of cable associated with typical fully-populated panel enclosures.
F. Where provided with integral power supply, provide complete with:
1. Power supply sized to maintain ≤ 60% average utilization of power supply output capacity.
2.A. Quantity of 7 AH and/or 12 AH sealed lead acid or gel type batteries sufficient to provide a minimum of eight (8) hours of battery backup run time. Provided by Owner.

2.010 ELECTRIFIED DOOR LOCKING HARDWARE POWER SUPPLY

A. Specified by Division 08.
1. Refer to Division 08 for additional information and requirements.
B. Furnished and installed by Division 08.
1. Refer to Division 08 for additional information and requirements.
C. Cabled, terminated, configured, programmed, tested, adjusted and made completely ready for use by This Contractor.
D. Where not specified, furnished, and installed by Division 08:
1. Features:
a. Wall mount
b. Steel enclosure with powder coat finish and lockable hinged door
c. Door tamper switch
d. Battery charging capability
e. Integral mounting brackets for housing backup batteries
f. One common power input
g. Eight outputs
1) 12 volt DC
2) Filtered and electronically regulated
3) PTC protected
4) Independently controlled
a) Activated by dedicated open collector input or normally open dry contact input

~~5) Fail safe or fail secure~~
~~h. Fire alarm disconnect input~~
~~1) Normally open or normally closed~~
~~2) Latching or non-latching~~
~~3) Individually selectable for each output~~
~~i. LED indicators for AC input, DC output, individual output status, and fire alarm disconnect status~~
~~j. AC input fail supervision contact~~
~~k. Battery presence supervision contact~~
~~l. Low battery supervision contact~~
~~m. UL listed~~
~~2. Specifications:~~
~~a. Dimensions: 14.5"w x 18"h x 4.62"d~~
~~b. Power Supply Input: 2.6 Amps at 120 Volts AC~~
~~c. Power Supply Output: 10 Amps at 12 Volts DC, total~~
~~d. Operating Temperature (Environmental): 32°F - 120°F~~
~~3. Basis of Design:~~
~~a. Altronix AL1012ULACMCBJ~~
~~4. Acceptable Alternates:~~
~~a. AMAG~~
~~b. Andover~~
~~c. Identiv Hirsch~~
~~d. Lenel~~
~~e. Mercury~~
~~f. Open Options~~
~~g. RS2~~
~~h. TYCO Software House~~
~~5. Provide complete with:~~
~~a. Quantity of 7 AH and/or 12 AH sealed lead acid or gel type batteries sufficient to provide a minimum of eight (8) hours of battery backup run time.~~
~~b. ≥ 3"x3" slotted finger duct around perimeter of each power supply enclosure, with section of same duct product extended from perimeter of each enclosure to horizontal ladder rack above enclosure.~~
~~1) Provide in larger dimensions as required to maintain maximum 40% fill.~~
~~a) Fill calculation based on anticipated amount of cable associated with typical fully-populated panel enclosures.~~
~~6.~~A. ~~Provide in quantity to maintain ≤ 60% average utilization of power supply output capacity.~~Provided by Owner.

2.011 CREDENTIAL READERS

~~A. Mullion Mounted Short-Range Contactless Smart Credential Readers~~
~~1. Features:~~
~~a. IP-55 rated weather-resistant and vandal-resistant grey polycarbonate housing~~
~~b. Supports contactless smart credential technologies~~
~~c. Integral bi-color LED indicator~~
~~d. Integral sounder~~
~~e. Integral tamper switch~~
~~f. UL listed~~
~~2. Specifications:~~
~~a. Dimensions: 1.9"w x 4.1"h x 0.9" deep~~

~~b. Operating Frequency: 13.56 MHz~~
~~c. Read Range: 1.2 - 3.6", credential dependent~~
~~d. Output Communication Protocol: Wiegand, Clock-and-Data, Open Supervised Device Protocol via RS485~~
~~e. Input Voltage: 5-16 volts DC~~
~~f. Power Consumption, Average: 60 milliamps at 16 volts DC~~
~~g. Power Consumption, Peak: 200 milliamps at 16 volts DC~~
~~h. Connections: Terminal strip~~
~~i. Operating Temperature (Environmental): -31°F - 150°F~~

~~3. Basis of Design:~~
~~a. HID RP10~~

~~4. Acceptable Alternates:~~
~~a. None.~~

~~B. Wall Mounted Medium-Range Contactless Smart Credential Readers~~

~~1. Features:~~
~~a. IP-55 rated weather-resistant and vandal-resistant grey polycarbonate housing~~
~~b. Mounts to a standard single gang electrical opening~~
~~c. Supports contactless smart credential technologies~~
~~d. Integral bi-color LED indicator~~
~~e. Integral sounder~~
~~f. Integral tamper switch~~
~~g. UL listed~~

~~2. Specifications:~~
~~a. Dimensions: 3.3"w x 4.8"h x 1.1" deep~~
~~b. Operating Frequency: 13.56 MHz~~
~~c. Read Range: 2.0 - 5.2", credential dependent~~
~~d. Output Communication Protocol: Wiegand, Clock-and-Data, Open Supervised Device Protocol via RS485~~
~~e. Input Voltage: 5-16 volts DC~~
~~f. Power Consumption, Average: 65 milliamps at 16 volts DC~~
~~g. Power Consumption, Peak: 200 milliamps at 16 volts DC~~
~~h. Connections: Terminal strip~~
~~i. Operating Temperature (Environmental): -31°F - 150°F~~

~~3. Basis of Design:~~
~~a. HID R40~~

~~4. Acceptable Alternates:~~
~~a. None.~~

~~C. Wall Mounted Medium-Range Contactless Smart Keypad Credential Readers~~

~~1. Features:~~
~~a. IP-55 rated weather-resistant and vandal-resistant grey polycarbonate housing~~
~~b. Mounts to a standard single gang electrical opening~~
~~c. Supports contactless smart credential technologies~~
~~d. Integral keypad~~
~~e. Integral bi-color LED indicator~~
~~f. Integral sounder~~
~~g. Integral tamper switch~~
~~h. UL listed~~

~~2. Specifications:~~
~~a. Dimensions: 3.3"w x 4.8"h x 1.1" deep~~
~~b. Operating Frequency: 13.56 MHz~~

c. Read Range: 2.0 - 5.5", credential dependent
d. Output Communication Protocol: Wiegand, Clock-and-Data, Open Supervised Device Protocol via RS485
e. Input Voltage: 5-16 volts DC
f. Power Consumption, Average: 85 milliamps at 16 volts DC
g. Power Consumption, Peak: 220 milliamps at 16 volts DC
h. Connections: Terminal strip
i. Operating Temperature (Environmental): -31°F - 150°F

3. Basis of Design:
a. HID RK40

4. Acceptable Alternates:
a. None.

D. Wall Mounted Long-Range Contactless Smart Credential Readers

1. Features:
a. IP-65 rated weather-resistant and vandal-resistant grey polycarbonate housing
b. Mounts to a standard single gang electrical opening
c. Supports contactless smart credential technologies
d. Integral bi-color LED indicator
e. Integral sounder
f. Integral tamper switch
g. UL listed

2. Specifications:
a. Dimensions: 13.1"w x 13.1"h x 1.55" deep
b. Operating Frequency: 13.56 MHz
c. Read Range: 3.1 - 14.2", credential dependent
d. Output Communication Protocol: Wiegand, Clock-and-Data, Open Supervised Device Protocol via RS485
e. Input Voltage: 12 or 24 volts DC
f. Power Consumption, Average: 110 milliamps at 12 volts DC
g. Power Consumption, Peak: 300 milliamps at 12 volts DC
h. Connections: Terminal strip
i. Operating Temperature (Environmental): -31°F - 150°F

3. Basis of Design:
a. HID R90

4. Acceptable Alternates:
a. None.

E. Mullion Mounted Short-Range Multi-Technology Credential Readers

1. Features:
a. IP-55 rated weather-resistant and vandal-resistant grey polycarbonate housing
b. Supports contactless smart and proximity credential technologies
c. Integral bi-color LED indicator
d. Integral sounder
e. Integral tamper switch
f. UL listed

2. Specifications:
a. Dimensions: 1.9"w x 4.1"h x 0.9" deep
b. Operating Frequency: 13.56 MHz, 125 kHz
c. Read Range, Proximity: 0.8 - 4.3", credential dependent
d. Read Range, Contactless Smart: 0.8 - 3.1", credential dependent

e. Output Communication Protocol: Wiegand, Clock-and-Data, Open Supervised Device Protocol via RS485
f. Input Voltage: 5-16 volts DC
g. Power Consumption, Average: 75 milliamps at 12 volts DC
h. Power Consumption, Peak: 200 milliamps at 12 volts DC
i. Connections: Terminal strip
j. Operating Temperature (Environmental): -31°F - 150°F

3. Basis of Design:
a. HID RP10

4. Acceptable Alternates:
a. None.

F. Wall Mounted Medium-Range Multi-Technology Credential Readers

1. Features:
a. IP-55 rated weather-resistant and vandal-resistant grey polycarbonate housing
b. Mounts to a standard single gang electrical opening
c. Supports contactless smart and proximity credential technologies
d. Integral bi-color LED indicator
e. Integral sounder
f. Integral tamper switch
g. UL listed

2. Specifications:
a. Dimensions: 3.3"w x 4.8"h x 1.0" deep
b. Operating Frequency: 13.56 MHz, 125 kHz
c. Read Range, Proximity: 1.2 - 4.3", credential dependent
d. Read Range, Contactless Smart: 1.2 - 4.7", credential dependent
e. Output Communication Protocol: Wiegand, Clock-and-Data, Open Supervised Device Protocol via RS485
f. Input Voltage: 5-16 volts DC
g. Power Consumption, Average: 85 milliamps at 12 volts DC
h. Power Consumption, Peak: 200 milliamps at 12 volts DC
i. Connections: Terminal strip
j. Operating Temperature (Environmental): -31°F - 150°F

3. Basis of Design:
a. HID RP40

4. Acceptable Alternates:
a. None.

G. Wall Mounted Medium-Range Multi-Technology Keypad Credential Readers

1. Features:
a. IP-55 rated weather-resistant and vandal-resistant grey polycarbonate housing
b. Mounts to a standard single gang electrical opening
c. Supports contactless smart and proximity credential technologies
d. Integral keypad
e. Integral bi-color LED indicator
f. Integral sounder
g. Integral tamper switch
h. UL listed

2. Specifications:
a. Dimensions: 3.3"w x 4.8"h x 1.1" deep
b. Operating Frequency: 13.56 MHz, 125 kHz
c. Read Range, Proximity: 1.2 - 3.1", credential dependent

~~d. Read Range, Contactless Smart: 0.8 - 4.7", credential dependent~~
~~e. Output Communication Protocol: Wiegand, Clock-and-Data, Open Supervised Device Protocol via RS485~~
~~f. Input Voltage: 5-16 volts DC~~
~~g. Power Consumption, Average: 95 milliamps at 12 volts DC~~
~~h. Power Consumption, Peak: 200 milliamps at 12 volts DC~~
~~i. Connections: Terminal strip~~
~~j. Operating Temperature (Environmental): -31°F - 150°F~~

~~3. Basis of Design:~~
~~a. HID RPK40~~

~~4. Acceptable Alternates:~~

~~a.~~A. ~~None.~~Provided by Owner.

2.012 ELECTRIFIED DOOR LOCKING HARDWARE

A. Provided Division 08. Refer to Division 08 for additional information and requirements.
B. Cabled, terminated, configured, programmed, tested, adjusted and made completely ready for use by This Contractor.

2.013 LATCH BOLT MONITORS

A. Provided Division 08. Refer to Division 08 for additional information and requirements.
B. Cabled, terminated, configured, programmed, tested, adjusted and made completely ready for use by This Contractor.

2.014 DOOR POSITION MONITORS

A. Provided Division 08. Refer to Division 08 for additional information and requirements.
B. Cabled, terminated, configured, programmed, tested, adjusted and made completely ready for use by This Contractor.

2.015 REQUEST TO EXIT DEVICES

~~A. Request to Exit Switch integral to Electrified Door Locking Hardware~~
~~1. Provided Division 08. Refer to Division 08 for additional information and requirements.~~
~~2. Cabled, terminated, configured, programmed, tested, adjusted and made completely ready for use by This Contractor.~~

~~B. Motion-Sensing Request to Exit Devices~~
~~1. Features:~~
~~a. Black ABS plastic housing~~
~~b. Wall or ceiling mountable~~
~~c. Adjustable pitch~~
~~d. Adjustable coverage pattern~~
~~e. Adjustable relay latch time~~
~~f. Integral activation LED~~
~~g. UL listed~~

~~2. Specifications:~~
~~a. Alarm Output: Form C relay contacts rated at 1 amp at 30 volts DC~~
~~b. Power Consumption, Average: 8 milliamps at 12 volts DC~~
~~c. Power Consumption, Peak: 39 milliamps at 12 volts DC~~
~~d. Operating Temperature (Environmental): -20°F - 120°F~~

~~3. Basis of Design:~~
~~a. Bosch DS161~~

~~4. Acceptable Alternates:~~
~~a. None.~~

~~5. Provide complete with same manufacturer's matching trim plate accessory for mounting over a single gang electrical opening.~~

~~C. Push-Button Request to Exit Devices with Pneumatic Timer~~

~~1. Features:~~

~~a. Single gang stainless steel faceplate~~

~~b. Wall mountable~~

~~c. Red mushroom button~~

~~1) Engraved with "PUSH TO EXIT" in white text~~

~~d. Integral field-adjustable pneumatic time delay~~

~~e. UL listed~~

~~2. Specifications:~~

~~a. Alarm Output: Form C relay contacts rated ≥ 2 amps at 28 volts DC~~

~~b. Time Delay Range: ≥ 2 - 45 seconds~~

~~3. Basis of Design:~~

~~a. Alarm Controls TS-60~~

~~4. Acceptable Alternates:~~

~~a. Camden~~

~~b.~~A.~~Rutherford~~Provided by Owner.

2.016 ELECTRONIC ACCESS CONTROL CABLE

A. General
   1. Refer to manufacturer's published product installation instructions for additional information and requirements. Wherever a discrepancy is identified between Project Documents and manufacturer's published product installation instructions, the more stringent requirement shall govern.
   2. Cable shall be plenum or riser rated as dictated by the environment in which the cable is installed. Refer to Mechanical drawings for additional information and requirements.
   3. Cable installed in wet or damp locations, including, but not limited to, in-slab and buried conduit, shall be rated for installation in wet locations.

B. Ethernet Cable and Connectivity
   1. Twisted Pair Copper Ethernet Cable and Connectivity
      a. Device Cables
         1) Refer to Section 27 1000 for information and requirements.
      b. Patch Cables
         1) Refer to Section 27 1600 for information and requirements

C. RS-485, RS-422 Cable
   1. 18/3 shielded
   2. Low-capacitance
   3. Basis of Design:
      a. Plenum: Belden 88770
      b. Nonplenum: Belden 8770
   4. Acceptable Alternates:
      a. West Penn

D. Credential Reader Cable
   1. 18/6 shielded
   2. Basis of Design:
      a. Plenum: Belden 6304FE
      b. Nonplenum: Belden 5304FE
   3. Acceptable Alternates:
      a. West Penn

E. Electrified Door Locking Hardware Cable
    1. Minimum 14/2 unshielded
        a. Provide in gauge(s) as required to maintain no more than 10% voltage drop
    2. Basis of Design:
        a. Plenum: Belden 6100UE
        b. Nonplenum: Belden 5100UE
    3. Acceptable Alternates:
        a. West Penn
F. Latch Bolt Monitor Cable
    1. 18/2 unshielded
    2. Basis of Design:
        a. Plenum: Belden 6300UE
        b. Nonplenum: Belden 5300UE
    3. Acceptable Alternates:
        a. West Penn
G. Door Position Monitor Cable
    1. 18/2 unshielded
    2. Basis of Design:
        a. Plenum: Belden 6300UE
        b. Nonplenum: Belden 5300UE
    3. Acceptable Alternates:
        a. West Penn
H. Request to Exit Device Cable
    1. Request to Exit Switch integral to Electrified Door Locking Hardware
        a. 18/2 unshielded
        b. Basis of Design:
            1) Plenum: Belden 6300UE
            2) Nonplenum: Belden 5300UE
        c. Acceptable Alternates:
            1) West Penn
    2. Motion-Sensing Request to Exit Devices
        a. 18/4 unshielded
        b. Basis of Design:
            1) Plenum: Belden 6302UE
            2) Nonplenum: Belden 5302UE
        c. Acceptable Alternates:
            1) West Penn
I. Local Alarm Sounder Cable
    1. 18/2 unshielded
    2. Basis of Design:
        a. Plenum: Belden 6300UE
        b. Nonplenum: Belden 5300UE
    3. Acceptable Alternates:
        a. West Penn
J. Local Alarm Strobe Cable
    1. 18/2 unshielded
    2. Basis of Design:
        a. Plenum: Belden 6300UE
        b. Nonplenum: Belden 5300UE

3. Acceptable Alternates:
    a. West Penn

K. Local Alarm Sounder/Strobe Cable
1. 18/2 unshielded
2. Basis of Design:
    a. Plenum: Belden 6300UE
    b. Nonplenum: Belden 5300UE
3. Acceptable Alternates:
    a. West Penn

L. Automatic Door Operator Integration Cable
1. 18/2 unshielded
2. Basis of Design:
    a. Plenum: Belden 6300UE
    b. Nonplenum: Belden 5300UE
3. Acceptable Alternates:
    a. West Penn

M. Automatic Door Operator Actuator Integration Cable
1. Push Button Automatic Door Operator Actuator
    a. 18/2 unshielded
    b. Basis of Design:
        1) Plenum: Belden 6300UE
        2) Nonplenum: Belden 5300UE
    c. Acceptable Alternates:
        1) West Penn
2. Contactless “Hands-Free” Automatic Door Operator Actuator
    a. 18/4 unshielded
        1) Basis of Design
            a) Plenum: Belden 6302UE
            b) Nonplenum: Belden 5302UE
    b. Acceptable Alternates:
        1) West Penn

N. Duress/Panic Button Cable
1. 18/2 unshielded
2. Basis of Design:
    a. Plenum: Belden 6300UE
    b. Nonplenum: Belden 5300UE
3. Acceptable Alternates:
    a. West Penn

O. System Equipment Panel Door Tamper Monitor Cable
1. 18/2 unshielded
2. Basis of Design:
    a. Plenum: Belden 6300UE
    b. Nonplenum: Belden 5300UE
3. Acceptable Alternates:
    a. West Penn

P. Knox-Style Key Vault Door Tamper Monitor Cable
1. 18/2 unshielded
2. Basis of Design:
    a. Plenum: Belden 6300UE

b. Nonplenum: Belden 5300UE
3. Acceptable Alternates:
a. West Penn

Q. Automated External Defibrillator (AED) Tamper Monitor Cable
1. 18/2 unshielded
2. Basis of Design:
a. Plenum: Belden 6300UE
b. Nonplenum: Belden 5300UE
3. Acceptable Alternates:
a. West Penn

PART 3 - EXECUTION

3.01 PRE-CONSTRUCTION COORDINATION MEETING

A. Prior to preparing and submitting shop drawings, Contractor shall arrange and conduct pre-construction coordination meeting to review and coordinate Electronic Access Control installation requirements.
1. Attendees shall include:
a. Owner's project manager, security representative, and facilities / buildings and grounds / maintenance door representative
b. Construction Manager / General Contractor project manager and site superintendent / field foreman
c. Division 08 subcontractor site superintendent / field foreman
d. Door frame, leaf, and hardware supplier representative(s)
e. Door hardware manufacturer's representative
f. Division 26 subcontractor site superintendent / field foreman
g. Division 28 project manager and site superintendent / field foreman
h. Electronic access control subcontractor/supplier representative
2. At a minimum, meeting agenda topics shall include:
a. Review and coordination of division of work among trades.
b. Identification and review of each door to be equipped with electronic access control devices, to include:
1) Location
2) Intended functionality and operation
3) Door hardware complement
4) Electronic access control device complement
5) Electronic access control device and cable rough-in requirements
c. Review of construction schedule and coordination of inter-trade installation schedule interdependencies
d. Coordination of door frame and door leaf mounted electronic access control device installation and wiring
e. Coordination of device configuration, testing, and adjustment
3. Meeting shall be scheduled with a minimum of two weeks' notice.
a. Contractor shall publish a meeting agenda for the meeting and distribute to invited attendees a minimum of one week prior to the meeting.
4. Contractor shall take detailed notes during the meeting and publish meeting minutes within one week after the meeting. Minutes shall be distributed to attendees, the Architect, and the Engineer.

3.02 CONFIGURATION AND PROGRAMMING COORDINATION MEETING

A. After Section 28 1000 shop drawings have been approved, Contractor shall arrange and conduct a configuration and programming coordination meeting to review and coordinate aspects of Electronic Access Control device and equipment configuration and programming.
   1. At a minimum, attendees shall include:
      a. Owner's project manager, security representative, and facilities / buildings and grounds / maintenance door representative
      b. Division 28 project manager and site superintendent / field foreman
      c. Electronic access control subcontractor/supplier project manager and system programmer
   2. At a minimum, meeting agenda topics shall include:
      a. Identification and review of each door to be equipped with electronic access control devices, to include:
         1) Location
         2) Intended functionality and operation
         3) Door hardware complement
         4) Electronic access control device complement
         5) Configuration of and programming for each device
      b. Identification and review of electronic access control devices not associated with a door, to include:
         1) Location
         2) Intended functionality and operation
         3) Configuration of and programming for each device
      c. Review of a product-specific configuration and programming guide detailing configuration and programming options applicable to the system software, hardware, equipment, and devices being provided.
      d. Configuration of credential holder database and programming of individual credential holders
      e. Configuration and programming of system server(s) and workstations and of server/workstation graphical user interface screens
      f. Review of installation, configuration, programming, and testing schedule, and of how those relate to the overall construction schedule.
   3. Meeting shall be held a minimum of two weeks prior to the commencement of configuration and programming work, and shall be scheduled with a minimum of two weeks' notice.
      a. Contractor shall publish a meeting agenda for the meeting and distribute the meeting agenda and configuration and programming guide to invited attendees a minimum of one week prior to the meeting.
   4. Contractor shall take detailed notes during the meeting and publish meeting minutes within one week after the meeting. Minutes shall be distributed to attendees, the Architect, and the Engineer.

3.03 GENERAL

A. Refer to Section 28 0000 for additional information and requirements.

3.04 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 28 0000 for additional information and requirements.

3.05 LOCATIONS OF WORK

A. Refer to Section 28 0000 for additional information and requirements.

3.06 FLOOR, WALL, CEILING, AND ROOF OPENINGS

A. Refer to Section 28 0000 for additional information and requirements.

3.07 EQUIPMENT ACCESS

A. Refer to Section 28 0000 for additional information and requirements.

3.08 EQUIPMENT SUPPORTS

A. Refer to Section 28 0000 for additional information and requirements.

3.09 SUPPORT PROTECTION

A. Refer to Section 28 0000 for additional information and requirements.

3.010 CABLE AND CONDUCTOR PROTECTION

A. Refer to Section 28 0000 for additional information and requirements.

3.011 HOUSEKEEPING PADS

A. Refer to Section 28 0000 for additional information and requirements.

3.012 LEAD SHIELDING

A. Refer to Section 28 0000 for additional information and requirements.

3.013 INSTALLATION

A. Refer to Section 28 0000 for additional information and requirements.
B. General
C. System Servers and Application Software
    1. Coordinate exact location with Owner and work by other trades prior to installation.
    2. Coordinate schedule for activating power with on-site Division 26 Contractor prior to the commencement of work on site.
    3. Properly ground system servers with minimum 6 AWG bonding conductor terminated with two-hole compression lugs. Refer to Section 270526 for additional information and requirements.
    4. Provide surge protective device in-line just before connection to electrical receptacle.
    5. Provide surge protective device in-line just before connection to Ethernet jack.
    6. Coordinate configuration of server operating system software with Owner and with system application software manufacturer prior to installation and configuration.
    7. Cable, terminate, configure, program, test, adjust, and make completely ready for use.
D. System Workstations and Application Software
    1. Coordinate exact location with Owner and work by other trades prior to rough-in.
    2. Coordinate power requirements, connection locations, and schedule for activating power with on-site Division 26 Contractor prior to the commencement of work on site.
    3. Provide surge protective device in-line just before connection to electrical receptacle.
    4. Provide surge protective device in-line just before connection to Ethernet jack.
    5. Coordinate configuration of workstation operating system software with Owner and with system application software manufacturer prior to installation and configuration.
    6. Cable, terminate, configure, program, test, adjust, and make completely ready for use.
E. Intelligent System Controllers, Credential Reader Interface Modules, Input Control Modules, and Output Control Modules
    1. Install intelligent system controllers and input/output control modules centralized in manufacturer's matching wall-mounted control panel enclosures in the nearest Equipment Room. Coordinate exact location(s) with Owner and work by other trades prior to installation.
        a. Electronic access control panel enclosure power supplies shall be fed via minimum 20-amp emergency power electrical circuit, dedicated to electronic access control system head end equipment.
            1) Provide machine-generated label on interior of the panel enclosure door indicating the name and number of the room where the electrical distribution

panel the circuit originates in is located, the name/number of the distribution panel, and the number of the circuit.
2) Provide hard-wired surge protective device in-line just before connection to the power supply.

b. Coordinate power requirements, connection locations, and schedule for activating power with on-site Division 26 Contractor prior to the commencement of work on site.
c. Properly ground system control panel cabinets and system components with minimum 6 AWG bonding conductor terminated with two-hole compression lugs. Refer to Section 27 0526 for additional information and requirements.

2. Cable shields and drain conductors of system communications cabling linking controllers in multiple locations shall be bonded to ground at primary system equipment location only.
3. Cable, terminate, configure, program, test, adjust, and make completely ready for use.

F. Electronic Access Control Power Supplies
1. Install electronic access control power supplies wall-mounted immediately adjacent to associated electronic access control panel enclosures. Coordinate exact location(s) with Owner and work by other trades before installation.
2. Electronic access control power supplies shall be fed via minimum 20-amp critical power electrical circuit, dedicated to electronic access control system head end equipment.
a. Provide machine-generated label on interior of the power supply enclosure door indicating the name and number of the room where the electrical distribution panel the circuit originates in is located, the name/number of the distribution panel, and the number of the circuit.
b. Provide hard-wired surge protective device in-line just before connection to the power supply.
3. Coordinate power requirements, connection locations, and schedule for activating power with on-site Division 26 Contractor prior to the commencement of work on site.
4. Properly ground electronic access control power supplies with minimum 6 AWG bonding conductor terminated with two-hole compression lugs. Refer to Section 270526 for additional information and requirements.
5. Cable, terminate, configure, program, test, adjust, and make completely ready for use.

G. Credential Readers
1. Coordinate exact locations with Owner, Architectural elevations, and work by other trades prior to rough-in.
2. Coordinate rough-in requirements with Division 26 Contractor prior to the commencement of work on site.
3. Install in accordance with the Americans with Disabilities Act and the Americans with Disabilities Act Accessibility Guidelines.
4. Where readers are specified to be installed on both sides of a wall, maintain sufficient physical separation between them to prevent cross-reading of credentials through the wall.
5. Mount with security screw fasteners provided with the credential reader.
6. Mount exterior credential readers with stainless steel fasteners.
7. Provide surge suppression for exterior credential readers not mounted directly on the exterior wall of the building or directly on the exterior side of a door mullion.
8. Cable shields and drain conductors of credential reader cabling shall be bonded to ground at credential reader interface module location only.
9. Configure with tamper switch monitor alarm enabled.

10. Cable, terminate, configure, program, test, adjust, and make completely ready for use.

H. Electrified Door Locking Hardware
   1. Coordinate rough-in requirements with Division 08 Contractor and Division 26 Contractor prior to the commencement of work on site.
   2. Cable, terminate, configure, program, test, adjust, and make completely ready for use.
   3. Coordinate cabling, termination, testing, and adjustment with on-site Division 08 Contractor.

I. Latch Bolt Monitors
   1. Coordinate rough-in requirements with Division 08 Contractor and Division 26 Contractor prior to the commencement of work on site.
   2. Cable, terminate, configure, program, test, adjust, and make completely ready for use.
   3. Coordinate cabling, termination, testing, and adjustment with on-site Division 08 Contractor.

J. Door Position Monitors
   1. Coordinate rough-in requirements with Division 08 Contractor and Division 26 Contractor prior to the commencement of work on site.
   2. Cable, terminate, configure, program, test, adjust, and make completely ready for use.
   3. Coordinate cabling, termination, testing, and adjustment with on-site Division 08 Contractor.

K. Request to Exit Devices
   1. Request to Exit Switch integral to Electrified Door Locking Hardware
      a. Coordinate rough-in requirements with Division 08 Contractor and Division 26 Contractor prior to the commencement of work on site.
      b. Cable, terminate, configure, program, test, adjust, and make completely ready for use.
      c. Coordinate cabling, termination, testing, and adjustment with on-site Division 08 Contractor.
   2. Motion-Sensing Request to Exit Devices
      a. Coordinate rough-in requirements with Division 26 Contractor prior to the commencement of work on site.
      b. Coordinate exact locations with Owner, Architectural elevations, and work by other trades prior to rough-in.
      c. Cable, terminate, configure, program, test, adjust, and make completely ready for use.
      d. Mask sensor lens, aim, tune, and adjust as necessary to minimize false activation from persons passing by but not exiting through the portal while still maintaining necessary REXing functionality.

L. Electronic Access Control Cable
   1. Electronic Access Control System cabling shall be installed in conduit from device location to cable tray below nearest accessible floor or above nearest accessible ceiling.
   2. Install cabling in pathways provided, or as designated on floor plans, and support from building structure.
      a. Where installed in free-air, support cables using J-hook type cable supports. Refer to Section 27 0528.29 - Hangers and Supports for Communications Systems for installation requirements.
         1) J-hook fill capacities shall be per manufacturer’s recommendations and shall consider diameter of cable type(s) being installed.
         2) Route cable/hooks at right angles, parallel to construction.
      b. Where installed in Cable Tray, lay cables neatly in tray.
         1) Do not tie.

2) Provide sufficient slack in cables to allow for unequal expansion coefficients of cable tray and cables. This requirement is in addition to slack required at cable tray expansion joints.

3. Identification:
   a. Label system device cabling with unique alphanumeric identifiers that include:
      1) Architectural door number
      2) Associated system device
      3) Unique alphanumeric identifier to distinguish between multiple instances of same device type at a door, where applicable
   b. Refer to Section 27 0553 for additional information and requirements.

M. Electronic Access Control Raceways and Boxes
   1. Refer to Section 280000 for additional information and requirements.
   2. Conduits:
      a. At Contractor's option, Electronic Access Control conduit home runs from EAC-controlled doorways to Security Equipment Rooms may be consolidated in to larger conduits.
         1) Where conduit home runs are consolidated, size larger conduits to provide conduit capacity equal to or greater than cumulative capacity of the smaller conduits being combined.
         2) Prior to the commencement of work on site, prepare and submit for review shop drawings documenting proposed conduit consolidation, including proposed conduit sizing, junction boxes, and conduit routes coordinated with work by other trades.
         3) Prior to rough-in, field-coordinate final routing of larger conduits on site with work by other trades.

N. Electronic Access Control Surface Raceways
   1. Refer to 280000 for additional information and requirements.

O. Configuration and Programming
   1. Coordinate configuration and programming with Owner.
   2. Coordinate IP address requirements with Owner a minimum of six weeks prior to commencement of programming work.

3.014 INSPECTION AND TESTING

A. Refer to Section 28 0000 for additional information and requirements.

B. After successful completion of testing and prior to final acceptance, verify final operation of each controlled and/or monitored portal on site with Owner.

C. Verification Follow-Up Visits
   1. Contractor shall include in their bid a minimum of two (2) unique visits to the site to review operation of each controlled and/or monitored portal and system device on site with Owner.
   2. Schedule of Visits:
      a. The first of these visits will occur within six (6) months of substantial completion, or at Owner’s request, whichever comes first.
      b. The second of these visits will occur within twelve (12) months of substantial completion, or at Owner’s request, whichever comes first.
      c. Contractor shall tentatively coordinate scheduling for both visits upon substantial completion of work on site, but before final acceptance of the project.
   3. At a minimum, Contractor shall provide for an average of fifteen (15) minutes per controlled and/or monitored portal or system device installed under this project or a total of eight (8) hours on site for each visit, whichever is longer.

4. After each visit, Contractor shall prepare a report detailing observation of operation at each controlled and/or monitored portal or system device, discussion about each controlled and/or monitored portal or system device with Owner, and adjustments made.
5. Contractor's bid shall include all labor costs associated with visits, to include:
    a. Off-site pre-preparation time
    b. On-site time
    c. Travel time
    d. Off-site report preparation time

3.015 START-UP

A. Refer to Section 28 0000 for additional information and requirements.

3.016 DOCUMENTATION

A. Refer to Section 28 0000 for additional information and requirements.

3.017 CLEANING

A. Refer to Section 28 0000 for additional information and requirements.

3.018 TRAINING

A. Refer to Section 28 0000 for additional information and requirements.
B. Contractor shall provide to Owner's designated representative(s) a minimum of two (2) 4-hour on-site training sessions related to work under this section within fifteen (15) days of substantial completion.

END OF SECTION

SECTION 28 2000
VIDEO SURVEILLANCE

PART 1 - GENERAL

1.01 SCOPE

A. This section includes product and execution requirements for Video Surveillance. Unless noted otherwise, work under this section is subject to requirements of Section 28 0000.

1.02 DESCRIPTION

A. Refer to Section 28 0000 for additional information and requirements.
B. Complete, turnkey Video Surveillance system compliant with applicable codes and standards referenced herein and as indicated on drawings.
C. The Video Surveillance system shall include the following major components:
   1. Video Surveillance System Application Software
   2. Video Surveillance System Server(s)
   3. Video Surveillance System Networked Video Storage
   4. Video Surveillance System Workstation(s)
   5. Ethernet Networking Electronics
   6. Video Surveillance Cameras
   7. Video Surveillance Cable
   8. Video Surveillance Raceways and Boxes

1.03 RELATED WORK

A. Refer to Section 28 0000 for additional information and requirements.

1.04 REQUIREMENTS OF REGULATORY AGENCIES

A. Refer to Section 28 0000 for additional information and requirements.

1.05 REFERENCES AND STANDARDS

B. Refer to Section 28 0000 for additional information and requirements.

1.06 DEFINITIONS

A. Refer to Section 28 0000 for additional information and requirements.

1.07 ABBREVIATIONS AND ACRONYMS

A. Refer to Section 28 0000 for additional information and requirements.

1.08 LISTING

A. Refer to Section 28 0000 for additional information and requirements.

1.09 SUBMITTALS

A. Shop Drawings:
   1. Refer to Section 28 0000 for additional information and requirements.
   2. Submit a Video Surveillance Camera Schedule that includes for each camera all information in Video Surveillance Camera Schedule on the drawings, plus the following:
      a. Camera IP address
      b. Camera subnet mask
      c. Required PoE power, in watts
B. Certificates and Inspections
   1. Refer to Section 28 0000 for additional information and requirements.
C. Operation and Maintenance Manuals
   1. Refer to Section 28 0000 for additional information and requirements.
   2. Provide a still image from each installed video surveillance camera:
      a. Obtained at full resolution at the time of final acceptance
      b. Scaled to and printed on a standard 8-1/2” x 11” sheet, one image per sheet

c. Marked with text indicating camera's unique alphanumeric identifier and network address

D. Record Documents
1. Refer to Section 28 0000 for additional information and requirements.
2. For each video surveillance camera, indicate the following:
a. Installed location of camera
b. Direction camera is aimed
c. Camera's field of view
1) Indicated by an isosceles triangle with it's apex at the camera and it's base at the vertical plane the camera is focused to.
a) Length of base of triangle shall match the horizontal width of the field of view the camera is focused to.

1.010 JOB CONDITIONS

A. Refer to Section 28 0000 for additional information and requirements.

1.011 WORK BY OWNER

A. Refer to Section 28 0000 for additional information.
B. Owner will provide:
1. Video Surveillance system Networked Video Storage
2. Ethernet Networking Electronics

1.012 QUALITY ASSURANCE

A. Refer to Section 28 0000 for additional information and requirements.

1.013 GUARANTEE

A. Refer to Section 28 0000 for additional information and requirements.

PART 2 - PRODUCTS

2.01 GENERAL

A. Refer to Section 28 0000 for additional information and requirements.
B. Unless noted otherwise, the following equipment and devices shall be the products of a single manufacturer and designed, manufactured, marketed, sold, and supported as an integrated system:
1. Video Surveillance System Application Software
2. Video Surveillance System Server(s)
3. Video Surveillance System Networked Video Storage
4. Video Surveillance System Workstation(s)
5. Video Surveillance Cameras

2.02 VIDEO SURVEILLANCE SYSTEM APPLICATION SOFTWARE

A. Basis of Design:
1. TYCO exacq exacqVision
B. Acceptable Alternates:
1. AMAG Symmetry CompleteView
2. Genetec Omnicast
3. Identiv 3VR VisionPoint
4. Milestone XProtect
5. OnSSI Ocularis
6. Salient CompleteView 20/20
7. TYCO American Dynamics Victor
C. Provide licenses required for new work specified in Contract Documents and to provide functionality specified in Contract Documents.

2.03 VIDEO SURVEILLANCE SYSTEM SERVER HARDWARE

A. Basis of Design:
   1. Lenovo
B. Acceptable Alternates:
   1. Dell
   2. Hewlett-Packard
C. Provide licenses required for new work specified in Contract Documents and to provide functionality specified in Contract Documents.

2.04 VIDEO SURVEILLANCE SYSTEM NETWORKED VIDEO STORAGE APPLIANCE(S)

A. Basis of Design:
   1. Dell
B. Acceptable Alternates:
   1. Hewlett-Packard
   2. Pure Storage
C. Provide licenses required for new work specified in Contract Documents and to provide functionality specified in Contract Documents.

2.05 VIDEO SURVEILLANCE SYSTEM WORKSTATION HARDWARE

A. Basis of Design:
   1. Lenovo
B. Acceptable Alternates:
   1. Dell
   2. Hewlett-Packard
C. Provide licenses required for new work specified in Contract Documents and to provide functionality specified in Contract Documents.

2.06 ETHERNET SWITCHES

A. Basis of Design:
   1. Cisco
B. Acceptable Alternates:
   1. Juniper
   2. Hewlett-Packard
C. Provide licenses required for new work specified in Contract Documents and to provide functionality specified in Contract Documents.

2.07 VIDEO SURVEILLANCE CAMERAS

A. Type 1 - Flush Indoor Ceiling Mounted Fixed Dome Camera, 2 MP
   1. Features:
      a. IK10-rated tamper resistant housing
      b. Transparent dome
      c. PoE powered
      d. Wide dynamic range
      e. Day/Night
      f. Remote zoom and focus
      g. Digital PTZ
      h. Multi-view streaming
      i. Built-in microphone
      j. Supports two-way audio
      k. Supports SD/SDHC/SDXC cards
   2. Specifications:
      a. Image Sensor: 1/2.8” RGB CMOS

b. Focal Length: 3 - 9mm, F1.3
c. Minimum Illumination, Color: 0.2 lux, F1.3
d. Minimum Illumination, B/W: 0.04 lux, F1.3
e. Shutter Time: 1/33500 - 2s
f. Camera Angle Adjustment, Pan: 360°
g. Camera Angle Adjustment, Tilt: 160°
h. Camera Angle Adjustment, Rotation: 340°
i. Video Compression: H.264
j. Resolution: 1920x1080 (2 MP)
k. Frame Rate: 30fps @ 60 Hz
l. Power Consumption: 4.2 watts
m. Operating Temperature (Environmental): 32 - 122°F
n. Network Connection: RJ-45, 10BASE-T/100BASE-T PoE
o. Audio Input Connection: 1/8", mic/line level
p. Audio Output Connection: 1/8", line level
q. Alarm Input Connection: Terminal Block
r. Alarm Output Connection: Terminal Block

3. Basis of Design:
   a. Axis P3365-V
4. Acceptable Alternates:
   a. None.

2.08 VIDEO SURVEILLANCE CABLE

A. General
   1. Refer to manufacturer's published product installation instructions for additional information and requirements. Wherever a discrepancy is identified between Project Documents and manufacturer's published product installation instructions, the more stringent requirement shall govern.
   2. Cable shall be plenum or riser rated as dictated by the environment in which the cable is installed.
      a. Refer to Mechanical drawings for additional information and requirements.
   3. Cable installed in wet or damp locations, including, but not limited to, in-slab and buried conduit, shall be rated for installation in wet locations.

B. Ethernet Cable and Connectivity
   1. Twisted Pair Copper Ethernet Cable and Connectivity
      a. Device Cables
         1) Refer to Section 27 1000 for information and requirements.
      b. Patch Cables
         1) Refer to Section 27 1600 for information and requirements

C. Low-Voltage Power Cable
   1. Minimum 18/2 unshielded
      a. Provide in gauge(s) as required to maintain no more than 10% voltage drop
   2. Basis of Design:
      a. Belden
   3. Acceptable Alternates:
      a. West Penn

D. Microphone and Line-Level Audio Cable
   1. 18/2 shielded
   2. Low-capacitance
   3. Basis of Design:

a. Plenum: Belden 88770
b. Nonplenum: Belden 8770

4. Acceptable Alternates:
   a. West Penn

2.09 VIDEO SURVEILLANCE RACEWAYS AND BOXES

A. Refer to Section 26 0533 for additional information and requirements.
B. Device Back Boxes:
   1. Dimensions: Minimum 4” square, 2-1/8” deep
C. Conduit:
   1. Minimum 3/4" trade size.
   2. No flexible conduit of any type.
   3. No conduit bodies or conduit outlet bodies of any type.

PART 3 - EXECUTION

3.01 CONFIGURATION AND PROGRAMMING COORDINATION MEETING

A. After Section 28 2300 shop drawings have been approved, Contractor shall arrange and conduct a configuration and programming coordination meeting to review and coordinate all aspects of Video Surveillance device and equipment configuration and programming.
   1. At a minimum, attendees shall include:
      a. Owner’s project manager and security representative
      b. Division 28 project manager and site superintendent / field foreman
      c. Video Surveillance subcontractor/supplier project manager and system programmer
   2. At a minimum, meeting agenda topics shall include:
      a. Identification and review of each video surveillance camera, to include:
         1) Intended field of view
         2) Intended use for video
         3) Mounting location
         4) Camera type and mount type/configuration
         5) General configuration and programming
         6) Network address
         7) Configuration of recorded video (resolution, frame rate, etc.)
      b. Review of a product-specific configuration and programming guide detailing all configuration and programming options applicable to the system software, hardware, equipment, and devices being provided.
      c. Configuration and programming of system server(s) and workstations and of server/workstation graphical user interface screens
      d. Review of installation, configuration, programming, and testing schedule, and of how those relate to the overall construction schedule.
   3. Meeting shall be held a minimum of two weeks prior to the commencement of work on site, and shall be scheduled with a minimum of two weeks’ notice.
      a. Contractor shall publish a meeting agenda for the meeting and distribute the meeting agenda and configuration and programming guide to all invited attendees a minimum of one week prior to the meeting.
   4. Contractor shall take detailed notes during the meeting and publish meeting minutes within one week after the meeting. Minutes shall be distributed to attendees, the Architect, and the Engineer.

3.02 GENERAL

A. Refer to Section 28 0000 for additional information and requirements.

3.03 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 28 0000 for additional information and requirements.

3.04 LOCATIONS OF WORK

A. Refer to Section 28 0000 for additional information and requirements.

3.05 FLOOR, WALL, CEILING, AND ROOF OPENINGS

A. Refer to Section 28 0000 for additional information and requirements.

3.06 EQUIPMENT ACCESS

A. Refer to Section 28 0000 for additional information and requirements.

3.07 EQUIPMENT SUPPORTS

A. Refer to Section 28 0000 for additional information and requirements.

3.08 SUPPORT PROTECTION

A. Refer to Section 28 0000 for additional information and requirements.

3.09 CABLE AND CONDUCTOR PROTECTION

A. Refer to Section 28 0000 for additional information and requirements.

3.010 HOUSEKEEPING PADS

A. Refer to Section 28 0000 for additional information and requirements.

3.011 LEAD SHIELDING

A. Refer to Section 28 0000 for additional information and requirements.

3.012 INSTALLATION

A. Refer to Section 28 0000 for additional information and requirements.

B. General
   1. Integrate all new work under this project in to Owner's existing system.

C. Video Surveillance Cameras
   1. Coordinate rough-in requirements with Division 26 Contractor prior to the commencement of work on site.
   2. Coordinate all locations with Owner and Division 26 Contractor prior to the commencement of work on site.
   3. Camera Mounting:
      a. Cameras and mounting accessories shall be rigidly attached to back boxes rigidly attached to structural members.
      b. Cameras installed in accessible ceiling tiles:
         1) Shall be supported by a tile bridge or other approved means
         2) Shall not be supported by the ceiling tile
         3) Shall be equipped with a safety cable secured to camera housing and structural member above
      c. Mount exterior cameras with stainless steel fasteners.
   4. Provide surge suppression for all exterior cameras, including exterior cameras connected via media converters.
   5. Provide media conversion for all cameras whose cabling exceeds maximum allowable length per applicable standards.
   6. Cable, terminate, configure, program, test, adjust, and make completely ready for use.
   7. Field-coordinate field of view, aim, and focus with Owner prior to commencement of final testing.
      a. Prior to final testing, Contractor shall, at no cost to Owner, make minor adjustments to camera locations and placement to address unanticipated obstructions to the field of view and/or unanticipated spatial interference.

1) For the purposes of these adjustments, “minor” is defined as adjustments requiring relocation of up to six (6) feet from the location coordinated with the Owner during the Configuration and Programming Coordination Meeting.

D. Media Converters
   1. Properly ground all media converter components and power supplies. Refer to Section 27 0526 for additional information and requirements.
E. Cable
   1. All Video Surveillance System cabling shall be installed in conduit from device location to cable tray above nearest accessible ceiling.
   2. Install cabling in pathways provided, or as designated on floor plans, and support from building structure.
      a. Where installed in free-air, support cables using J-hook type cable supports. Refer to Section 27 0528.29 - Hangers and Supports for Communications Systems for installation requirements.
         1) J-hook fill capacities shall be per manufacturer’s recommendations and shall consider diameter of cable type(s) being installed.
         2) Route cable/hooks at right angles, parallel to construction.
      b. Where installed in Cable Tray, lay cables neatly in tray.
         1) Do not tie.
         2) Provide sufficient slack in cables to allow for unequal expansion coefficients of cable tray and cables. This requirement is in addition to slack required at cable tray expansion joints.
   3. Where work under this Section is installed in a pole, bollard, etc. on site shared by work under Division 26, all work under Division 26 in the shared pole, bollard, etc. shall be installed in metallic raceway and boxes from end to end.
   4. Systems Identification:
      a. Label all system device cabling with unique alphanumeric identifiers that include:
         1) Video surveillance camera location:
            a) Exterior cameras - General location on site, based on direction (“North”, Northeast”, “East”, “Southeast”, etc.).
            b) Interior cameras - Architectural room number
         2) Unique alphanumeric identifier
      b. Refer to Section 27 0553 for additional information and requirements.
F. Configuration and Programming
   1. Coordinate all configuration and programming with Owner.
   2. Coordinate all IP address requirements with Owner a minimum of six weeks prior to commencement of programming work.
   3. Integration with other systems

3.013 INSPECTION AND TESTING

A. Refer to Section 28 0000 for additional information and requirements.
B. After successful completion of testing and prior to final acceptance, visually verify final field of view, aim, and focus of each video surveillance camera on site with Owner.
C. Verification Follow-Up Visits
   1. Contractor shall include in their bid a minimum of two (2) unique visits to the site to review field of view, aim, and focus of each video surveillance camera with Owner.
   2. Schedule of Visits:
      a. The first of these visits will occur within six (6) months of substantial completion, or at Owner’s request, whichever comes first.

   b. The second of these visits will occur within twelve (12) months of substantial completion, or at Owner's request, whichever comes first.
   c. Contractor shall tentatively coordinate scheduling for both visits upon substantial completion of work on site, but before final acceptance of the project.
3. At a minimum, Contractor shall provide for an average of fifteen (15) minutes per video surveillance camera installed under this project or a total of eight (8) hours on site for each visit, whichever is longer.
4. After each visit, Contractor shall prepare a report detailing observation of each camera's operation, discussion about each camera with Owner, and adjustments made.
5. Contractor's bid shall include all labor costs associated with visits, to include:
   a. Off-site pre-preparation time
   b. On-site time
   c. Travel time
   d. Off-site report preparation time

3.014 START-UP

A. Refer to Section 28 0000 for additional information and requirements.

3.015 DOCUMENTATION

A. Refer to Section 28 0000 for additional information and requirements.

3.016 CLEANING

A. Refer to Section 28 0000 for additional information and requirements.

3.017 TRAINING

A. Refer to Section 28 0000 for additional information and requirements.
B. Contractor shall provide to Owner's designated representative(s) a minimum of two (2) 4-hour on-site training sessions related to work under this section within fifteen (15) days of substantial completion.

END OF SECTION

SECTION 28 3116
MULTIPLEXED FIRE DETECTION AND ALARM SYSTEMS

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 14 2400 - Hydraulic Elevators
B. Section 21 1314 - Automatic Fire Sprinkler System
C. Section 26 0000 - General Electrical Requirements
D. Section 26 0519 - Low-Voltage Electrical Power Conductors and Cables
E. Section 26 0526 - Grounding and Bonding for Electrical Systems
F. Section 26 0533 - Raceway and Boxes for Electrical Systems
G. Section 26 0553 - Electrical Systems Identification

1.02 DESCRIPTION

A. In general, work consists of:
   1. Furnish and install complete Multiplexed Fire Alarm System as shown on plans.
   2. System shall:
      a. Be an intelligent analog system
      b. Allow for loading and editing special instructions and operating sequences as required
      c. Be capable of on-site programming to accommodate system expansion and facilitate changes in operation
      d. Be wired, connected, and left in operating condition
   3. System includes:
      a. Control Panel(s)
      b. Annunciator Panel(s)
      c. Manual Stations
      d. Heat Detectors
      e. Smoke Detectors
      f. Alarm Indicating Devices
      g. Terminations
      h. Other necessary material for complete operating systems
   4. Software operations shall be stored in non-volatile programmable memory within fire alarm control panel. Loss of primary and secondary power shall not erase instructions stored in memory.

1.03 REFERENCE STANDARDS

A. FBC - 2020 - Florida Building Code
B. FFPC - 2020 - Florida Fire Prevention Code
C. NECA 305 - Standard for Fire Alarm System Job Practices
D. NFPA 72 - National Fire Alarm and Signaling Code
E. NFPA 101 - Life Safety Code
F. UL 268 - Smoke Detectors for Fire Protective Signaling Systems
G. UL 497B - Protectors for Communications and Fire Alarm Circuits
H. UL 521 - Heat Detectors for Fire Protective Signaling Systems
I. UL 864 - Control Units for Fire Protective Signaling Systems
J. UL 1480 - Speakers for Fire Protective Signaling Systems
K. UL 1481 - Power Supplies for Fire Protective Signaling Systems
L. UL 1711 - Amplifiers for Fire Protective Signaling Systems

1.04 QUALIFICATIONS

A. Equipment shall be supplied by company specializing in fire alarm and smoke detection systems with 5 yrs documented experience

B. Work shall be performed by licensed contractor, regularly engaged in installation and servicing of fire alarm systems.
C. Furnish proof of 5 yrs documented experience and factory authorization to furnish and install equipment proposed.
D. Contractor shall be located within 100 miles of Project site.

1.05 SUBMITTALS

A. Submit bill of materials listing part number and quantity of components and devices.
B. Submit general catalog cutsheets of all devices that are to be provided as part of system. Mark cutsheets with items specific to the project when multiple items are identified.
C. Submit block diagrams showing layout and operation of entire system.
D. Submit schematic diagrams, of circuits from field devices to terminal strip(s) associated with control panel.
    1. Diagrams shall show schematic wiring of equipment; and connections to be made to devices.
    2. Terminal connections in equipment shall be numbered to correspond to diagrams.
    3. Wiring diagrams shall be coordinated so that terminal numbering, circuit designation and equipment or device designations are same on drawings.
E. Submit standby battery power calculations.
F. Submit sound amplifier and strobe power supply calculations showing current draws for every device and module during standby, alarm and trouble conditions.
G. Submit voltage drop calculations for both initiating and alarming circuits.
H. Submit list of device addresses with location labeling as they will appear in 2 line, 40 character display of fire alarm panel and remote annunciator.
I. Submit to Authority Having Jurisdiction (AHJ):
    1. Copy of shop drawings as required to show component locations.
    2. Upon receipt of comments from AHJ, make resubmissions if required to make clarifications or revisions to obtain approval.
    3. All fees associated with this shall be included in the bid.

1.06 QUALITY ASSURANCE

A. Product Components and Materials are to comply with FAR 52.225-9 Buy American Act – Construction Materials (May 2014), with the following words inserted in the indicated space in paragraph (b)(2): “The articles listed in FAR 25.104(a) that are acquired as construction materials.”

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Johnson Controls Inc (JCI)/Simplex
B. Edwards Systems Technologies
C. Honeywell
D. Siemens Cerberus
E. Equivalent that meets performance specifications

2.02 SYSTEM OPERATIONS

A. Alarm Initiation
    1. System alarm operation after activation of any manual station, automatic detection device, or sprinkler flow switch shall be:
        a. Appropriate initiating device circuit red LED shall flash on Control Panel and remote annunciator until the alarm has been acknowledged at Control Panel or remote annunciator.
        b. Once acknowledged, this same LED shall latch on.

c. Subsequent alarm received after acknowledging shall flash subsequent zone alarm LED on Control Panel and remote annunciator.
d. Acknowledgment of alarm shall not reset activated device.
e. Pulsing alarm tone shall occur within Control Panel and remote annunciator until event has been acknowledged.
f. Alarm audible-indicating devices shall sound in three pulse temporal pattern until silenced by alarm silence switch at Control Panel or remote annunciator.
g. Visual alarm indicating devices shall operate in continuous flashing pattern until system is reset.
h. Signal to notify the local fire department shall be activated.
i. Doors held open by door control devices shall close.

2. System shall have single key to allow operator to display alarms, troubles, and supervisory service conditions, including time and date of each occurrence.
3. Alarm shall be displayed on an 80-character LCD display as follows:
   a. 40 characters for:
      1) Point address and loop number
      2) Type of device
      3) Point status
   b. 40 characters for:
      1) Custom location label

B. Silencing
1. Alarm audible indicating devices shall be silenced by operating alarm silence switch or by use of key operated switch at remote annunciator.
2. Strobes shall remain active until system is reset.
3. Subsequent zone alarm shall reactivate alarm signals.

C. Reset
1. SYSTEM RESET button shall return system to its normal state after an alarm condition has been remedied.

D. Supervision
1. System shall independently supervise:
   a. Initiating device circuits
   b. Sprinkler flow and tamper switches
   c. Independently fused indicating appliance circuits for alarm horn/strobe units
   d. Auxiliary manual controls. "Off normal" position of any switch shall cause an "off normal" system trouble
   e. Auxiliary circuits for addressable relays. Blown fuse or open in circuit shall be visibly and audibly annunciated.
   f. Remote annunciator panel. Any ground, short, or open in the wiring to fire alarm Control Panel, as well as malfunction of the annunciator panel, shall be annunciated at control panel.
   g. Incoming power. Power failure shall be audibly and visually indicated at Control Panel and remote annunciator. Green "power on" LED shall be displayed continuously while incoming power is present.
   h. System Modules for module placement. Should modules become disconnected, system trouble indicator shall illuminate and audible trouble signal shall sound.
   i. System batteries. Low battery condition or disconnection of battery shall be audibly and visually indicated at Control Panel and remote annunciator.
2. Device activation shall be annunciated at Control Panel and remote annunciator.
3. Independently supervised circuits shall include visible amber "Trouble" LED to indicate disarrangement conditions per circuit.

4. Disarrangement conditions of any circuit shall not affect operation of other circuits.
5. Alarm activation of any initiation circuit shall not prevent subsequent alarm operation of any other initiation circuit.
6. System shall have provisions for disabling and enabling circuits individually for maintenance or testing purposes.

E. Power Requirements
1. Provide 120 VAC power via dedicated branch circuit in emergency panel.
2. Branch circuit shall have "breaker lock" to prevent accidentally de-energizing of power to fire alarm panel.
3. Circuit breaker shall be painted red and labeled "FIRE ALARM."
4. Provide disconnect switch for AC power near panel or within Fire Alarm Control Panel itself. Switch shall be labeled "Fire Alarm Power Disconnect."
5. Where new Control Panel is to remain at same location as existing panel, contractor may use existing branch circuit, if it meets requirements stated above.
6. Provide power surge and transient protection.
7. Provide back-up battery capacity to operate entire system in normal supervisory mode for period of 24 h with 10 minutes of alarm operation at end of period.
8. System shall automatically transfer to standby batteries upon power failure.
   a. Battery charging and recharging operations shall be automatic.
9. Provide power limited, filtered and regulated battery charger.
   a. Charger shall:
      1) Be combination high rate/float maintenance type
      2) Charge fully discharged battery to 70% in 12 h
      3) Monitor for AC fail/disconnect, low/no battery, and high battery level
      4) Include switches and associated LEDs for high rate and AC disconnect
      5) Provide 5 amps of regulated 24 VDC for peripheral devices requiring ± 5% regulation and 8 amps at 24 VDC for standard peripheral devices.
      6) Be compatible with lead acid batteries
10. External circuits requiring system operating power shall be 24 VDC and shall be individually supervised and fused at Control Panel.

F. Smoke Detection Operation
1. Smoke detector alarms shall be processed and reported immediately.
2. Upon building completion, alarm verification shall be added to detector(s) as directed by project engineer.
3. Control Panel shall:
   a. Be capable of displaying number of times (tally) detector has gone into verification mode from the system history
   b. Download alarm set point to detector
   c. Determine condition of each detector by comparing detector's value to stored values.
   d. Maintain moving average of detectors' smoke chamber value to automatically compensate for dust and dirty conditions
   e. Continuously perform an automatic self-test routine on each detector
   f. Have capability of being programmed for pre-alarm or two-stage function
   g. Clear "detector dirty" trouble after detector has been removed from its base cleaned and replaced
4. System shall maintain constant smoke obscuration sensitivity for each detector by compensating for environmental factors.
5. Photoelectric detector's smoke obscuration sensitivity shall be adjustable to within 0.3% of either limit of UL window (0.5% to 4.0%) to compensate for any environment.

6. System shall indicate when individual detector needs cleaning. When detector's average value reaches predetermined level, trouble MESSAGE shall be audible and visibly indicated at Control Panel. LED on detector base shall glow steady giving visible indication.
7. For scheduling of maintenance, Control Panel shall generate MESSAGE indication for any detector approaching trouble condition due to dirt or contamination.
8. Operator shall have capability to manually access the following information for each detector:
    a. Primary status
    b. Device type
    c. Present average value
    d. Present sensitivity value selected
    e. Detector range (normal, dirty, etc.)
9. Values at Control Panel shall be in "percent of smoke obscuration" format, so that no interpretation is required by operator.
10. Operator shall be able to manually control following for each detector:
    a. Enable or disable detector
    b. Establish alarm sensitivity
    c. Control detector's relay driver output
11. It shall be possible to program Control Panel to automatically change sensitivity settings of each detector based on time-of-day and day-of-week. There shall be 3 sensitivity settings available for each detector.

G. Elevator Recall Operation
1. When an elevator lobby or machine room smoke detector alarm is activated it shall cause Phase I Emergency Recall Operation according to following sequence:
    a. If alarmed detector is on any floor other than main level of egress, elevator car(s) shall be recalled to main level of egress.
    b. If alarmed detector is on main level of egress, elevator car(s) shall be recalled to predetermined alternate recall level as determined by Owner.
2. Elevator lobby smoke detector shall annunciate on separate zone from other devices.
3. Zoning shall be done by floor.
4. Upon reset of Fire Alarm Control Panel, elevators shall automatically resume normal operations.

H. Elevator Shunt Trip
1. After elevator machine room or elevator shaft heat detector is activated, elevator control panel shall deactivate shunt trip breaker supplying power to elevator.
2. Specific elevator shaft zone shall be put into alarm and sound general fire alarm.

I. System Response
1. Maximum elapsed time from sensing fire at non-smoke detector initiating device or second smoke detector until it is recorded at Control Panel and remote annunciator shall not exceed 5 seconds, and not exceed 15 seconds for remote station reporting.

J. Air Handling Unit System Operation/Interface
1. Control Panel shall provide alarm interface to air handling/energy management system controllers, which shall perform automatic functions as specified in Division 23.
2. Fire Alarm Control Panel shall provide manual control mode to override fire alarm panel’s signal so that air handling units can be restarted.

K. Sprinkler System Operation/Interface
1. Activation of any standpipe or sprinkler system tamper or water flow switch shall activate system supervisory service audible signal and illuminate LED at Control Panel and remote annunciator.

2. Control Panel shall provide differentiation between switch operation and opens and/or grounds on initiation circuit wiring.
3. Pressing acknowledge key will silence audible signal while maintaining supervisory service LED "on" indicating off-normal condition.
4. Restoring valve to normal position shall cause supervisory service audible signal to pulse indicating restoration to normal position.
5. Acknowledge key shall silence audible signal.

L. Manual Evacuation (Drill) Operation
1. Manual evacuation (drill) switch shall be provided to operate alarm indicating appliances without causing other control circuits to be activated.
2. Should true alarm occur, alarm functions would occur.

M. LED and LCD Test Operation
1. Activation of Lamp Test switch shall turn on all LED indicators, LCD display, and the local sounder and then return to previous condition.

N. System Diagnosis
1. System shall include special software to detect, diagnose and report failures and isolate such failures to printed circuit board level.

O. Watch-Dog Timers
1. System shall include independent "Watch-Dog" timers to detect and report failure of any microprocessor circuit, memory, or software.

P. Walk Test Operation
1. Actuation of "Walk Test" switch/program at Control Panel shall activate "Walk Test" mode of system, which shall cause following to occur:
   a. Fire department circuit connection shall be bypassed.
   b. Control relay functions shall be bypassed, such as elevator capture, fan shut down, etc.
   c. Audio and visual circuits shall be bypassed.
   d. Control Panel shall show trouble condition.
   e. Alarm activation of initiation device shall cause audible signals to sound for 2 seconds.
   f. Control Panel shall automatically reset itself after signaling is complete.
   g. Momentary opening of initiating or indicating appliance circuit wiring shall cause audible signals to sound for 2 seconds indicating trouble condition.
   h. If system becomes inactive for period of longer than 30 minutes, Control Panel shall default to normal fire alarm functions.
   i. Activation of any initiation device shall be silently logged as an alarm condition in historical data file.
2. Panel shall have capability of dividing system into distinctive walk test groups.

Q. One-Way Voice Communications
1. Automatic voice evacuation sequence shall be as follows:
   a. Audio alarm signal shall consist of alarm tone for maximum of 2 seconds followed by temporal code-three. Temporal code-three shall sound until alarm silence switch at Fire Alarm Control Panel or the remote annunciator has been operated.
   b. Audio alarm operations of speaker circuit selection and alarm tone timing variations shall be activated by system software so that required future changes to evacuation sequence or re-arrangements of audio circuits can be facilitated by authorized personnel without additional components or rewiring.
2. All Call:
   a. Upon activation of "All Call" switch, 2 seconds of tone shall sound over all speakers in system. At end of this tone, the operator shall be able to make announcements via push-to-talk paging microphone over all system speakers.

b. Strobes shall flash in all areas or floors.
c. System shall default to normal operations if the microphone becomes inactive for more than 1 minute.

2.03 ENCLOSURE

A. Provide cabinets of sufficient size to accommodate equipment.
B. Cabinet shall be equipped with door, with lock and transparent door panel, providing tamper proof enclosure and allowing full view of various lights and controls.

2.04 CONTROL PANEL

A. Control Panel shall be modular, expandable with solid state, microprocessor based electronics.
B. Control Panel shall provide the following features:
1. Support intelligent (analog) detection devices.
2. Number of initiating device loops required for specified quantity of initiating devices. Each active loop shall include 5% spare capacity.
3. Number of indicating device (horn/speaker) circuits required for quantity of horns/speakers alarm. Each active circuit shall include 25% spare capacity.
4. Number of indicating device (strobe) circuits required for specified quantity of strobes plus one (1) spare circuit for each 10 active circuits. Each active circuit shall include 25% spare capacity.
5. 80-character liquid crystal display
6. Printer interface
7. History log file with minimum of 600 events
8. Field programmable
9. Drift compensation
10. Sensitivity display in %
11. Sensitivity adjustment
12. Day/night sensitivity adjustment
13. Auto detector test
14. Silent walk test
15. Maintenance alerts
C. System shall provide ability to recall alarms and trouble conditions in chronological order.
D. Under normal condition viewing window shall display "System is Normal" message and current time and date.
E. When an abnormal condition occurs appropriate LED (Alarm, Supervisory or Trouble) shall flash.
F. Audible signal shall pulse for alarm conditions and sound steady for trouble and supervisory conditions.
G. Panel shall display the following information relative to abnormal condition of a point in system prior to acknowledgement:
1. 40 characters for:
a. Point address and loop number
b. Type of device (i.e. smoke, pull station, water-flow)
c. Point status (i.e. alarm, trouble)
2. 40 characters for:
a. Custom location label (i.e. 2nd Floor - Room 202)
H. Keyboards or keypads shall not be required to operate the system during fire alarm conditions.
I. Following software functions shall be provided:
1. Setting of time and date
2. LED testing
3. Alarm, trouble, and abnormal condition listing

4. Enabling and disabling of each monitor point separately
5. Activation and deactivation of each control point separately
6. Changing operator access levels
7. Walk Test enable
8. Running diagnostic functions
9. Displaying historical logs
10. Point listing

J. Following hardware functions shall be provided:
1. Acknowledge alarm or trouble
2. Silence alarm or trouble
3. Reset system after alarm
4. Connect/disconnect fire department tie
5. Provide manual evacuation (drill)
6. Bypass elevator recall and shunt trip operation
7. Bypass door holders
8. Allow computer interface

2.05 STATUS INDICATORS AND DISPLAYS

A. Audible device shall sound during Alarm, Trouble or Supervisory conditions.
B. Audible device shall sound during each key-press.
C. Visual display shall distinguish between alarm, trouble and supervisory conditions.
D. Indicators and displays to be visible:
1. One red system alarm LED
2. One yellow supervisory service LED
3. One yellow trouble LED
4. Green "power on" LED
5. Eighty-character LCD

E. 2-line by 40-character LCD shall be backlit.
F. Cursor shall be visible on LCD when entering information.
G. Scrolling through menu options shall be in self-directing manner in which prompting messages shall direct user.
H. Controls shall be located behind an access door.
I. Status data to be available on display:
1. Initiating device circuits
2. Indicating device circuits
3. Auxiliary relays
4. Primary State of point
5. Zone information
6. Class "A" Status
7. Current priority of outputs
8. Disable/Enable status
9. Automatic/Manual Control Status of output points
10. Acknowledge status

2.06 CONTROLS

A. Controls (one switch per function per system) visible through front viewing window:
1. Alarm Acknowledge key
2. Trouble Acknowledge key
3. Alarm Silence key
4. System Reset key

B. Controls accessible with front door open:

1. Fire department disconnect/switch
2. Manual evacuation (drill)
3. Elevator bypass
4. Fan shut down override/bypass switches
5. Key pad for data input and microprocessor control

2.07 LED SUPERVISION

A. Slave module LEDs shall be supervised. When problem occurs, LCD shall display module and LED location.

2.08 ACKNOWLEDGMENT

A. Two methods of acknowledgment for each abnormal condition shall be provided:
   1. Acknowledge one event at a time from an unacknowledged list of events.
   2. Pressing acknowledge button shall display first unacknowledged condition in list (either alarm, supervisory or trouble), and require another acknowledge button. Press to acknowledge only displayed point.

B. After all points have been acknowledged, LEDs shall glow steadily and alarm will be silenced. Total number of alarms, supervisory and trouble conditions shall be displayed.

C. Pressing appropriate acknowledge button shall acknowledge all points

D. Acknowledge functions shall be behind locked door or pass-code protected.

2.09 SILENCING

A. If an alarm condition exists and "Alarm Silence" button is pressed, all alarm signals shall cease operation. Strobes shall remain active until system is reset.

B. If trouble conditions exist in system and "Trouble Silence" button has been pressed, audible trouble signal shall cease, but shall resound at timed intervals to act as reminder that fire alarm system is not in normal operating mode.

2.010 RESET

A. SYSTEM RESET button shall be used to return system to normal state after alarm condition has been remedied.

B. Should an alarm condition continue to exist, system shall provide indications that resetting can not be completed and shall remain in an abnormal state.

C. Sonalert and Alarm LED shall remain activated.

D. Display shall indicate total number of alarms and troubles present in system along with prompt to use ACK keys to review points.

E. Points shall not require acknowledgment if they were previously acknowledged.

F. Should Alarm Silence Inhibit function be active, system shall ignore all key presses. An indication of enabling and disabling inhibit state shall be provided as feedback to operator.

2.011 ACCESS LEVELS

A. Provide 4 access levels with level 4 being highest level. Level 1 actions shall not require pass-code.

B. Pass-codes shall consist of up to 5 digits.

C. Pass-code digits entered shall be displayed as an X to indicate that digit has been accepted.

D. Key presses shall be acknowledged by local audible sound.

E. When correct pass-code is entered, system shall indicate to operator "*Access Granted."*

F. Access level shall be in effect until operator manually logs out or keypad has been inactive for 5 minutes.

G. Operator entering invalid code shall be notified with message *"Incorrect Pass- Code*" and shall be allowed three chances to enter valid code. After three unsuccessful tries, the message "*Access Denied*" shall be displayed.

H. Following keys/switches shall have associated access levels:
   1. Alarm Silence

2. System Reset
3. Set Time/Date
4. Manual Control
5. On/Off/Auto Control
6. Disable/Enable
7. Programming functions
8. Clear Historical Alarm Log
9. Clear Historical Trouble Log
10. Walk Test

I. Acknowledge keys shall require pass code access to acknowledge points. If operator presses an (ACK) key with insufficient access, an error message shall be displayed.

2.012 POINT LISTING

A. Point list menu includes:
1. All points list by address
2. Monitor point list
3. Signal/speaker list
4. Auxiliary control list
5. Feedback point list

2.013 HISTORY LOGGING

A. System shall be capable of logging and storing the last 400 events (alarm and trouble) in history log. These events shall be stored in battery protected random access memory.
B. Following historical alarm log events shall be stored:
1. Alarms
2. Alarm Acknowledgment
3. Alarm Silence
4. System Reset
5. Alarm Historical log cleared
C. Following historical trouble log events shall be stored:
1. Trouble conditions
2. Supervisory alarms
3. Trouble acknowledgment
4. Supervisory acknowledgment
5. Walk Test results
6. Trouble Historical log cleared

2.014 COMPUTER INTERFACE

A. Control Panel shall operate as proprietary local system with capability of sending status data to and receiving control data from Central Processing Unit (CPU).
B. CPU shall monitor all alarms and troubles and control selected functions of Control Panel.
C. CPU shall supervise all data communication wiring between CPU and Control Panel for opens, shorts and grounds.

2.015 FIELD PROGRAMMING

A. System shall be fully programmable, configurable, and expandable in field and shall not require replacement of memory IC's.
B. Programming may be accomplished through Control Panel keyboard or use of PC.
C. Programs shall be stored in non-volatile memory.
D. Programming or reprogramming shall be done by supplier at no charge until system is accepted by Owner.

2.016 TERMINAL/PRINTER INTERFACE

A. Control Panel shall be capable of operating remote monitors and/or printers.
B. Output shall be ASCII from RS-232-C connection with an adjustable baud rate.
C. Each RS-232-C port shall be capable of supporting and supervising up to 4 remote CRTs and Printers.
D. Data amplifiers shall be used to increase CRT or printer line distance.

2.017 INTELLIGENT NETWORK

A. System shall provide communications with intelligent initiating and control devices individually.
B. Devices shall be individually annunciated at control panel.
C. Annunciation shall include the following conditions for each point:
    1. Alarm
    2. Trouble
    3. Open
    4. Short
    5. Device missing/failed
D. Devices shall have capability of being disabled or enabled individually.
E. There shall be no limit to number of detectors, stations, or addressable modules, which may be activated or "in alarm" simultaneously.
F. Multiple intelligent devices shall be connected to a single pair of wires.
G. Communication format must be completely digital poll/response protocol to allow t-tapping of circuit wiring.

2.018 ONE-WAY VOICE COMMUNICATION SYSTEM

A. Provide central audio control module for:
    1. Alarm message/tone generation
    2. Main and remote microphone connections
    3. Mixer/pre-amplifier circuits
    4. Continuous supervision shall be provided for all circuits, amplifiers and modules.
B. Hand-held, push-to-talk microphone:
    1. Recessed in panel-mounted enclosure
    2. Dynamic communication type with frequency range of 200 Hz to 4000 Hz
    3. Equipped with self-winding 5’ coiled cable
    4. LED indicator shall be provided to indicate microphone push-to-talk button has been pressed and speaker circuits are ready for transmission.
    5. Supervised for disconnection
C. Audio control switch module:
    1. Provide manual access to audio operations personnel.
    2. Include "All circuits" switch, "Aux Tone" switch and tone generator stop switch
    3. Switches and LED indicators shall be supervised for disarrangement on failure.
D. Automatic message player:
    1. Provide a pre-recorded digitized voice message to building occupants during alarm conditions
    2. Not rely on tape or other mechanical means of transmitting evacuation message
    3. Be capable of transmitting a custom message of up to 3 minutes long
E. Self-contained speaker and switching arrangement shall provide testing of message(s) without disturbing occupants of the facility.
F. Provide standard message, approved by Authority Having Jurisdiction.
G. Audio power amplifiers:
    1. Be furnished with self-contained filtered 24 VDC power supply, transformer and amplifier monitoring circuits
    2. Provide 25 or 75 VRMS output with frequency response of 100 Hz to 7000 Hz

3. Be constantly monitored
4. Be current limited or disconnected from circuit should a short develop on speaker circuit
5. Individual speaker circuits shall not be loaded more than 70%of rated amplifier power output.

H. Provide amplifiers to operate system speakers at 1-watt tap simultaneously plus 50% reserve capacity.
I. Provide at least one back-up amplifier capable of automatically replacing any failed amplifier. Stand-by amplifier shall be rated at same output capacity as the largest amplifier in evacuation system.
J. Speaker and strobe circuits shall be zoned by floor or as noted on plans, with isolating module on each circuit.
K. Audio Evacuation Supervision:
   1. Each speaker zone, amplifier, preamplifier, and power supply shall be supervised for component or circuit failure.
   2. Detection of amplifier failure shall automatically cause substitution of stand-by amplifier and shall activate trouble light and audible signal at console and initiate trouble alarm on fire alarm system.
   3. Provide minimum of one circuit for each zone or area of distinct communication.
L. Manual Voice Paging Sequence
   1. System shall allow selective voice paging.
   2. An "All Call" switch shall be provided to allow for activation of all speakers.
   3. Control Panel shall provide a method for remote fire fighters telephone patch-in to one-way voice communication speakers.
   4. Manual operation shall be controlled at Fire Alarm Control Panel, or remote microphone; if provided.
M. Tones
   1. Main evacuating tone shall be temporal code-three.
   2. Optional tones shall include:
      a. Hi/Lo
         1) Free running tone with high frequency of 544 Hz and low frequency of 440 Hz
         2) "On time" (Hi) shall be 100 milliseconds while the "off time" (Lo) is 400 milliseconds.
      b. Slow whoop
         1) Slowly ascending tone from 200 to 830 Hz in 2.5 seconds
   3. One primary and one secondary tone generator shall be furnished.
      a. Automatic transfer to secondary unit should primary unit fail
      b. Trouble signals shall indicate a failure of either primary or secondary unit.

2.019 REMOTE ANNUNCIATOR PANEL

A. Provide 80-character LCD remote annunciator panel.
   1. LED annunciators will not be accepted.
B. Annunciator shall provide:
   1. Control push-button switches for; alarm silence, trouble silence, system reset and LED and LCD test.
   2. Tone Alert - Duplicates Control Panel tone alert during alarm and trouble conditions
   3. System trouble LED
   4. System alarm LED
   5. Power on LED
C. Annunciator shall communicate to Control Panel over one shielded twisted pair cable.
D. Operating power shall be 24 VDC and be fused at control panel.
E. Annunciator shall have black finish.

F. Wiring between annunciator panel and Control Panel shall be supervised for opens, grounds and shorts.
G. Under normal operating conditions, LCD shall indicate time, date and "SYSTEM IS NORMAL" label.
H. During abnormal conditions, LCD shall indicate type and number of abnormal conditions, such as alarms, troubles, and supervisory services.

2.020 MULTIPLEXED PERIPHERAL DEVICES

A. Devices shall be supervised for trouble conditions.
B. Failure of device shall not hinder operation of other system devices.
C. Device Identification
   1. Each intelligent device shall be identified by an address code.
   2. Location of end-of-line device shall be indicated on device that containing same.
   3. System must verify that proper type device is in place and matches software configuration.
D. Intelligent Detector Bases
   1. Either base or head shall contain electronic circuits that communicate detector's status (normal, alarm, sensitivity status, trouble) to Control Panel over two wires. Same two wires shall also provide power to base and detector.
   2. Contacts between base and head shall be of bifurcated type using spring-type, self-wiping contacts.
   3. Base shall have locking capability. Locking feature must be field removable when not required.
   4. Upon removal of detector's head, trouble signal shall be transmitted to Control Panel.
   5. Detector base or head shall contain LED(s) that flash when detector is being scanned by Control Panel.
   6. LED(s) shall turn on steady when detector is in alarm condition.
E. Intelligent Detector Heads - General
   1. Intelligent detector heads shall be low-profile type.
   2. Heads shall be plug-in units, which mount to common base.
   3. Heads shall be 24 VDC type.
   4. Heads may be reset by actuating Control Panel reset switch.
   5. To minimize false alarms, voltage and RF transient suppression techniques shall be employed.
   6. Smoke detectors:
      a. Listed for sensitivity testing from Control Panel.
      b. Include an insect screen.
      c. Communicate actual smoke chamber values to Control Panel.
      d. Covered with plastic bags after installation to maintain cleanliness. Bags shall be red for quick visual identification for removal at time of occupancy.
F. Intelligent Photoelectric Smoke Detectors
   1. Detectors:
      a. Contain no radioactive material
      b. Be of solid state photoelectric type and shall operate on light scattering photodiode principle using pulsed infrared LED light.
G. Intelligent Heat Detectors
   1. Detectors:
      a. Be a combination rate-of-rise and fixed temperature (135°F unless noted).
      b. Sense within temperature range of 32° to 158°F. The control panel shall be capable of sensing either a set point of 135°F, or a rate-of-rise of 15°F per minute for fire sensing.
H. Intelligent Duct Smoke Detectors:

1. Duct detectors shall be of photoelectric type.
2. Detectors shall be rated for air velocity to be expected.
3. It shall be possible to alarm duct detector by using remote or local test switch.
4. It shall be possible to clean sampling tubes by access through duct housings front cover.
5. Provide relays adjacent to motor controller, and remote keyed test switch and alarm LED indicator.
6. In mechanical rooms, alarm LED indicators shall be grouped on a stainless steel cover plate.
    a. Mount adjacent to main mechanical room door.
    b. Each LED shall be labeled with detectors loop and address.
    c. Floor plan of room showing detectors and addresses shall be located adjacent to cover plate.
    d. Provide Plexiglas cover over plan.

I. Manual Stations
1. Manual stations:
    a. Single action
    b. Constructed of high impact, red Lexan with raised white lettering and smooth high gloss finish
    c. Contain circuits that communicate station's status (alarm, normal) to Control Panel over two wires
    d. Mechanically latch upon operation and remain so until manually reset. Stations that use Allen wrenches or special tools to reset shall not be accepted.
    e. Fitted with screw terminals for field wire attachment
2. Address shall be field programmable on station.

J. Interface Modules - General
1. Interface Modules:
    a. Receive 24 VDC power from separate two wire circuit
    b. Available in either Class B or Class A supervision version
    c. Supervised and identified by Control Panel
    d. Capable of being programmed for its "address" location
    e. Compatible with addressable manual stations and intelligent detectors on same intelligent initiating circuit
2. Class A wiring shall be looped back and connected to module.
3. Class B wiring shall be supervised by an end-of-line device.
4. Should interface module become non-operational or removed, trouble signal shall be transmitted to Control Panel.
5. Interface module LED's shall be clearly visible on the face of the trim plate.

K. Interface Modules - Supervised Control
1. Interface Modules shall be used for control of indicating appliances, door holders, and AHU systems.
2. For signals, speakers, fire fighter phone jacks and other device control interface module shall provide double-pole/double-throw relay switching that can connect any of the following through 2 amp fuses:
    a. Zone of signals to power source
    b. Speakers to audio source
    c. Fire fighter phone jacks to communications channel
    d. Variety of controlled devices to appropriate controlling circuits.
3. Interface modules:
    a. Communicate supervised wiring status (normal, trouble) to fire alarm control panel.
    b. Receive from fire alarm control panel command to transfer relay.

L. Interface Modules - Supervised Monitoring
   1. Interface Modules:
      a. Suited for monitoring of water-flow, valve tamper, and non-intelligent detectors.
      b. Addressable interface module shall be provided for interfacing normally open direct-contact devices to an intelligent initiating circuit.
      c. Provide power to and monitor status of zone consisting of conventional 2-wire smoke or heat detectors and N/O contact devices.
      d. Communicate zone's status (normal, alarm, trouble) to Control Panel.
   2. Supervision of zone wiring shall be Class B or Class A.

M. Interface Modules - Non-Supervised Control
   1. Interface module shall provide double-pole/double-throw relay switching for loads up to 120VAC. It shall contain 2 amp fuses, one on each common leg of relay.

2.021 SPEAKER/STROBE DEVICES

A. Combination Speaker/Strobe Devices
   1. Speakers:
      a. Operate on 24 V DC circuit
      b. Include separate wire leads for in/out wiring for each leg of associated signal circuit. T tappings of signal device conductors shall not be acceptable.
      c. Be suitable for rear mounting behind audio-visual assemblies, which shall be flush or semi-flush mounted, with manufacturer back boxes and flush trim ring.
      d. Have field adjustable output taps, 3 taps minimum.
      e. Provide minimum sound pressure level of 85.7 dBA at 10’ using 1-watt tap.
      f. Speakers located in mechanical rooms shall have 3 taps minimum with 8W being the highest.
      g. Provide a minimum sound pressure level of 90 dBA at 10’ using the 2-watt tap.
      h. Include a blocking capacitor for line supervision and screw terminal for in-out wiring.
   2. Strobes shall be:
      a. Multi-tap units with taps at 15, 30, 75, and 110 cd.
      b. Tapped at 15-candela peak power or as noted on drawings.
      c. Have flash synchronization module on circuit when more than one strobe is visible at a time.
      d. On separate supervised circuit from speaker circuit.
   3. White Lexan lens shall have "FIRE" in red lettering visible from a 180° field of view.
   4. Have off-white semi flush housing.
   5. Strobe circuit loading shall be calculated at 75 cd tap for all devices, except in mechanical, interstitial spaces where circuit loading shall be calculated at 110 cd tap

B. Speaker Devices
   1. Speakers without strobe units:
      a. Include above-listed features
      b. Flush ceiling mounted white baffle and recessed back box for installation in suspended ceiling system.
      c. Red baffle with surface mounted back box, furnished by speaker manufacturer, where installed in areas with exposed structure.
      d. Cast metal grille and back box where installed in mechanical/interstitial spaces.

2.022 CONVENTIONAL PERIPHERAL DEVICES

A. Sprinkler Waterflow Switches - Wet Systems
   1. To be furnished and installed by Fire Protection Contractor under Division 21.
   2. To prevent false alarms, flow switch shall incorporate adjustable time delay mechanism between the paddle-operated stem and alarm initiating contacts.

3. Tapped 1/2” conduit connection

B. Sprinkler Valve Tamper Switches - Wet Systems
   1. Sprinkler valve tamper switches shall be furnished and installed by Fire Protection Contractor under Division 21.
   2. Switch shall be provided with either 1 or 2 sets of S.P.D.T. micro switches as required.

C. Door Holders
   1. Magnetic door holders:
      a. Provided by the General Contractor. Refer to Section 08 7110 - Door Hardware.
      b. Capable of being surface, flush, or semi-flush mounted as required
   2. Power for door holders shall be 24 V.

D. Fault Isolator Module
   1. Provide Fault Isolator Module (FIM) on initiating device circuits in following situations:
      a. Loop extends to another floor
      b. Loop extends to another building
      c. For each 25 devices on a loop
   2. Fault Isolator Module shall:
      a. Automatically re-connect isolated section of loop upon correction of fault conditions.
      b. Not require any address setting
      c. Operations shall be totally automatic. It shall not be necessary to replace or reset FIM after its normal operation.
      d. Include LED, which shall flash under normal operation and illuminate steady to indicate short circuit.

2.023 ISOLATED LOOP CIRCUIT PROTECTORS (ILCP)

A. Fire Alarm Control Panel shall include Isolated Loop Circuit Protector (ILCP) on circuits which extend beyond building. Circuits include, initiating device circuits, alarm notification appliance circuits, and signaling line circuits.

B. ILCP shall:
   1. Be located as close as practical to point where circuits leave or enter building.
   2. Have line-to-line response time of less than 1 nanosecond.
   3. Have #12 AWG grounding conductor with maximum length of 25’. It shall be run in straight line and connected to building grounding electrode system.

C. Spark gap devices or devices incorporated in or installed within control panel in lieu of ILCP are not acceptable.

PART 3 - EXECUTION

3.01 GENERAL

A. Class B circuiting shall be used.

B. Installation shall be done in neat, workmanlike manner in accordance with manufacturer's recommendations.

C. Smoke detectors shall not be mounted until construction is completed.

3.02 RACEWAYS

A. Fire Alarm Panel risers shall be in conduit system separate from other building wiring.

B. Wiring shall be in conduit system separate from other building wiring. See Section 26 0533 - Raceway and Boxes for Electrical Systems.

C. Minimum 3/4” steel raceway.

D. Contractor shall size conduit and boxes by circular mil size of cable in conduit or box.

E. Surface access to existing alarm initiating circuits in public areas shall be via surface metal raceways (minimum equivalent to 3/4” conduit) and box extensions.

F. Existing conduit and surface metal raceway that are not 3/4” size may be reused if found to have adequate space for existing and new conductors.

3.03 CONDUCTORS

A. Cables and wires shall be provided per manufacturer shop drawings.
B. Conductors shall be color-coded. Coding shall be consistent through out facility.
C. Green wire shall be used only for equipment ground.
D. Control Panel power wiring shall be #12 AWG.
E. Control Panel shall have #12 AWG equipment ground wire.
F. Where fire alarm circuits enter or leave building, additional transient 75 to 90 V gas tube protection shall be provided for each conductor.
G. Cable Detector Loops shall be twisted pair with shield jacket. Shield shall be connected to earth ground only at control panel.
H. Detector wiring shall not be in same conduit with 120/240 VAC wiring or other high current circuits.
I. T-taps or branch circuit connections allowed for class B intelligent loop circuits.
J. Leave 8” wire tails at each device box and 36” wire tails at Control Panel and Remote Annunciator Panel.
K. Cable for RS 485 devices (Remote Annunciators) shall be shielded-twisted pair for data signal.
L. Wiring of initiating device circuits, alarm horn circuits, and alarm strobe circuits shall be #14 AWG minimum.
M. Fire alarm cable shall be held in place at device box by means of 2-screw connector, (do not use squeeze or crimp type connectors).
N. Splices or connections shall be made within approved junction boxes and with approved fittings.
O. Boxes shall be red and labeled "FIRE ALARM SYSTEM" by decal or other approved markings.
P. Horn and strobe circuits shall have separate conductors, and shall operate independently of each other.
Q. Tray cable is not acceptable for use as fire alarm systems raceway.

3.04 DEVICE MOUNTING

A. Recommended mounting heights, and requirements are as follows:
    1. Fire Alarm Control Panels
        a. Mount control panel so visual indicators and controls at 60” above floor level.
    2. Remote Annunciators
        a. Mount panel so visual indicators and controls at 60” above floor level.
        b. Install multi-gang box as required by manufacturer, flush or surface mounted.
    3. Audio-Visual Devices
        a. Install flush, semi-flush or surface mount (unfinished areas only) 6” below finished ceiling or 80” from bottom of device to finished floor.
        b. No devices protruding 4” or more shall be installed lower than 80”.
        c. Audio/visual devices may be installed on the ceilings in accordance with NFPA 72 - Table 2-A.
        d. For surface mounting, use manufacture-supplied backboxes and trim plates.
        e. Mark each device with its circuit number.
    4. Manual Stations
        a. Operable part of manual stations shall be installed not less than 3-1/2’ (42”) and not more than 4-1/2’ (54”) above finished floor.
        b. Manual stations shall be in unobstructed locations.
        c. For surface mounting, use manufacturers supplied backboxes and trim plates
        d. Mark unit’s address on inside and outside of housing.
    5. Heat and Smoke Detectors
        a. Location of detectors shown on plans is schematic only. Detectors must be located according to code requirements.

b. Surface mounted detectors shall be installed using back boxes equal to base size. Standard octagon and square boxes are not acceptable.
c. Detectors shall be located on the highest part of smooth ceiling so that edge of detector is no closer than 4” from sidewall.
d. Ceilings with beams, joists or soffits that exceed 8” in depth require special planning and closer spacing.
e. Mount detectors on sidewalls with top of detector no closer than 4” from ceiling and no further away than 12”.
f. Smoke detectors shall not be installed closer than 3’ from air supply diffusers.
g. No detectors shall be installed in direct airflow.
h. Heat and smoke detectors should be located near center of open area, which they protect.
i. Mark zone number and ranking of each detector on its base.
j. For intelligent systems, mark address and loop number on each detector's base.

3.05 IDENTIFICATION LABELS

A. Junction boxes shall be painted red and labeled "Fire Alarm.”
B. Circuits must be labeled with name of circuit and area being served by circuit.
C. Labels shall be permanent, and be machine generated. NO HANDWRITTEN OR NON-PERMANENT LABELS SHALL BE ALLOWED.
D. Labels shall be self-laminating, white/transparent vinyl and be wrapped around cable.
E. Flag type labels are not allowed.
F. Labels shall be of adequate size to accommodate circumference of cable being labeled and properly self-laminate over full extent of printed area of label.
G. Adhesive type labels not permitted except for phase and wire identification.
H. Wiring color code shall be maintained throughout installation.
I. Green wire shall be used only for equipment ground.

3.06 MANUFACTURER'S SERVICES

A. Supervision of installation shall be provided by trained service technician from manufacturer of fire alarm equipment.
B. Technician shall be US certified and have had minimum of 2 yrs of service experience in fire alarm industry.
C. Technician's name shall appear on equipment submittals, and letter of certification from fire alarm manufacturer shall be sent to project engineer.
D. Manufacturer's service technician shall be responsible for following items:
    1. Pre-installation visit to job site to review equipment submittals and verify method by which system shall be wired.
    2. Make periodic job site visits to verify installation and wiring of system.
    3. Upon completion of wiring, final connections shall be made under supervision of technician.
    4. At time of final checkout, technician shall give operational instructions to Owner and/or his representative.
    5. Job site visits shall be dated and documented in writing and signed by Electrical contractor.
    6. Discrepancy shall be noted on document and copy kept in system job folder, which shall be available to project Engineer any time during project.

3.07 TESTING

A. Manufacturer's authorized representative shall perform complete functional test of each system and submit written report to Contractor attesting to proper operation of completed system prior to final inspection.
B. Contractor shall test each device in system before system is considered substantially complete.

C. Completed fire alarm system shall be fully tested by Contractor in presence of Owner's representative and local Fire Marshal.
D. Upon completion of successful test, Contractor shall:
   1. Certify system to Owner in writing
   2. Complete NFPA 1-7.2.1 record of completion form
   3. Provide as-builts and O&M manuals

3.08 WARRANTY

A. Warrant completed fire alarm system wiring and equipment to be free from inherent mechanical and electrical defects for a period of 2 yrs from the date of substantial completion of project.
B. Post warranty period along with company's name and telephone number inside fire alarm panel.
C. Warranty service for equipment shall be provided by system supplier's factory trained representative.
D. Warranty shall include parts, labor, and necessary travel.
E. Occupied facility shall not be without UL and NFPA approved and fully operational fire alarm system for period longer than 2 h. Emergency response shall be provided within 2 h of notification, to contractor, of failure of system to perform operationally per UL and NFPA standards.
F. Non-emergency service calls shall be responded to within 24 h of notification to contractor.
G. Repairs and/or replacement shall be completed within 72 h of time of notification. Other than emergency, actual repairs and/or replacement shall be provided during normal working hours, Monday through Friday, excluding holidays.
H. If repair and/or replacement cannot be made within prescribed time, other means and methods of protection shall be provided to ensure safety of building occupants during which time system is not in compliance with standards. This may involve up to and include hiring Owner approved qualified personnel to stand fire watch, at contractor's expense.

3.09 TRAINING

A. Contractor shall provide minimum of 4 h system operation training for Owner, Architect/Engineer, and fire department personnel.
B. Training session shall be at a time to be stipulated by Owner.
C. Training shall be completed prior to final inspection.

3.010 MAINTENANCE CONTRACT

A. Equipment manufacturer shall make available to Owner, maintenance contract proposal to provide minimum of 2 inspections and tests per year in compliance with NFPA-72 Codes.

3.011 SPECIAL CONSIDERATIONS

A. Contractor shall notify Owner's security officer 24 h in advance of any zones inoperative for a period of time exceeding 2 h.
B. Existing fire alarm systems must be returned to full operation at end of each working day, or notification to campus security of what zones are inoperative on a daily basis in writing, hand delivered.

END OF SECTION

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SECTION 328400
PLANTING IRRIGATION

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. Piping.
2. Manual valves.
3. Automatic control valves.
4. Miscellaneous piping specialties.
5. Sprinklers.
6. Drip irrigation specialties.
7. Controllers.
8. Boxes for automatic control valves.

1.3 DEFINITIONS

A. Circuit Piping: Downstream from control valves to sprinklers, specialties, and drain valves. Piping is under pressure during flow.

B. Drain Piping: Downstream from circuit-piping drain valves. Piping is not under pressure.

C. Main Piping: Downstream from point of connection to water distribution piping to, and including control valves. Piping is under water-distribution-system pressure.

D. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.4 PERFORMANCE REQUIREMENTS

A. Irrigation zone control shall be automatic operation with controller valves.

B. Location of Sprinklers and Specialties: Design location is approximate. Make minor adjustments necessary to avoid plantings and obstructions such as signs and light standards. Maintain 100 percent irrigation coverage of areas indicated.

C. Minimum Working Pressures: The following are minimum pressure requirements for piping, valves, and specialties unless otherwise indicated:

1. Irrigation Main Piping: **200 psig**
2. Circuit Piping: **150 psig**

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics and furnished specialties and accessories.

B. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal: For irrigation systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional responsible for their preparation.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Irrigation systems, drawn to scale, on which components are shown and coordinated with each other, using input from Installers of the items involved. Also include adjustments necessary to avoid plantings and obstructions such as signs and light standards.

B. Qualification Data: For qualified Installer.

C. Zoning Chart: Show each irrigation zone and its control valve.

D. Controller Timing Schedule: Indicate timing settings for each automatic controller zone.

E. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For sprinklers, drip, controllers, and automatic control valves to include in operation and maintenance manuals.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers that include a certified irrigation designer qualified by The Irrigation Association or Professional Class member of the American Society of Irrigation Consultants

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.

1.9 DELIVERY, STORAGE, AND HANDLING

A. 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.

B. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

1.10 PROJECT CONDITIONS

A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of water service.
2. Do not proceed with interruption of water service without Owner's written permission.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Comply with requirements in the piping schedule for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.

B. PVC Pipe: ASTM D 1785, PVC 1120 compound, Schedules 40 and 80.

1. PVC Socket Fittings: ASTM D 2466, Schedules 40 and 80.
2. PVC Threaded Fittings: ASTM D 2464, Schedule 80.
3. PVC Socket Unions: Construction similar to MSS SP-107, except both headpiece and tailpiece shall be PVC with socket ends.

C. PVC Pipe, Pressure Rated: ASTM D 2241, PVC 1120 compound, SDR 21 and SDR 26.

1. PVC Socket Fittings: ASTM D 2467, Schedule 80.
2. PVC Socket Unions: Construction similar to MSS SP-107, except both headpiece and tailpiece shall be PVC with socket or threaded ends.

2.2 PIPING JOINING MATERIALS

A. Solvent Cements for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 6q56.

B. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.3 ENCASEMENT FOR PIPING

A. Standard: ASTM A 674 or AWWA C105.

2.4 MANUAL VALVES

A. Plastic Ball Valves:

1. Description:
   a. Standard: MSS SP-122.
   b. Pressure Rating: 150 psig
   c. Body Material: PVC.
   d. Type: Union.
   e. End Connections: Socket or threaded.
   f. Port: Full.

2.5 AUTOMATIC CONTROL VALVES

A. Plastic Automatic Control Valve

1. General Information
   a. Provide valve as per the specification.

2. Valve
   a. Irrigation valve specifications include but are not limited to:
      1) The valve body and bonnet shall be constructed of heavy-duty and ultra-violet resistant plastic.
      2) The bonnet shall be assembled to the body using multi-drive screws for use with flathead, Phillips, or hexagonal tools.

3) Shall possess a water tight seal between the body and bonnet.
4) Shall be a normally closed, forward flow design.
5) Shall have a filtered pilot flow to resist debris and clogging.
6) Shall be slow closing to prevent water hammer from causing subsequent system damage.
7) Shall have a Ø1 inch NPT globe and angle inlet as well as a Ø1 inch NPT outlet.
8) Shall have a manual internal bleed capability to operate the valve without allowing water into the valve box.
9) Shall have a non-rising flow control handle to adjust water flow as needed.
10) Shall include a 24 VAC 50/60 Hz solenoid capable of 2-wire operation.
    a) Inrush current: 0.41A (9.9VA) at 60Hz
    b) Holding current: 0.14A (3.43 VA) at 60Hz
11) Operating flow rate of 2-40 gpm (7.6-151.4 l/min).
12) Operating pressure range of 15-150 psi (1.04-10.4 bar).
13) Water temperature: Up to 110°F (43°C).
14) Ambient temperature: Up to 125°F (52°C).
15) Shall accommodate an optional field-installed pressure regulating dial.
16) Shall accept an optional latching solenoid for use with battery operated controllers.
17) Shall be available with an optional purple flow control handle for use with non-potable water applications.
18) Shall have a heavy-duty stainless steel spring for positive diaphragm closure.

2.6 SPRINKLERS

1. Rotors
    a. designed to provide uniform coverage over entire area of spray shown on drawings at available water pressure or as follows:
        1) Rotor for shrub or small turf areas (25-50 feet) spacing: maximum 65 psi.
2. Pop-Up Spray
    a. Rotor for shrub or small turf areas (25-50 feet) spacing: maximum 65 psi. Irrigation rotor specifications include but are not limited to:
        1) The rotor body, stem and nozzle, shall be constructed of heavy-duty and ultra-violet resistant plastic.
            a) Shall have a heavy-duty stainless steel retract spring for positive pop-down.
        2) Shall have integrated seals and method for clearing debris.
            a) Oversized pressure activated wiper seal prevents leaks and protects internals from debris.

b) Precision controlled flush at pop-down to clear debris from the unit, to assure positive stem retraction in all soil types.
c) Ported arc adjustment screw to clear debris from unit at pop-down

3) Shall have a slip clutch installation feature to allow easy arc alignment.
4) Non-reversing 360° full arc rotation.
5) 7.38 inch body height; 4.0 inch pop-up height (measured to center of nozzle).
6) Operating range of 25 to 50 feet.
7) Operating pressure range of 15 to 55 psi.
8) Shall have a precipitation rate of 0.20 to 1.50 in/hr.
9) Shall include a green cover and a flow shut-off valve in the rotor head.
10) Exposed surface diameter shall measure 1.5 inch.
11) Shall include Ø3/4 inch NPT female threaded bottom inlet.
12) Shall include a nozzle tree containing twelve nozzles with indicated flow rates from 0.76 to 9.63 gpm and an exit trajectory of 10-25°.
13) All rotor body components shall be removable from the top without special tools in order to provide quick and easy flushing and maintenance of the sprinkler.
14) Shall include slot in cover for use of a pull up tool for ease of nozzle installation and replacement.
15) Shall include nozzle retention screw that may also be used to reduce spray radius by 25%.
16) Shall have a filter screen in the stem to protect the drive from clogging and to simplify removal for cleaning and flushing the system.
17) Shall utilize nozzles designed to deliver even distribution over the entire radius including large wind resistant droplets and gentle close-in-watering.

3. Pressure Compensating Bubbler
   a. Pressure compensating bubblers shall have a full circle discharge rate of 1 GPM at 30 PSI. The bubbler shall be constructed of corrosion and UV-resistant plastic, with an integral elastomeric flow bushing for maintaining a constant flow rate over the operating pressure range of 15 to 7 PSI.
   b. The bubbler shall be compatible with a plastic filter screen to protect the nozzle from debris in the water. The PCB version shall have a ½-inch Female National Pipe Thread (FNPT) inlet for connection to a ½-inch male threaded riser. The PCN version shall have standard female threads that are compatible with the threaded riser on Hunter spray heads as well as some other manufacturer's spray heads.

2.7 DRIP IRRIGATION SPECIALTIES

A. Lateral Pipe and Fittings

1. Use rigid, unplasticized polyvinyl chloride (PVC) 1120, 1220 National Sanitation Foundation (NSF) approved pipe, extruded from material meeting requirements of Cell Classification 12454-A or 12454-B, ASTM Standard D1784, with integral belled end suitable for solvent welding.
2. Use Class 200, SDR-21, rated at 200 PSI (13,8 bar), conforming to dimensions and tolerances established by ASTM Standard D2241. Use PVC pipe rated at higher pressures than Class 200 in the cases where small nominal diameters are not manufactured in Class 200.
3. Use Schedule 40, Type 1, PVC solvent weld fittings conforming to ASTM Standards D2466 and D1784 for PVC pipe. Use primer approved by pipe manufacturer. Solvent cement to conform to ASTM Standard D2564, of type approved by pipe manufacturer.
4. Use PVC Schedule 80 nipples and PVC Schedule 40 or 80 threaded fittings for threaded pipe connections as specified on the drawings and details.
5. Threaded joint sealant: Use non-hardening, nontoxic pipe thread sealant formulated for use on threaded connections and approved by pipe fitting or valve manufacturer.
6. Hunter On-Surface Dripline with pressure-compensating.
    a. Hunter On-Surface Dripline model numbers for POTABLE water systems; a dual-layered, brown colored dripline tubing with emitter flow rates and spacing as shown:
        1) MLD0512250, 12” spacing emitter, thick walled, dual-layered and brown in color
        2) PLD-LOC fittings compatible with Hunter Professional Landscape Dripline (PLD)

B. Drip Control Zone Kits
1. The valve, filter and pressure regulator assembly will be capable of operating between 20-120 PSI with a flow range of between 2 - 20 GPM.
2. The valve shall be a normally closed, electronically-actuated, hydraulic, remote-control valve. The valve shall be equipped with a non-rising stem-type, manual flow control mechanism. This mechanism will be operable by hand that will regulate flow from full on to completely off. When specified for use with reclaimed water, a reclaimed water identifier handle shall be available.
3. The standard solenoid shall be a 24 VAC unit with a 350 mA inrush current and 190 mA holding current at 60 cycles and a 370 mA inrush current and 210 mA holding current at 50 cycles. When specified, the unit shall be equipped with a DC latching solenoid for use with 12-volt battery-operated controllers. The solenoid shall be an encapsulated, one-piece unit with captive plunger. It shall be equipped with manual internal bleed capability to release the upper chamber water to the downstream piping,

allowing the valve to open. The valve shall have an external manual bleed screw that provides an additional method for manual operation of the valve.

4. The body and bonnet shall be molded of non-corrodible, glass-reinforced nylon, rated to 220 PSI. The body of the valve shall have brass inserts, with through-holes, which will accept the bonnet bolts. The bonnet bolts shall be serviceable with a slotted screwdriver, Phillips screwdriver, or a hex wrench, and shall be held captive in the bonnet when the bonnet is removed from the valve body. The diaphragm assembly shall be of molded construction, reinforced with nylon fabric and have a thermoplastic elastomer seating material. The valve shall be equipped with an internal filter as well as a self-cleaning metering rod, so only clean water can enter the solenoid chamber. In addition, the valve shall be equipped with a filter cleaning system that cleans a stainless steel filter each time the valve opens and closes. All metal parts internal to the valve shall be manufactured from corrosion-resistant stainless steel. A perforated diaphragm support ring shall fit into the valve body just below the diaphragm to relieve stress on the diaphragm when the valve is closed.
5. The valve shall have a 1-inch Female National Pipe Thread (FNPT) inlet and outlet. All valve parts shall be serviceable after installation by unscrewing the bonnet bolts, and removing the bonnet from the valve body to access the internal components. This may be accomplished without removing the valve body from the line.
6. The filter shall be an in-line configuration. The filter will have a 1-inch Male National Pipe Thread (MNPT) inlet and outlet. The housing shall be molded of non-corrodible PVC, rated to 150 PSI. The filter shall be equipped with a 150 mesh stainless steel filter, so only clean water can be discharged through the regulator. The filter assembly must have removable cap for easy service and cleaning.
7. The regulator shall be an in-line configuration. The regulator will have a 1-inch Female National Pipe Thread (FNPT) inlet and outlet. The regulator shall be molded of non-corrodible PVC, rated to 150 PSI. The regulator shall be a non-adjustable pressure-regulating device that is factory calibrated for the correct outlet pressure. The regulator shall be capable of reducing the outlet pressure to 25 or 40 PSI depending on the specified model when the inlet pressure is 15 PSI or greater than the regulated outlet pressure. The regulated downstream pressure shall remain constant regardless of variations in upstream pressure.
8. The valve, filter and regulator assembly shall be rated for use up to 120 degrees F (49 degrees C).

2.8 CONTROLLERS

A. Description:

1. The controller shall be a full-featured, commercial-industrial product for the purpose of irrigation operation, management, and monitoring of control valves and sensors. The controller shall be of a modular design that is provided with a standard 8-station output module. The controller shall be expandable with 4-, 8-, or 22-station conventional modules or one 54-station decoder output module controller Stations for Automatic Control Valves: Each station is variable from approximately 5 to 60 minutes. Include switch for manual or automatic operation of each station.
2. Exterior Control Enclosures: NEMA 250, Type 4, weatherproof, with locking cover and two matching keys; include provision for grounding.
   a. Body Material: Molded plastic.
   b. Mounting: Pole mounted.
3. Control Transformer: 24-V secondary, with primary fuse.
4. Depending on requirements, transformer input shall be 120 VAC, 60 Hz or 230 VAC, 50 Hz. Maximum output per station shall be 24 VAC, up to 0.56 A. Maximum output per P/MV terminal shall be 24 VAC, up to 0.56 A.
5. The controller transformer shall be equipped with an internal, self-resetting thermal circuit breaker to protect against overheating.
6. The controller transformer shall also be equipped with a ground lug for connecting to proper earth-ground hardware.
7. Station Modules
   a. Controller shall provide 4 (plastic enclosure) or 6 (metal and pedestal enclosures) separate station output module slots Timing Device: Adjustable, 24-hour, 14-day clock, with automatic operations to skip operation any day in timer period, to operate every other day, or to operate two or more times daily.
   b. Controller shall use 4-, 8-, or 22-station conventional output modules, or one 54-station decoder output module.
   c. Station modules shall be secured against field wiring tension by locking levers.
   d. Using conventional wire only, the controller shall be expandable from 8 to 38 stations (plastic) and 8 to 54 stations (metal and pedestals).
   e. Using conventional station modules in conjunction with one decoder output module (model: EZ-DM), all controller configurations (plastic, metal, pedestal) shall expand up to 54 stations.
   f. Using only one decoder output module (model: EZ-DM) all controller configurations (plastic, metal, pedestal) shall expand up to 54 stations.
   g. The controller shall have a base model capacity of 8 stations, consisting of one 8-station output module.
   h. Each station output shall supply 24 VAC, up to 0.56 A current for solenoid activation.

i. The controller shall have self-diagnostic, electronic short circuit protection that detects a faulty circuit, continues watering the remainder of the program, and reports the faulty station via alert/notification to the user's smartphone, tablet, or computer. The built-in milliamp sensor shall constantly be measuring the current draw of each individual station.

j. Module hardware
   1. The controller output modules shall have metal oxide varistors (MOVs) and copper induction coils on each station output circuit to help protect the micro-circuitry from power surges
      i. Sensor inputs - The controller shall be equipped with two dedicated general-purpose sensor ports.
   2. The sensor inputs shall be compatible with any standard normally closed or normally open "Clik-type" sensors for automatic shutdown during rain, freeze, soil moisture, and/or wind events.
   3. The sensor inputs shall also be compatible with the Hunter HC Flow Meter for flow monitoring, alerts, and reporting.

k. P/MV outputs
   1. The controller shall have one built-in P/MV (24 VAC) output with a capacity of up to 0.56 A.
   2. The P/MV output shall be selectable as active or disabled per each individual station.
   3. A common wire terminal is provided on the controller's power module, and additional commons are provided on each station output module.
      a. SmartPort®
         1) The controller shall be pre-wired with a SmartPort connector for easy connection of optional wireless remote controls.
         2) For international or short-range uses, the wireless remote control shall be the Hunter model ROAM with a useful range of up to 1,000' (330 m).
         3) For use in the United States or long-range uses, where permitted, the wireless remote shall be Hunter model ROAM-XL with a useful range of up to 2 mi. (3.2 km).
   4. 3.10 Wi-Fi information
      a. The controller shall be equipped with built-in Wi-Fi.
      b. Wi-Fi operation shall be 802.11 b/g/n.
      c. Wi-Fi frequency is 2.4 GHz.
      d. Security shall have the ability to auto detect and offer the following security settings: WPA2, WPA Personal, and WPA Auto.

8. Moisture Sensor: Adjustable from one to seven days, to shut off water flow during rain.
9. Wiring: UL 493, Type UF multiconductor, with solid-copper conductors; insulated cable; suitable for direct burial.
    a. Feeder-Circuit Cables: No. 12 AWG minimum, between building and controllers.
    b. Low-Voltage, Branch-Circuit Cables: No. 14 AWG minimum, between controllers and automatic control valves; color-coded different from feeder-circuit-cable jacket color; with jackets of different colors for multiple-cable installation in same trench.
    c. Splicing Materials: Manufacturer's packaged kit consisting of insulating, spring-type connector or crimped joint and epoxy resin moisture seal; suitable for direct burial.

2.9 BOXES FOR AUTOMATIC CONTROL VALVES

A. Plastic Boxes:
    1. Description: Box and cover, with open bottom and openings for piping; designed for installing flush with grade.
        a. Size: As required for valves and service.
        b. Shape: Round (for gate valves) and Rectangular for control valves.
        c. Sidewall Material: PE.
        d. Cover Material: PE
B. Drainage Backfill: Cleaned gravel or crushed stone, graded from 3/4 inch minimum to 3 inches maximum.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."

B. Install warning tape directly above pressure piping, 12 inches below finished grades, except 6 inches below subgrade under pavement and slabs.

C. Drain Pockets: Excavate to sizes indicated. Backfill with cleaned gravel or crushed stone, graded from 3/4 to 3 inches to 12 inches below grade. Cover gravel or crushed stone with sheet of asphalt-saturated felt and backfill remainder with excavated material.

D. Provide minimum cover over top of underground piping according to the following:

1. Irrigation Main Piping: Minimum depth of 36 inches below finished grade, or not less than 18 inches below average local frost depth, whichever is deeper.
2. Circuit Piping: 12 inches.
3. Drain Piping: 12 inches.
4. Sleeves: 24 inches.

3.2 PREPARATION

A. Set stakes to identify locations of proposed irrigation system. Obtain Architect's approval before excavation.

3.3 PIPING INSTALLATION

A. Location and Arrangement: Drawings indicate location and arrangement of piping systems. Install piping as indicated unless deviations are approved on Coordination Drawings.

B. Install piping at minimum uniform slope of 0.5 percent down toward drain valves.

C. Install piping free of sags and bends.

D. Install groups of pipes parallel to each other, spaced to permit valve servicing.

E. Install fittings for changes in direction and branch connections.

F. Install unions adjacent to valves and to final connections to other components with NPS 2 or smaller pipe connection.

G. Install underground thermoplastic piping according to ASTM D 2774 and ASTM F 690.

H. Install expansion loops in control-valve boxes for plastic piping.

I. Lay piping on solid subbase, uniformly sloped without humps or depressions.

J. Install ductile-iron piping according to AWWA C600.

K. Install PVC piping in dry weather when temperature is above 40 deg F. Allow joints to cure at least 24 hours at temperatures above 40 deg F before testing.

L. Install water regulators with shutoff valve and strainer on inlet and pressure gage on outlet. Install shutoff valve on outlet. Install aboveground or in control-valve boxes.

M. Water Hammer Arresters: Install between connection to building main and circuit valves aboveground or in control-valve boxes.

N. Install piping in sleeves under parking lots, roadways, and sidewalks.

O. Install sleeves made of Schedule 40 PVC pipe and socket fittings, and solvent-cemented joints.

P. Install transition fittings for plastic-to-metal pipe connections according to the following:
   1. Underground Piping:
      a. NPS 1-1/2 and Smaller: Plastic-to-metal transition fittings.
      b. NPS 2 and Larger: AWWA transition couplings.
   2. Aboveground Piping:
      a. NPS 2 and Smaller: Plastic-to-metal transition fittings.
      b. NPS 2 and Larger: Use dielectric flange kits with one plastic flange.

Q. Install dielectric fittings for dissimilar-metal pipe connections according to the following:
   1. Underground Piping:
      a. NPS 2 and Smaller: Dielectric coupling or dielectric nipple.
      b. NPS 2-1/2 and Larger: Prohibited except in control-valve box.

   2. Aboveground Piping:
      a. NPS 2 and Smaller: Dielectric union.
      b. NPS 2-1/2 to NPS 4: Dielectric flange.
      c. NPS 5 and Larger: Dielectric flange kit.
   3. Piping in Control-Valve Boxes:
      a. NPS 2 and Smaller: Dielectric union.
      b. NPS 2-1/2 to NPS 4: Dielectric flange.
      c. NPS 5 and Larger: Dielectric flange kit.

3.4 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.

2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Flanged Joints: Select rubber gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

E. Ductile-Iron Piping Gasketed Joints: Comply with AWWA C600 and AWWA M41.

F. Copper-Tubing Brazed Joints: Construct joints according to CDA's "Copper Tube Handbook," using copper-phosphorus brazing filler metal.

G. Copper-Tubing Soldered Joints: Apply ASTM B 813 water-flushable flux to tube end unless otherwise indicated. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy (0.20 percent maximum lead content) complying with ASTM B 32.

H. PE Piping Fastener Joints: Join with insert fittings and bands or fasteners according to piping manufacturer's written instructions.

I. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.

1. Plain-End PE Pipe and Fittings: Use butt fusion.
2. Plain-End PE Pipe and Socket Fittings: Use socket fusion.

J. PVC Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. PVC Pressure Piping: Join schedule number, ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.

3.5 VALVE INSTALLATION

A. Pressure-Reducing Valves: Install in boxes for automatic control valves or aboveground between shutoff valves.

3.6 SPRINKLER INSTALLATION

A. Install sprinklers after hydrostatic test is completed.

B. Install sprinklers at manufacturer's recommended heights.

C. Locate part-circle sprinklers to maintain a minimum distance of 6 inches from walls and 2 inches from other boundaries unless otherwise indicated.

3.7 DRIP IRRIGATION SPECIALTY INSTALLATION

A. Install drip tubes with direct-attached emitters on ground.

3.8 AUTOMATIC IRRIGATION-CONTROL SYSTEM INSTALLATION

A. Equipment Mounting: Install exterior freestanding controllers on pressure treated post.
   1. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   2. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Install control cable in same trench as irrigation piping and at least 2 inches below piping. Provide conductors of size not smaller than recommended by controller manufacturer. Install cable in separate sleeve under paved areas.

3.9 CONNECTIONS

A. Comply with requirements for piping specified in Section 221113 "Facility Water Distribution Piping" for water supply from exterior water service piping, water meters, protective enclosures, and backflow preventers. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment, valves, and devices to allow service and maintenance.

C. Connect wiring between controllers and automatic control valves.

3.10 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplates and signs on each automatic controller.
   1. Text: In addition to identifying unit, distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

C. Warning Tapes: Arrange for installation of continuous, underground, detectable warning tapes over underground piping during backfilling of trenches. See Section 312000 "Earth Moving" for warning tapes.

3.11 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. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Operational Test: After electrical circuitry has been energized, operate controllers and automatic control valves to confirm proper system operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Any irrigation product will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.12 STARTUP SERVICE

A. Perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Verify that controllers are installed and connected according to the Contract Documents.
   3. Verify that electrical wiring installation complies with manufacturer's submittal.

3.13 ADJUSTING

A. Adjust settings of controllers.

B. Adjust automatic control valves to provide flow rate at rated operating pressure required for each sprinkler circuit.

C. Adjust sprinklers and devices, except those intended to be mounted aboveground, so they will be flush with finish grade.

3.14 CLEANING

A. Flush dirt and debris from piping before installing sprinklers and other devices.

3.15 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain automatic control valves and controllers.

3.16 PIPING SCHEDULE

A. Install components having pressure rating equal to or greater than system operating pressure.

B. Piping in control-valve boxes and aboveground may be joined with flanges or unions instead of joints indicated.

C. Underground irrigation main piping NPS 4 shall be one of the following:
   1. Class 200 PVC pipe and socket fittings, and solvent-cemented joints.

D. Underground irrigation main piping, NPS 5 and larger, shall be the following:
   1. Class 200 PVC pipe and socket fittings; and solvent-cemented joints.

E. Circuit piping, NPS **2** the following:
   1. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.

F. Circuit piping, NPS 2-1/2 to NPS 4 shall be the following:
   1. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.

G. Underground Branches and Offsets at Sprinklers and Devices: Schedule 80, PVC pipe; threaded PVC fittings; and threaded joints.
   1. Option: Plastic swing-joint assemblies, with offsets for flexible joints, manufactured for this application.

END OF SECTION 328400

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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. Sodding.

B. Related Requirements:
   1. Section 329300 "Plants" for trees, shrubs, ground covers, and other plants as well as border edgings and mow strips.
   2. Section 334600 "Subdrainage" for below-grade drainage of landscaped areas.

1.3 DEFINITIONS

A. Finish Grade: Elevation of finished surface of planting soil.

B. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

C. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

D. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See “Soil Preparation (Performance Specification)" and drawing designations for planting soils.

E. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For landscape Installer.

B. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture, stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.
   1. Certification of each seed mixture for sod. Include identification of source and name and telephone number of supplier.

C. Product Certificates: For fertilizers, from manufacturer.

D. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to Project.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of turf during a calendar year. Submit before expiration of required maintenance periods.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful turf establishment.
   1. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
   2. Experience: Five years' experience in turf installation in addition to requirements in Section 014000 "Quality Requirements."
   3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws, as applicable.

B. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" sections in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver sod within 24 hours of harvesting and in time for planting promptly. Protect sod from breakage and drying.

C. Bulk Materials:
   1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
   2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
   3. Accompany each delivery of bulk materials with appropriate certificates.

PART 2 - PRODUCTS

2.1 TURFGRASS SOD

A. Turfgrass Sod: Certified, complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture that is strongly rooted and capable of vigorous growth and development when planted.

B. Turfgrass Species: Zoysia Grass (Zoysia species).

C. Turfgrass Species: Sod of grass species as follows, with not less than 85 percent germination, not less than 95 percent pure seed, and not more than 0.5 percent weed seed:

2.2 FERTILIZERS

A. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
   1. Composition: 1 lb/1000 sq. ft. of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
   2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

B. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:

1. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

2.3 PESTICIDES

A. General: Pesticide, registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

B. Pre-Emergent Herbicide (Selective and Nonselective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.

C. Post-Emergent Herbicide (Selective and Nonselective): Effective for controlling weed growth that has already germinated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to be planted for compliance with requirements and other conditions affecting installation and performance of the Work.
1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
2. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
3. Uniformly moisten excessively dry soil that is not workable or which is 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 TURF AREA PREPARATION

A. General: Prepare planting area for soil placement and mix planting soil according to Section 329113 "Soil Preparation**."**

B. Coordinate "Placing Planting Soil" Paragraph below with Section 329113 "Soil Preparation" or Section 329115 "Soil Preparation (Performance Specification)."

C. Placing Planting Soil: Blend planting soil in place.
   1. Reduce elevation of planting soil to allow for soil thickness of sod.

D. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

E. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

F. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

3.3 SODDING

A. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.

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 soil or sod during installation. Tamp and roll lightly to ensure contact with soil, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.
   1. Lay sod across slopes exceeding 1:3.
   2. Anchor sod on slopes exceeding 1:6 with wood pegs spaced as recommended by sod manufacturer but not less than two 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.

3.4 TURF MAINTENANCE

A. General: Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and re-mulch

to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.

1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
3. Apply treatments as required to keep turf and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.

B. Watering:

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 one-third of grass height. Remove no more than one-third of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:

1. Mow zoysia grass to a height of 2 to 3 inch.

3.5 SATISFACTORY TURF

A. Turf installations shall meet the following criteria as determined by Architect:

1. Satisfactory Seeded Turf: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. and bare spots not exceeding 5 by 5 inches.
2. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.

B. Use specified materials to reestablish turf that does not comply with requirements, and continue maintenance until turf is satisfactory.

3.6 PESTICIDE APPLICATION

A. Apply pesticides and other chemical products and biological control agents according to requirements of authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and

others in proximity to the Work. Notify Owner before each application is performed.

B. Post-Emergent Herbicides (Selective and Nonselective): Apply only as necessary to treat already-germinated weeds and according to manufacturer's written recommendations.

3.7 CLEANUP AND PROTECTION

A. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off Owner's property.

C. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.

D. Remove non-degradable erosion-control measures after grass establishment period.

3.8 MAINTENANCE SERVICE

A. Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in "Turf Maintenance" Article. Begin maintenance immediately after each area is planted and continue until acceptable turf is established, but for not less than the following periods:

1. Sodded Turf: 30 days from date of Substantial Completion.

END OF SECTION 329200

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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. Tree stabilization.
3. Erosion-control material(s).

B. Related Requirements:

1. Section 329200 "Turf and Grasses" for turf.

C. Backfill: The earth used to replace or the act of replacing earth in an excavation.

D. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown, with a ball size not less than diameter and depth recommended by ANSI Z60.1; 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.

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. Finish Grade: Elevation of finished surface of planting soil.

G. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or

mixtures intended for use as a plant regulator, defoliant, or desiccant. Some sources classify herbicides separately from pesticides.

H. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

I. Planting Area: Areas to be planted.

J. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

K. Plant; Plants; Plant Material: These terms refer to vegetation in general, including trees, shrubs, vines, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.

L. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.

M. Stem Girdling Roots: Roots that encircle the stems (trunks) of trees below the soil surface.

N. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

1.3 COORDINATION

A. 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.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Plant Materials: Include quantities, sizes, quality, and sources for plant materials.
   2. Plant Photographs: Include color photographs in digital format of each required species and size of plant material as it will be furnished to Project. Take photographs from an angle depicting true size and condition of the

typical plant to be furnished. Include a scale rod or other measuring device in each photograph.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For landscape Installer. Include list of similar projects completed by Installer demonstrating Installer's capabilities and experience. Include project names, addresses, and year completed, and include names and addresses of owners' contact persons.

B. 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.

C. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to Project.

D. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of plants during a calendar year. Submit before expiration of required maintenance periods.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful establishment of plants.
   1. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
   2. Experience: Five years' experience in landscape installation in addition to requirements in Section 014000 "Quality Requirements."
   3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
   4. Pesticide Applicator: State licensed, commercial.

B. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.

1. Selection of plants purchased under allowances is made by Architect, who tags plants at their place of growth before they are prepared for transplanting.

C. Measurements: Measure according to ANSI Z60.1. Do not prune to obtain required sizes.
   1. Trees and Shrubs: Measure with branches and trunks or canes in their normal position. Take height measurements from or near the top of the root flare for field-grown stock and container-grown stock. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip to tip. Take caliper measurements 6 inches 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.

D. 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 may also observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and may reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.
   1. Notify Architect of sources of planting materials seven days in advance of delivery to site.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws if applicable.

B. Bulk Materials:
   1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
   2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
   3. Accompany each delivery of bulk materials with appropriate certificates.

C. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.

D. Handle planting stock by root ball.

E. 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.

F. 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.

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 less than moist condition in water for two hours. Reject plants with dry roots.
   2. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
   3. Do not remove container-grown stock from containers before time of planting.
   4. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly wet condition.

1.9 FIELD CONDITIONS

A. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.

B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.

1.10 WARRANTY

A. Special Warranty: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by Owner.
      b. Structural failures including plantings falling or blowing over.

   2. Warranty Periods: From date of acceptance from County.

a. Trees, Shrubs, Vines, and Ornamental Grasses: 12 months.
b. Ground Covers, Biennials, Perennials, and Other Plants: 12 months.
c. Annuals: Three months.

3. Include the following remedial actions as a minimum:
   a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
   b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
   c. A limit of one replacement of each plant is required except for losses or replacements due to failure to comply with requirements.
   d. Provide extended warranty for period equal to original warranty period, for replaced plant material.

PART 2 - PRODUCTS

2.1 PLANT MATERIAL

A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant List, Plant Schedule, or Plant Legend indicated on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
   1. Trees with damaged, crooked, or multiple leaders; tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); crossing trunks; cut-off limbs more than 3/4 inch in diameter; or with stem girdling roots are unacceptable.

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 begins at root flare according to ANSI Z60.1. Root flare shall be visible before planting.

D. 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.

2.2 FERTILIZERS

A. Planting Tablets: Tightly compressed chip-type, long-lasting, slow-release, commercial-grade planting fertilizer in tablet form. Tablets shall break down with soil bacteria, converting nutrients into a form that can be absorbed by plant roots.
   1. See plan specifications.

2.3 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. See plan specifications.

2.4 EROSION -CONTROL BARRIERS

A. Erosion control blanket shall provide a temporary, biodegradable cover material to reduce slope and/or channel erosion and enhance revegetation. Erosion control blanket performance capabilities shall be determined by ASTM D 6459, “Determination of Erosion Control Blanket (ECB) Performance in Protecting Hillslopes from Rainfall-Induced Erosion”, and ASTM D 6460,

B. Erosion control blanket shall be furnished in rolls and wrapped with suitable material to protect against moisture intrusion and extended ultraviolet exposure prior to placement. Each roll shall be labeled with a date code identification, which allows for sufficient tracking of the product back to date of manufacturing and for quality control purposes.

C. Erosion control blanket shall be of consistent thickness with fibers distributed evenly over the entire area of the blanket.

D. Erosion control blanket shall be free of defects and voids that would interfere with proper installation or impair performance.

E. Erosion control blanket shall be stored by the Contractor in a manner that protects them from damage by construction activities.

F. Site Preparation:
   1. Before placing erosion control blanket, the Contractor shall certify that the subgrade has been properly compacted, graded smooth, has no depressions, voids, soft or uncompacted areas, is free from obstructions such as tree roots, protruding stones or other foreign matter, and is seeded and fertilized according to project specifications.
   2. The Contractor shall not proceed until all unsatisfactory conditions have been remedied. By beginning construction, the Contractor signifies that the preceding work is in conformance with this specification.

3. Contractor shall fine grade the subgrade by hand dressing where necessary to remove local deviations

G. Slope Installation
   1. Erosion control blanket shall be installed as directed by the owner's representative in accordance with manufacturer's Installation Guidelines, Staple Pattern Guides, and CAD details. The extent of erosion control blanket shall be as shown on the project drawings.
   2. Erosion control blanket shall be orientated in vertical strips and anchored with staples, as identified in the Staple Pattern Guide. Adjacent strips shall be abutted or overlapped to allow for installation of a common row of staples that anchor through the nettings of both blankets. Horizontal joints between erosion control blankets shall be sufficiently overlapped with the uphill end on top for a common row of staples so that the staples anchor through the nettings of both blankets.
   3. Where exposed to overland sheet flow, a trench shall be located at the uphill termination. Erosion control blanket shall be stapled to the bottom of the trench. The trench shall be backfilled and compacted. Where feasible, the uphill end of the blanket shall be extended three feet over the crest of the slope

2.5 PESTICIDES

A. General: Pesticide registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

B. Pre-Emergent Herbicide Selective: 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: Effective for controlling weed growth that has already germinated.

2.6 TREE-STABILIZATION MATERIALS

A. Trunk-Stabilization Materials:
   1. See plan specifications.

2.7 MISCELLANEOUS PRODUCTS

A. 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.

B. 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, with Installer present, for compliance with requirements and conditions affecting installation and performance of the Work.
   1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
   2. Verify that plants and vehicles loaded with plants can travel to planting locations with adequate overhead clearance.
   3. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
   4. Uniformly moisten excessively dry soil that is not workable or which is dusty.

B. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

C. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Architect's acceptance of layout before excavating or planting. Make minor adjustments as required.

D. Lay out plants at locations directed by Architect. Stake locations of individual trees and shrubs and outline areas for multiple plantings.

3.3 PLANTING AREA ESTABLISHMENT

A. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

B. Application of Mycorrhizal Fungi: At time directed by Architect, broadcast dry product uniformly over prepared soil at application rate according to manufacturer's written recommendations.

3.4 EXCAVATION FOR TREES AND SHRUBS

A. See plan specifications.

3.5 TREE, SHRUB, AND VINE PLANTING

A. See plan specifications.

3.6 TREE, SHRUB, AND VINE PRUNING

A. Remove only dead, dying, or broken branches. Do not prune for shape.

B. Prune, thin, and shape trees, shrubs, and vines as directed by Architect.

C. Prune, thin, and shape trees, shrubs, and vines according to standard professional horticultural and arboricultural practices. Unless otherwise indicated by Architect, do not cut tree leaders; remove only injured, dying, or dead branches from trees and shrubs; and prune to retain natural character.

D. Do not apply pruning paint to wounds.

3.7 TREE AND PALM STABILIZATION

A. See plan specifications.

3.8 GROUND COVER AND PLANT PLANTING

A. See plan specifications.

3.9 PLANTING AREA MULCHING

A. Mulch backfilled surfaces of planting areas and other areas indicated.
   1. Trees and Treelike Shrubs in Turf Areas: Apply organic mulch ring of 3-inch average thickness, with 36-inch radius around trunks or stems. Do not place mulch within 3 inches of trunks or stems.

2. Organic Mulch in Planting Areas: Apply 3-inch average thickness of organic mulch extending 12 inches beyond edge of individual planting pit or trench and over whole surface of planting area, and finish level with adjacent finish grades. Do not place mulch within 3 inches of trunks or stems.

3.10 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.

B. Fill in, as necessary, soil subsidence that may occur because of settling or other processes. Replace mulch materials damaged or lost in areas of subsidence.

C. Apply treatments as required to keep plant materials, planted areas, and soils free of pests and pathogens or disease. Use integrated pest management practices when possible to minimize use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.

3.11 PESTICIDE APPLICATION

A. Apply pesticides and other chemical products and biological control agents according to authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

B. Pre-Emergent Herbicides (Selective and Nonselective): Apply to tree, shrub, and ground-cover areas according to manufacturer's written recommendations. Do not apply to seeded areas.

C. Post-Emergent Herbicides (Selective and Nonselective): Apply only as necessary to treat already-germinated weeds and according to manufacturer's written recommendations.

3.12 REPAIR AND REPLACEMENT

A. General: Repair or replace existing or new trees and other plants that are damaged by construction operations, in a manner approved by Architect.
   1. Submit details of proposed pruning and repairs.
   2. Perform repairs of damaged trunks, branches, and roots within 24 hours, if approved.
   3. Replace trees and other plants that cannot be repaired and restored to full-growth status, as determined by Architect.

B. Remove and replace trees that are more than 25 percent dead or in an unhealthy condition before the end of the corrections period or are damaged during construction operations that Architect determines are incapable of restoring to normal growth pattern.
   1. Provide new trees of same size as those being replaced for each tree of 6 inches or smaller in caliper size.

3.13 CLEANING AND PROTECTION

A. During planting, keep adjacent paving and construction clean and work area in an orderly condition. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.

C. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.

D. After installation and before Substantial Completion, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and Project site.

E. At time of Substantial Completion, verify that tree-watering devices are in good working order and leave them in place. Replace improperly functioning devices.

3.14 MAINTENANCE SERVICE

A. Maintenance Service for Trees and Shrubs: Provide maintenance by skilled employees of landscape Installer. Maintain as required in "Plant Maintenance" Article. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established, but for not less than maintenance period below:

B. Maintenance Service for Ground Cover and Other Plants: Provide maintenance by skilled employees of landscape Installer. Maintain as required in "Plant Maintenance" Article. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established, but for not less than maintenance period below:

END OF SECTION 329300

SECTION 313116
TERMITE CONTROL

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Chemical soil treatment.

1.02 RELATED REQUIREMENTS

A. Section 033000 - Cast-in-Place Concrete: Vapor barrier placement under concrete slab-on-grade.

1.03 REFERENCE STANDARDS

A. Title 7, United States Code, 136 through 136y - Federal Insecticide, Fungicide and Rodenticide Act 2006.

1.04 SUBMITTALS

A. See Section 013000 - Administrative Requirements, for submittal procedures.

B. Product Data: Submit manufacturers' data on manufactured products showing compliance with specified requirements.

C. Manufacturer's Certificate: Certify that toxicants meet or exceed specified requirements.

D. Record and document moisture content of soil before application.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: Company specializing in performing this type of work and:
   1. Having minimum of three (3) years documented experience.
   2. Licensed in Florida.

PART 2 PRODUCTS

2.01 CHEMICAL SOIL TREATMENT

A. Toxicant Chemical: EPA Title 7, United States Code, 136 through 136y approved; synthetically color dyed to permit visual identification of treated soil.

B. Diluent: Recommended by toxicant manufacturer.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that soil surfaces are unfrozen, sufficiently dry to absorb toxicant, and ready to receive treatment.

B. Verify final grading is complete.

3.02 APPLICATION - CHEMICAL TREATMENT

A. Comply with requirements of U.S. EPA and applicable state and local codes.

B. Spray apply toxicant in accordance with manufacturer's instructions.

C. Apply toxicant at following locations:
   1. Under Slabs-on-Grade.

D. Under slabs, apply toxicant immediately prior to installation of vapor barrier.

E. Apply extra treatment to structure penetration surfaces such as pipe or ducts, and soil penetrations such as grounding rods or posts.

F. Re-treat disturbed treated soil with same toxicant as original treatment.

G. If inspection or testing identifies the presence of termites, re-treat soil and re-test.

3.03 PROTECTION

A. Do not permit soil grading over treated work.

END OF SECTION 313116

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