JUDGE DOYLE SQUARE
PUBLIC PARKING FACILITY

FOR

THE CITY OF MADISON, WISCONSIN

ISSUED FOR FINAL BID
CONSTRUCTION SPECIFICATIONS

VOLUME II (Divisions 21 through 33)
June 23, 2017

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A WSP | PARSONS BRINCKERHOFF COMPANY

MEP/FP ENGINEERS:
AEI Affiliated Engineers

CIVIL ENGINEERS:
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PART 1 - GENERAL

1.1 REFERENCE

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

1.2 DESCRIPTION

A. Intent of drawings and Specifications is to obtain complete systems, tested, adjusted, and ready for operation.

B. 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.

1.3 RELATED WORK

A. Utility Services:
   1. Determine utility connection requirements and include in Base Bid all costs to Owner for utility service.

2. Include costs for temporary service, temporary routing of piping or any other requirements of a temporary nature associated with utility service.

B. Temporary Services:
1. Division 01 - Temporary Facilities and Controls.

C. Continuity of Service:
1. No service shall be interrupted or changed without permission from Architect and Owner. Obtain written permission before any work is started.
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 required to be cast in concrete or used to form concrete for support of mechanical equipment.

E. Painting:
1. Painting of mechanical equipment will be done under Division 09 unless specified otherwise or unless equipment is to be furnished with factory applied finish coats.
2. Equipment
   a. Furnish equipment with factory applied prime finish unless otherwise specified.
   b. If factory finish on equipment furnished by Contractor is damaged in shipment or during construction, refinish equipment to satisfaction of Architect.
3. Piping:
   a. Uninsulated Piping
      1) [Paint cast iron, carbon steel, and copper piping located outside building.] [Paint cast iron, carbon steel, and copper piping located outside building and inside building within unfinished spaces without ceilings.] [Paint cast iron, carbon steel, and copper piping.]
      2) [Paint exposed fire protection piping.]
      3) [Paint exposed natural gas piping.]
      4) Galvanized steel and stainless steel piping shall not be painted.
   b. [Insulated Piping]
      1) [Paint exposed insulated piping located within unfinished spaces without ceilings.] [Paint exposed insulated piping.]
      2) Aluminum, stainless steel, PVC, and pre-colored insulation jackets shall not be painted.
   c. Paint Colors
      1) Fire Protection: [Red] [XXX]
      2) Natural Gas: [Yellow] [XXX]
      3) Domestic Water: [Green] [XXX]
      4) Sanitary Waste and Vent: [Yellow] [XXX]
      5) Storm and Overflow: [Green] [XXX]
      6) Chilled Water: [Green] [XXX]
      7) Heating Hot Water: [Yellow] [XXX]
      8) Steam: [Yellow] [XXX]

1.4 REQUIREMENTS OF REGULATORY AGENCIES

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

1.5 REFERENCE STANDARDS

A. Agencies or publications referenced herein refer to the following:
1. AGA American Gas Association
2. AMCA Air Movement and Control Association
3. ANSI American National Standards Institute
4. AHRI Air-Conditioning, Heating and Refrigeration Institute
5. ASHRAE American Society of Heating Refrigerating and Air Conditioning Engineers
6. ASPE American Society of Plumbing Engineers
7. ASSE American Society of Sanitary Engineering
8. AWS American Welding Society
9. AWWA American Water Works Association
10. ASME American Society of Mechanical Engineers
11. ASTM American Society for Testing and Materials

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

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

1.6 SUBMITTALS

A. Shop Drawings (Product Data):
1. Refer to Division 01 - Submittal Procedures.
2. Note that for satisfying submittal requirements for Divisions 20, 21, 22 or 23, "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 the respective specification sections. Submittals that 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 numbers for each item. Clearly mark and note submittals accordingly.
7. Submit complete record of required components when fixtures, equipment and items specified include accessories, parts and additional items under one designation.
8. Include composite wiring diagrams for electrically powered equipment and devices.
9. Submit equipment room layouts drawn to scale, including equipment, piping, accessories and clearance for maintenance.
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.

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

C. Operation and Maintenance Manuals:
1. Refer to Division 01 - Operation and Maintenance Data.
2. Upon completion of Work but before final acceptance of system, submit to Architect for approval, 3 copies of operation and maintenance manuals in loose-leaf binders. If "one copy" is larger than 2" thick or consists of multiple volumes, submit only one set initially for review. After securing approval, submit 3 copies to Owner.
3. Organize manuals by specification section number and furnish table of contents and tabs for each piece of equipment or system.
4. Fire protection system shall be separately bound.
5. Manuals shall include the following:
   a. Copies of Shop Drawings

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 of O&M data with exploded parts lists where available
d. Phone numbers and addresses of local parts suppliers and service companies
e. Internet/WEB page addresses where applicable
f. Wiring diagrams
g. Startup and shutdown procedures
h. Composite electrical diagrams
i. Flow diagrams
j. Lubrication instructions
k. Factory and field test records (Refer to Test and Balancing in Part 3 of this section.)
l. Air and water balance reports
m. Valve identification charts as specified in Section 20 0553 - Mechanical System Identification
n. Access panel identification charts as specified in Section 20 0553 - Mechanical System Identification
o. Additional information, diagrams or explanations as designated under respective equipment or systems specification sections.

6. Instruct Owner's representative in operation and maintenance of equipment. Instruction shall include complete operating cycle on all apparatus.
7. Furnish O&M Manuals and instructions to Owner prior to request for final payment.

D. Record Documents:
1. Refer to General Conditions of Contract, and Division 01 - Project Record Documents. Prepare complete set of record drawings in accordance with Division 01.

1.7 JOB CONDITIONS

A. Building Access:
1. Arrange for necessary openings in building to allow for admittance of all apparatus.

B. Electrical Coordination:
1. Refer to Section 20 0513 - Motors
2. Contractors for Divisions 20, 21, 22 and 23 shall 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 Contractor for apparatus indicating external connection and internal controls.
i. Disconnect devices furnished with units (VFDs, chillers, prepackaged control devices, etc.)
1) Devices shall have an interrupting rating not less than that of the upstream overcurrent device as shown on electrical drawings.
2) Equipment electrical connection points shall be labeled with listed electrical short circuit current rating (SCCR). SCCR shall not be less than interrupting rating of upstream overcurrent device as shown on electrical drawings. SCCR shall be marked on equipment control enclosure in accordance with UL508, or other acceptable, accredited third-party testing agency standards.
3) Electrical Contractor will provide the following devices required for control of motors or electrical equipment, unless noted otherwise.
j. Starters
k. Disconnect devices
l. Control devices:
1) Pushbuttons
2) Pilot lights
3) Contacts
m. Conduit, boxes and wiring for power wiring.
n. Conduit, boxes and wiring for control wiring, except temperature control wiring.
3. Electrical Contractor will make connections, from power source to starter or variable frequency drive and from starter or variable frequency drive, where specified, to motor.

4. Where starters or other similar control devices are furnished by this contractor, they shall be installed by this contractor and wired by Electrical Contractor.
5. Should any change in size, hp rating, voltage, or means of control be made to any motor or other electrical equipment after Contracts are awarded, this contractor shall immediately notify Electrical Contractor of change. Additional costs due to these changes shall be responsibility of this contractor.

C. Cutting and Patching:
1. Refer to General Conditions of the Contract, and Division 01 - Cutting and Patching.
2. Perform cutting and patching required for complete installation of systems, unless otherwise noted. Patch and restore work cut or damaged to original condition. This includes openings remaining from removal or relocation of existing system components.
3. Provide materials required for patching unless otherwise noted.
4. Do not pierce beams or columns without permission of Architect and then only as directed. If openings are required through walls or floors where no sleeve has been provided, hole shall be core drilled to avoid unnecessary damage and structural weakening.
5. Where alterations disturb lawns, paving, walks, etc., replace, repair or refinish surfaces to condition existing prior to commencement of work. This may include areas beyond construction limits.

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

1.8 WARRANTY

A. Refer to Division 01 for general warranty requirements.
B. Refer to technical sections for warranty requirement for each system.
1. Where no warranty requirements are called out, warrant equipment, materials, and workmanship to be free from defect as called out in Division 01.

C. Warrant that systems will operate without objectionable noise, vibration and uncontrolled expansion.
D. Repair, replace or alter systems or parts of systems found defective at no extra cost to Owner.
E. In any case, wherein fulfilling requirements of any warranty, if this contractor disturbs any work warranted under another contract, this contractor shall restore such disturbed work to condition satisfactory to Architect and warranty such restored work to same extent as it was warranted under such other contract.
F. Warranty shall include labor, materials, and travel time.

PART 2 - PRODUCTS

2.1 PRODUCT SUBSTITUTIONS

A. Refer to Division 01 - Product Requirements.

PART 3 - EXECUTION

3.1 GENERAL

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

3.2 DELIVERY, STORAGE, HANDLING, AND PROTECTION

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

3.3 EXCAVATION AND BACKFILL

A. Refer to Division 31 - Earthwork.
B. Provide excavation and backfill for underground work unless otherwise indicated. Blasting is not allowed on this project without written permission of Architect and Owner.

C. Backfill trenches beneath concrete floor and stair slabs within building and beneath concrete slabs, walks, stairs and drives at exterior of building with gravel fill and compact to same density as surrounding area.

3.4 FLOOR, WALL, ROOF AND CEILING OPENINGS

A. Coordinate location of openings, chases, furred spaces, etc., with appropriate Contractors. Provide sleeves and inserts that are to be built into structure during progress of construction.

B. Remove temporary sleeves, if used to form openings, prior to installation of permanent materials. Utilize minimum 24 ga galvanized sheet metal for permanent sleeves unless otherwise noted.

C. Provide Schedule 40 carbon steel pipe with integral water stop for steel sleeves required in interior floor slabs.

D. Submit to Structural Engineer for review and approval size and location of core-drilled holes prior to execution.

E. Submit product data and installation details for penetrations of building structure. Include schedule indicating penetrating materials (metal pipe, plastic pipe, conduit, etc.), sizes of each, opening sizes and sealant products intended for use.

F. Where penetrations of fire-rated assemblies are involved, seal penetrations with appropriate firestopping systems as specified in Section 20 0573 - Mechanical Systems Firestopping.

G. Submit complete penetration layout drawings showing openings in building structural members including floor slabs, bearing walls, shear walls, etc. Indicate and locate, by dimension, all required openings, including those sleeved, formed or core drilled. Drawings shall be approved prior to preparing openings in structural member.

H. Provide minimum 1” clearance around penetration openings intended for pipe. Where fire resistant penetrations are required, size openings in accordance with written recommendations of firestopping systems manufacturer.

I. Openings for underground pipes passing through foundations or under footings shall have minimum clearance of 1-1/2” to concrete. Do not disturb footing bearing soil.

J. Openings for underground pipe passing through on grade concrete slabs shall have minimum 1/4” clearance to concrete. Seal openings with urethane caulk.

K. Openings for insulated piping shall be sized based on outside diameter of insulation when it is specified or detailed to be continuous through opening.

L. Openings for duct penetrations shall be no more than 1/2” larger on all sides than size of duct or duct including duct insulation, if applicable. Where firestopping systems are required at penetrations, size in accordance with recommendations of firestopping systems manufacturer, but opening shall not exceed 1” average clearance on all sides. Openings for ducts with fire dampers shall be in accordance with fire damper installation requirements.

M. Duct penetrations through concrete floors in mechanical rooms containing liquid heat exchangers and/or pumps shall have 2” high water stopped curbs surrounding openings. This applies to mechanical rooms above the lowest floor level.

N. Seal non fire-rated floor penetrations with non-shrink grout equal to Embeco by Master Builders, or urethane caulk, as appropriate.

O. Seal non fire-rated wall openings with urethane caulk.

P. Where penetrations occur through exterior walls into building spaces, use sleeves with integral water stop. For piping having outer surface temperature less than 150°F, use plastic (HDPE) sleeves, similar to PSI Link-Seal Model CS, rated to 150°F. For piping having outer surface temperature 150°F or higher, or where steel sleeves are shown or walls are fire rated, use steel sleeves with hot dip galvanizing, similar to PSI Link-Seal Model WS. Seal annular space between sleeves and pipe with Thunderline "Link-Seal" modular wall and casing seals, or sealing system by another manufacturer approved as equal by Engineer. Where "Link-Seals" are used with insulated pipe, insulation shall be butted against seals on both sides. Sealing system shall utilize Type 316 stainless steel bolts, washers and nuts.

Q. In lieu of openings as specified herein penetration systems as manufactured by Pro Set may be used, including sleeve couplings and plug.

R. If total Pro Set system with Water Guard “CR” is used, opening shall not need additional water proofing or riser clamps.

S. Finish and trim penetrations as shown on details and as specified.

T. Provide chrome or nickel plated escutcheons where piping passes through walls, floors or ceilings and is exposed in finished areas. Size escutcheons to fit pipe and pipe covering for finished appearance. Finished areas shall not include mechanical/electrical rooms, janitors' closets, storage rooms, etc., unless suspended ceilings are specified.

U. Trim duct penetrations exposed in finished areas with 2” wide galvanized or aluminum trim collars properly sized to fit duct. Collars shall be same gauge as duct, prime finish unless noted otherwise. Finished areas shall not include mechanical rooms, janitors' closets, storage rooms, etc., unless suspended ceilings are specified.

3.5 EQUIPMENT SHUTOFF VALVES

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

3.6 EQUIPMENT ACCESS

A. Install piping, conduit and accessories to permit access to equipment for maintenance. Relocate piping, equipment or accessories to provide access at no additional cost to Owner.

B. Install equipment with sufficient maintenance space for removal, repair or changes to equipment. Provide ready accessibility to equipment without moving other future or installed equipment or system components.

C. Access doors in walls, chases, or inaccessible ceilings will be provided under Division 08 - Access Doors and Frames, unless otherwise indicated. Access doors for valves, shock stops or other equipment shall provide access for servicing, repairs, and/or maintenance.

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

E. Provide access doors in walls, chases or above inaccessible ceilings for valves, shock stops, unions or equipment/devices requiring access for servicing, repairs or maintenance, unless otherwise noted. Access frames and doors shall be as manufactured by Milcor, Incorporated, or similar, of style applicable to surface. Provide access doors used in fire rated construction with UL Label. Provide steel, prime coated access doors unless otherwise specified. Provide stainless steel doors in ceramic tile walls, toilet rooms, locker rooms and in areas subject to excessive moisture. Provide access doors of sufficient size to allow complete maintenance. Coordinate location of access doors with General Contractor and rough-in equipment accordingly.

3.7 EQUIPMENT SUPPORTS

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

3.8 EQUIPMENT GUARDS

A. Provide equipment guards over belt driven assemblies, pump shafts, exposed fans, and elsewhere as indicated in this Specification or required by Code.

B. Paint equipment guards bright yellow.

C. Equipment guards shall comply with OSHA requirements.

3.9 SUPPORT PROTECTION

A. In occupied areas, mechanical rooms, parking areas, and areas requiring normal maintenance access, guard certain equipment to protect personnel from injury.

B. Provide minimum 1/2” thick Armstrong Armaflex insulation or similar product applied with Armstrong 520 adhesive on lower edges of equipment and mechanical supporting devices suspended less than 7 ft above floors, platforms or catwalks in these areas.

C. Protect threaded rod or bolts at supporting elements as described above. Trim threaded rod or bolts such that they do not extend beyond supporting element and devices.

3.10 MECHANICAL SYSTEMS IDENTIFICATION

A. Refer to Section 20 0553 - Mechanical Systems Identification

3.11 TEST AND BALANCING

A. Tests for equipment, ductwork and piping systems shall be performed as specified in their respective specification sections in accordance with technical requirements noted.

B. Provide equipment required for testing, including fittings for additional openings required for test apparatus.

C. All ductwork and piping inspections and testing shall be successfully completed and approved before application of covering materials.

D. When equipment or systems fail to meet minimum test requirements, replace or repair defective work or material as necessary and repeat inspection and test until equipment or systems meet test requirements. Make repairs with new materials. Caulking of holes or threaded joints is not allowed.

E. Contractor is responsible for certifying in writing equipment and system test results. Certification shall include identification of portion of system tested, date, time, test criteria, test medium and pressure used, duration of test and name and title of person signing test certification document.

F. Maintain copies of certified test results, including those for any failed tests, at project site. At completion of project, include copies of test records and certifications in O&M Manuals.

G. Balancing of various systems shall be in accordance with associated specification sections in addition to requirements noted herein.

H. If exterior domestic water supply also serves as source for fire protection systems, either exterior or interior or both, it shall be tested according to fire protection system requirements as specified in applicable Specification Section.

3.12 START-UP

A. Systems and equipment shall be started, tested, adjusted and turned over to Owner ready for operation. This includes "Owner-Furnished, Contractor-Installed" (OFCI) and "Contractor-Furnished, Contractor-Installed" (CFCI) systems and equipment.

B. Follow manufacturer's pre-start-up check-out, start-up, trouble shooting and adjustment procedures.

C. Contractor shall provide services of technician/mechanic knowledgeable in start-up and check-out of types of systems and equipment on project.

D. Provide start-up services by manufacturer's representative where specified or where Contractor does not have qualified personnel.

E. Coordinate start-up with all trades.

3.13 LUBRICATION

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

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

3.14 CLEANING

A. Clean systems after installation is complete.

B. Clean piping and ductwork both internally and externally to remove dirt, plaster dust or other foreign materials. When external surfaces of piping are rusted, clean and restore surface to original condition.

C. Clean pipeline strainers to restore them to original condition or replace with new strainer elements.

D. Clean equipment and plumbing fixtures as recommended by manufacturers.

E. Replace throwaway or replaceable media air filters used during construction period with new filters or new filter media after construction has been completed and before building is turned over to Owner. Filter replacement shall be as hereinafter specified.

F. Blow and clean dirt, plaster dust and other foreign matter from coils, terminal devices, diffusers, registers and grilles.

G. Thoroughly clean equipment of stains, paint spots, dirt and dust. Remove temporary labels not used for instruction or operation.

H. Provide additional cleaning of individual piping systems and apparatus as hereinafter specified.

END OF SECTION

SECTION 20 05 14

VARIABLE FREQUENCY DRIVE (VFD) SYSTEM

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PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 0513 - Motors
B. Section 23 0901 - Control Systems Integration
C. Section 23 0993 - Control Sequences
D. Section 23 2123 - Pumps
E. Section 23 3400 - Fans
F. Section 23 7313 - Packaged Air Handling Units
G. Section 23 7323 - Factory Fabricated Custom Air Handling Units (Low End)
H. Section 23 7328 - Factory Fabricated Custom Air Handling Units (Standard or High End)
I. Section 26 2816 - Enclosed Switches and Circuit Breakers
J. Section 26 2913 - Enclosed Controllers

1.2 SYSTEM DESCRIPTION

A. Provide Variable Frequency Drives (VFD) for each pump, fan or other driven equipment sized to accommodate motors shown on drawings or schedules. 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, pump or other driven equipment motor in response to either 4-20 mA or 0-10 VDC control signal provided by Control Contractor.
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. Internal reactor with minimum 5% impedance or equivalent line reactor

G. Drives shall have SCCR (short circuit current rating) of 42,000 amps.

1.3 QUALIFICATIONS

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

1.4 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/SCCR
5. Warranty
6. System wiring and block diagram showing system components
7. Performance, control and protection data with specified features clearly shown
8. Operating and monitoring devices with specified features clearly indicated
9. Start-up operation, maintenance, spare parts, and field tests
10. Manufacturer's installation instructions
11. Other appropriate data

B. After quality assurance tests are complete, submit written certification that drive and components have passed factory quality assurance tests.

C. Submit calculations indicating conformance with electrical noise criteria specified. Refer to Electrical Documents for information regarding electrical building distribution system.

D. 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.

E. Submit printed list of settings for all items that require setting during startup or list of Factory Default Parameters.

1.5 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. Voltage total harmonic distortion (VTHD) 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. Area of commutation notch (An) shall not exceed 16,400 volt-microseconds measured at point of coupling to distribution system. Point of common coupling shall be primary side of upstream utility transformer for current and secondary side of upstream utility transformer for voltage.

B. VFD manufacturer shall perform harmonic analysis at point of common coupling of distribution transformer to define compliance to IEEE-519-1992, General Category, is attained. Analysis shall include electrical one line drawing defining resistance and impedance of each wire run and transformer leading to each VFD. VFDs provided under other specification sections (chillers, elevators, packaged equipment, etc.) shall also be included in analysis. Contractor shall be responsible for gathering VFD information from other specification sections and providing it to VFD manufacturer performing analysis. Analysis shall be computer generated and perform Fourier analysis of system. Results shall list current and voltage amplitudes of all harmonics up to 50th level at input of distribution transformer. A summary shall detail percent total harmonic distortion for voltage and total demand distortion for current. Analysis shall assume maximum transformer loading of 75% of nameplate value.

C. Drive type shall be based on findings of the IEEE 519 analysis with minimum configurations based on motor horsepower (horsepower shall include total horsepower connected to given drive, e.g. 4@30 hp = 120 hp) as indicated by the following:
1. Less than 50 hp – 6 pulse with reactor
2. 50 hp and larger including 75 hp – 6 pulse with line reactor and passive harmonic filter or 12 pulse drive
3. In lieu of requirements noted above, engineered solution specific to this project that employs multi-pulse drives, passive filtering, active filtering, line reactors, etc. may be used. Proposed solution shall be submitted for Engineer’s approval prior to bidding.

D. Electrical one line diagrams shown on Electrical Drawings include transformer kVA and impedance, and typical configuration of electrical system. Use this information for evaluation of harmonics for bidding purposes.

E. Successful contractor must provide required data for VFD manufacturer to complete harmonic analysis. Information shall include utility short circuit amperes capability; distribution transformer kVA and impedance; length, size and number of wires per phase to motor control center feeding VFD's; wire data to VFD's from motor control center; wire data to motor from VFD; and motor nameplate data.

F. VFD manufacturer is responsible for cost of all equipment required to meet IEEE-519. Equipment, which can be provided, includes input line reactors, DC bus reactors and harmonic filters.

1.6 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; and instruct and train Owner's representative in operation and maintenance of VFD systems. Provide minimum of 4 h of Owner training for VFD system.

B. Should drive operation be deficient, 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 report signed by manufacturer's service representative, including start-up and test log.

D. Manufacturer shall include additional 2 yr (total 3 yrs) warranty for VFD system, covering parts, labor and travel expenses.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Manufacturers: ABB, Allen Bradley/Rockwell Automation, Emerson, Cutler-Hammer, Danfoss, GE, Yaskawa, or Toshiba

2.2 FABRICATION

A. VFD shall be variable torque, solid state, microprocessor based control, modular design for standard induction AC motor.

B. VFD components shall be factory mounted and wired.

C. Provide NEMA enclosure with lockable door handle
   1. NEMA 4 within parking bays and unheated / conditioned areas.
   2. NEMA 1 within enclosed heated / conditioned rooms.

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.

G. For motor 600 hp or larger, inverter section may be current source design.

2.3 PERFORMANCE REQUIREMENTS

A. Input: 460 (+10%, -15%) VAC, 3 Ph, 60 (± 2) Hz

B. Output: 460 VAC, 3 Ph, 10 to 60 Hz

C. Operating Environment Conditions for NEMA 1 VFDs located in heated / conditioned spaces: Ambient -10° 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 430-250.

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 up to VFD current rating without damage to or shutdown of drive. Unit shall be capable of starting into rotating load.

I. Output Frequency Stability: ± 0.5% of base frequency in 24 h 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. Control Power Loss Ride-Through: Min 2 seconds
N. Linearity (speed reference to output frequency): ± 1.0%
O. Input Power Factor: Minimum of 0.95 regardless of speed and load.
P. 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

2.4 CONTROL FEATURES

A. VFD speed control circuit shall accept either 4-20 mA DC or 0-10 VDC isolated ungrounded transmitter signal in automatic mode and from manual speed control keypad in manual mode.
B. Provide adjustable minimum and maximum speed settings (0 - 100%) for both auto and manual mode. Initial minimum setting shall be 25%.
C. Provide adjustable automatic reset for fault trips, except short circuit type faults. After selected number of unsuccessful restart attempts, drive shall be shut down. Number of restart attempts and time interval between resets shall be selective.
D. When unit shuts down due to power outage, unit shall be capable of being restarted manually or automatically.
E. VFD shall be capable of starting into rotating loads spinning in any direction.
F. Provide critical frequency avoidance circuit with at least 3 field adjustable bands to avoid operation at speeds, which cause excessive vibration in driven equipment.
G. Provide isolated ungrounded output signal to indicate drive percent of speed or drive frequency.
H. Provide control for automatically switching from VFD to by-pass line through adjustable time delay relay or equivalent protection whenever VFD shuts down automatically.
I. Generator Supply Fan VFD Additional Requirements:
1. Provide VFD with internal single loop PID controller allowing VFD logic to modulate VFD speed using a pressure transmitter supplied by others.
2. Provide VFD with additional analog input (4-20mA) to read pressure transmitter. VFD shall provide 24VDC for 4-20mA signal.
3. VFD shall ramp to preset speed upon startup and PID loop shall offset speed to maintain room pressure.

2.5 COORDINATION WITH BUILDING AUTOMATION SYSTEM (BAS)

A. Furnish each VFD with digital communication bus card for BAS use. Protocol shall be BACnet IP. Coordinate with Control Contractor for specific interface requirement and final protocol selected.
B. Provide contacts (1 NO and 1 NC contact) for remote input control of start/stop function for VFD mode.
C. Provide three programmable relay/contacts (1 NO and 1 NC contact each) for remote output indication of VFD fault condition. VFD status, and bypass mode if bypass is specified.

2.6 PROTECTION FEATURES

A. Power circuits shall be protected by electronic protection circuits. Electronic protection circuits shall provide orderly shutdown without blowing fuses and prevent component loss under the following abnormal conditions.
1. Instantaneous overcurrent and over voltage trip of output
2. Solid state protective circuit shall provide NEC motor running overload protection tested in accordance with UL Standard 991
3. Power line overvoltage or undervoltage
4. Phase sequence detection or insensitivity to incoming power phase sequence
5. Single and 3 Ph short circuit protection
6. Control circuit malfunction
7. Overtemperature
8. Ground fault for all 3 phases
B. VFD shall protect itself from damage due to phase-to-phase or phase-to-ground faults without fuse blowing or use of isolation transformers. VFD's which require isolation transformers to provide ground fault protection are not acceptable.
C. In addition, provide the following protection features.
1. Input line-to-line and line-to-ground transient protection up to 3000 V
2. Control circuit transformer fusing
3. Grounded control chassis

4. Diagnostic indication
5. One set of three (3) spare fuses for each size or type of VFD

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

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

2.7 OPERATING AND MONITORING DEVICES

A. The following functionality shall be provided and may be controlled via touchscreen/keypad:
1. Door interlock to disconnect VFD input power
2. Hand-Off-Auto device
3. Operating mode selector device marked "Hand-Off-Auto"
4. Manual speed control keypad
5. Power on indication
6. Drive run indication
7. Drive fault indication with testable feature
8. Fault reset device

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

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

D. Provision shall be included to provide selectable programming security by inhibiting program parameter changes with password security.

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

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

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

H. VFD with Manual Bypass Starter:
1. Manual selector switch to select power through VFD or bypass line with label marked "VFD/OFF/BYPASS".
2. Electrically-interlocked VFD/BYPASS contactors with padlocking capability on input side of VFD and bypass starter. Interlock shall be accomplished such that shorting together of any 2 control circuit points cannot cause non-selected device to be energized. Provide electrically-interlocked device that connects only output of selected starting device (VFD or bypass starter) to VFD system output lug. Single shorting of any 2 control circuit points shall not cause both VFD and bypass starter outputs to be interconnected.
3. Bypass shall include high speed fuses for VFD (not in bypass circuit).
4. Service switch to disconnect power to VFD (not in bypass circuit).

2.8 QUALITY ASSURANCE TESTS

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

2.9 DISCONNECT DEVICE

A. Provide integral switch to disconnect incoming electrical power to units. Disconnect device shall be UL Listed devices:
1. Enclosed molded case breaker; ampere rated and providing over current protection. Minimum 42kAIC rated.
2. Fused switch may be used as option. Fused switch shall be ampere rated and provide overcurrent protection. Non-time delay fuses shall be sized for connected drive and motor.

B. Disconnect device shall be capable of being padlocked in OFF position and complying with OSHA Requirements. Operating handle shall indicate whether switch is “ON” or “OFF”.

C. Switch shall have cover interlock to prevent unauthorized opening of switch door when handle is in "ON" position and to prevent closing of switch mechanism with door open. Provide defeater mechanism to defeat the interlock for user required access.

2.10 MOTOR CONTROL EQUIPMENT (BYPASS STARTERS)

A. Bypass starter shall be NEMA or IEC Rated device of the following:
   1. Electromechanical across-the-line starter with solid state overload protection for 50 hp or smaller.

2.11 LINE REACTORS

A. Series line reactors shall be designed for harmonic filtering service and shall be UL component recognized. Construction shall be copper wire wound on steel cores. Inductors shall be 3-phase. Series line reactors shall be sized per harmonic analysis and appropriately for total connected load. Design maximum temperature rise for inductors shall be 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. Provide disconnect switch for line side filters.

2.12 PASSIVE LC FILTER (WHERE REQUIRED BY IEEE 519 STUDY)

A. LC filter shall consist of gapped, three phase, iron core inductor; AC-rated polypropylene capacitors; and wire-wound resistors. Filter shall be rated for application at maximum fundamental system frequency of 60 Hz at nominal system voltages up to 600 V. Filter shall operate at maximum carrier frequency of 8 kHz at 40% of fundamental voltage. Ambient temperature of operation shall be 104°F.

B. Three phase inductors shall be designed for harmonic filtering service and for slowing rate of rapid current changes. Inductors shall be UL component-recognized and shall be built to comply with UL 508A Standard. Construction shall be of copper wire wound on magnetic grade steel. Inductors shall be sized appropriately for total connected load. Design maximum temperature rise for reactors shall be 239°F at rated current.

C. 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 shall be locked in place using vertical ties or rods.

D. Windings shall consist of copper wire or of copper foil. Terminations shall be copper alloy ring lugs, UL-recognized terminal blocks, or solid copper bus. Sheet insulation shall be DuPont Nomex 410 of thickness as required for UL insulation systems.

E. Inductors shall be air-gapped to control saturation. Inductance shall be measured under full load and shall be within 10% of design value.

F. Completed inductors shall be impregnated with 100% solid epoxy resin. Insulation varnish systems shall be rated Class H (180°C), 600 V.

G. Filter shall be housed internal to drive enclosure.

H. Filter shall include relay contactor to disengage circuit capacitor if VFD operating at 50% electrical capacity or less. Set point shall be field programmable. Activation of contactor shall leave inductor in circuit for benefits of added circuit impedance. Relay required for this control shall be provided in VFD by VFD manufacturer.

2.13 ACTIVE FRONT END FILTER (WHERE REQUIRED BY IEEE 519 ANALYSIS)

A. Active front end filter shall supply non-linear loads with near sinusoidal current waveform. Filter shall be rated for application at maximum fundamental system frequency of 60 Hz and nominal system voltages up to 600 V. TDD at installed location shall be limited to <5% and THD shall be limited to threshold defined in Electrical Noise Criteria in Part 1 above on line side of filter.

B. Unit shall include input circuit breaker with minimum kAIC rating to match upstream electrical distribution equipment. Current limiting protection shall also be provided.

C. Unit shall have ability to communicate via standard Ethernet protocol to match Building Automation System.

D. Multiple units may be installed in parallel as necessary to meet load requirements. Failure of single unit shall not impact other units in parallel.

E. Unit shall have field configurable relay based fault output.

2.14 SPARE PARTS

A. Additional enclosure cooling fan for each different type of drive.

B. Additional key pad/touch screen for each different type of drive.

PART 3 - EXECUTION

3.1 INSPECTION

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

3.2 PROTECTION

A. Protect VFD cabinets from dust/dirt during storage and operation until turned over to Owner.

B. If VFDs are not furnished with internal air filter racks, provide temporary filter media to protect VFD cabinets and replace filter media as required.

3.3 INSTALLATION

A. Install VFD system in accordance with details, approved 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 filters, line reactors and/or by-pass starter if bypass starter is specified and the wiring is not installed at factory. Install wiring in metal conduit and in accordance with Electrical sections of this Specification and applicable Electrical Code.

C. Provide 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. Do not combine control wiring with power wiring.

G. Use minimum 18 ga shielded wiring with ground for control wiring.

H. Unless otherwise indicated, mount VFD so that display and keypad are at approximately 5’-0” to 5’-6” above floor.

I. Install floor mounted drives on 3-1/2” high concrete housekeeping pad.

3.4 START UP

A. VFD manufacturer shall perform field inspection, start-up and testing of VFD in accordance with procedures as defined by manufacturer for proper operation.

B. Adjust critical frequency avoidance feature to step over frequencies which cause excessive vibration in driven equipment.

END OF SECTION

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SECTION 20 05 29

PIPING AND EQUIPMENT SUPPORTING DEVICES

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3.15 PIPE ROOF PENETRATION PROTECTIONS
3.16 PIPE GUIDES
3.17 PIPE ANCHORS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 0700 - Mechanical Systems Insulation
B. Section 23 0550 - Vibration Isolation (Spring Hangers and Mounts)
C. Section 23 3114 - Ductwork (for duct supports requirements)

1.2 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 NFPA 13 Standard for the Installation of Sprinkler Systems, 2016 Edition.

1.3 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. Submit ICC-ES Evaluation Report for each type of anchor.
9. Calculations and drawings for concrete inserts and anchors for each application
10. Drawings showing specific locations of any weld attachments to structure, including weight supported by such attachments
11. Drawings showing specific locations of any suspended loads which exceed 100 lbs within joist chord panel to be attached to open web steel joist structural members. Include weight supported by such attachments. (Panel is length of chord between two adjacent diagonal web members at point of connection to chord.)
12. Equipment mounting devices
13. Pipe guides and anchors
14. All other appropriate data

1.4 DESIGN CRITERIA

A. Materials and application of pipe hangers and supports shall conform to latest requirements of ANSI/ASME B31 Code for Pressure Piping and MSS Standard Practice SP-58-2009 (Pipe Hangers and Supports Materials, Design, Manufacture, Selection, Application, and Installation), except as supplemented or modified herein.

B. Support materials shall be steel or stainless steel unless specifically indicated.

C. Support devices shall 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, and hot-dipped galvanized finish for outdoor application and corrosive atmospheres. Coat cut edges, welds or any damaged finish with galvanized paint.

1. Corrosive atmospheres include the following locations:
   a. Exterior locations
   b. General below ground parking areas
   c. Chemical storage and hazardous waste storage rooms
   d. Locker rooms

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. In addition to hangers specified in this Section, piping connected to pumps, compressors, and similar rotating or reciprocating equipment shall have vibration isolation hangers or supports for distance of 100 pipe diameters or 50 ft away from equipment, whichever is greater.

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. Refer to Structural Documents and ICC-ES Evaluation Report for application of concrete inserts and concrete anchors.

P. Lateral braces shall be designed and detailed to apply loads as directly as possible to structural floor slabs, roof decks, or other building lateral elements. Braces shall not be applied to bottom flanges of steel beams or bottom chords of open web steel joists.

Q. Coordinate with General Contractor for any proposed weld attachments to building structure. This 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.

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

PART 2 - PRODUCTS

2.1 STRUCTURAL SUPPORTS

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

2.2 PIPE HANGERS AND SUPPORTS (METALLIC)

A. Manufacturers: Anvil, 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 plastic, vinyl or epoxy 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)	---
Cold Pipes with Insulation (33°F to 59°F)	2” and smaller	65 (MSS Type-1), 260 (MSS Type-1)	---
	2-1/2” and larger	260 (MSS Type-1), 295 (MSS Type-1)	---

E. 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	---	171 or 177(MSS Type-41), 271 (MSS Type-45), 274 (MSS Type-46)	257 or 436 with 212 or 432 clamps, Type 1, 2 or 3 for longitudinal movement only and Type 4, 5 or 6 for both longitudinal and transverse movement of piping.
Ambient Bare Steel Pipes (60°F to 119°F)	6” and smaller 8” and larger	B-Line BVT 137 (MSS Type-24)	---	---
Ambient Bare (Copper) pipes (60°F to 119°F)	all sizes	B-Line BVT		
Cold Pipes with Insulation (33°F to 59°F)	10” and smaller	137 (MSS Type-24)	---	---
	12” and larger	432	---	---

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

System	Pipe Size	Supports	Clamps, Brackets/Inserts	Pre-insulated Inserts
Hot and Cold Pipes with Insulation	All sizes	Anvil 137	HoldRite 260 series with SBIS bracket, Anvil 262	Anvil Klo-Sure, Pipe Shields A2000
Ambient Bare Steel Pipes (60° to 119°F)	All sizes	Anvil 137, 138-R	Anvil 262	---
Ambient Bare Copper Pipes	All sizes	Anvil CT-138R	HoldRite 260 series with SBIS bracket	---

2.3 INSULATION PROTECTION SHIELDS

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

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

2.4 INSULATION PROTECTION SADDLES

A. Anvil Fig. 160 Series (MSS Type-39) constructed of carbon steel or alloy steel plate. Select saddles to accommodate insulation thickness specified in Section 20 0700 - Mechanical Systems Insulation.

2.5 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. Compressive strength 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):

D. High-density calcium silicate insulation (Type H) similar to Johns Manville Thermo-12 or cellular glass insulation (Type G) similar to Pittsburgh Corning Foamglas. Maximum compression strength for load calculation shall be 90 psi.

E. Cold Pipes (59°F and below):

1. Cellular glass insulation (Type G) similar to Pittsburgh Corning Foamglas, maximum compressive strength 90 psi, rigid closed cell insulation (Type PP) similar to Trymer Green by ITW, maximum compressive strength for load calculation 31 psi, or expanded polyisocyanurate insulation (Type P) similar to Trymer 2000XP by ITW, maximum compressive strength for load calculation 24 psi.
2. SNAPP ITZ pre-insulated pipe supports by Mechanical Pipe Shields Mfg or Tru-Balance Insulated Saddles by Buckaroos, Inc. may be used. Pre-insulated pipe supports shall use polyisocyanurate (Trymer 2000 or 4000 or Insul-Phen insulation), with 360° PVC jacket up to 3" and 180 or 360 degree G90 galvanized steel shield.

2.6 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·ft2·°F) at 75°F mean temperature, minimum density of 13 lb/ft3, 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/ft3 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.

2.7 HANGER RODS (METALLIC)

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

B. Rods shall have electroplated zinc or hot dip galvanized finish.

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

Max. Pipe Size With Single Rigid Rod	Rod Diameter (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
8”	3/4	3230
12”	7/8	4480
18”	1	5900
30”	1-1/4	9500

2.8 BOLTS, NUTS, STUDS AND WASHERS

A. ASTM A307, electroplated zinc finish

2.9 ROD ATTACHMENTS

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

2.10 U-BOLTS

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

2.11 BEAM CLAMPS

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

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

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

2.12 ADJUSTABLE PIPE SADDLE SUPPORTS

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

2.13 RISER CLAMPS

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

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

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

2.14 CONCRETE INSERTS (WOODEN FORMED CONCRETE)

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

2.15 CONCRETE INSERTS (METAL DECK FORMED CONCRETE)

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

2.16 CONCRETE ANCHORS

A. Manufacturers: Hilti, Powers Fasteners or Red Head

B. Anchors shall be selected, sized, and detailed by Contractor’s structural engineer registered in project’s jurisdiction, based on project conditions and in accordance with project building code. Calculations and drawings shall be submitted.

C. Anchors shall meet ICC Acceptance Criteria, and ICC-ES Evaluation Reports (ESRs) shall specifically list the current applicable codes.

D. Anchors installed in hardened concrete for purpose of transmitting structural loads from one connected element to another, or for safety related elements such as sprinkler pipes, heavy suspended pipes, and barrier rails shall have ICC-ES report demonstrating anchors have met requirements of AC 193 for mechanical anchors in concrete elements.

E. Post-installed expansion anchors and undercut anchors installed in hardened concrete shall be qualified for strength design and tested according to ACI 355.2. Designs shall be per the requirements of ACI 318, Appendix D.

F. Anchors for seismic load application shall be approved by ICC-ES Evaluation Reports to resist seismic loads and selected to meet project seismic design requirements. Refer to Section 20 0549 – Seismic Anchorage and Restraints and Structural drawings.
G. Anchors shall be zinc plated in accordance with ASTM B633.
H. Select anchors with load ratings based on cracked concrete conditions.

2.17 METAL FRAMING SUPPORT SYSTEM (STRUT SYSTEM)

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

2.18 PIPE MOUNTING PEDESTALS

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

2.19 EQUIPMENT RAILS

A. Manufacturers: Roof Products & Systems, ThyCurb, Custom Curb, Inc. or Vent Products equal to Roof Products & Systems Model ER-4 with raised cant style. Mounting rails shall be galvanized steel with integral base plate, continuous welded corner seams, factory installed 2x4 wood nailer and 18 ga galvanized steel counter flashing.
B. Mounting rail gauge shall be selected to support equipment adequately but shall be not less than 18 ga.
C. Height shall be as detailed, but not less than 8” above finished roof.
D. Equipment rails shall span minimum of 2 joists and not cantilever more than 6” where joists are used. Rails shall be level at top with pitch built in when deck slopes 1/4" per foot or greater.

2.20 PIPE ROOF PENETRATION PROTECTIONS

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

2.21 PIPE GUIDES

A. Unless otherwise indicated, guides shall be Pipe Shields, Bergen Pre-Insulated Pipe Supports, or Rilco equal to Pipe Shields "B" Series B3000, B4000, B7000, B8000, selected by load and movement.

2.22 PIPE ANCHORS

A. Unless otherwise indicated, anchors shall be no-moment type, Shaw Pipe Shields or Rilco equal to Shaw Pipe Shields Insulated Positive Pipe Anchor Model C3000 or C4000 Series, sized to meet anchor forces shown with minimum safety factor of 3.0.
B. Contractor may fabricate anchors of steel sections suitable for location of installation and for withstanding anchor forces shown with minimum safety factor of 3.0.

2.23 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

3.1 INSTALLATION

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

C. Coordinate hanger and support installation to properly group piping of all trades.
D. Suspend piping hangers by means of hanger rods. Perforated band iron and flat wire (strap iron) are not allowed.
E. Piping and ductwork shall be supported independently from other piping or ductwork.
F. Pipe hangers and supports shall not penetrate vapor barrier of pipe insulation.
G. Do not support equipment, 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.

3.2 HANGER AND SUPPORT SPACING

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

Pipe Size	Max Spacing
1-1/4” and smaller	7’-0”
1-1/2”	9’-0”
2”	10’-0”
2-1/2”	11’-0”
3”	12’-0”
4”	14’-0”
6”	17’-0”
8”	19’-0”
10” and larger	20’-0”

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

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” and larger	12’-0”

D. Copper Tube (Unless Otherwise Noted):

Pipe Size	Max Spacing
3/4” and smaller	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):

Pipe Size	Max Spacing
1-1/4” and smaller	6’-0”
1-1/2” and larger	10’-0”

F. 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."

G. 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.
H. Spacing less than indicated above may be required to conform to building structure design or loading limitations.
I. If pipe size changes between support points, maximum spacing shall be based on the smaller pipe size.
J. If trapeze hangers are used to support multiple services, spacing shall be based on the most restrictive pipe size and material on trapeze hanger.
K. For non-metallic pipe, follow manufacturer's installation recommendations in addition to requirements noted herein.

L. Install supports for vertical piping and anchors as recommended by pipe manufacturer.
M. 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.
N. Hangers and supports shall bear on outside of insulation when pipes are to be insulated.
O. 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.
P. Place hanger or support at first elbow upstream of pump inlet and first elbow downstream of pump outlet.

3.3 RISER SUPPORTS

A. Insulated Piping:
1. Unless otherwise indicated, support vertical piping as indicated below:
2. Support vertical piping at [bottom] [approximately midpoint] of riser, secured and anchored to building structure. Provide guides on vertical piping. Use spring hangers at [top] [top and bottom] of riser and at take offs from riser at each floor. Use spring hangers for minimum 3 hangers away from top and bottom elbows and from each take off at riser.
3. Guide vertical piping 2" 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. Non-insulated Piping:
1. Unless otherwise indicated, maximum vertical support spacing for ambient bare steel and cast iron pipes shall be 15 ft.
2. Maximum vertical support spacing for other piping including copper tubing and plastic piping shall be 10 ft.
3. Install riser clamps and intermediate supports as required.
4. Rest riser clamps on floor or on pipe sleeve.
5. Non-insulated piping above 120°F shall be supported per insulated piping requirements.

3.4 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.

3.5 INSULATION PROTECTION SADDLES

A. Install saddles at support points as specified under Insulated Pipe Supports. Tack weld saddle to pipe by tacking center of each point of contact. Pack saddle cavity with insulation of same type as specified for piping system.
B. Where depth of single saddle is less than specified insulation thickness, provide additional saddle tack welded to first saddle to equal insulation thickness.

3.6 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.

3.7 PIPE FLOOR SUPPORTS

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

3.8 CONCRETE INSERTS

A. Concrete insert application, size, loading, and placement shall be this Contractor's responsibility.

B. Coordinate with General Contractor for placement of inserts before concrete pour. Minimize use of inserts and anchors after concrete pour.

3.9 BEAM CLAMPS

A. Provide locknut for hanging rod at clamp.

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

C. C-clamps are not allowed for open web steel joist application.

D. C-clamps are not allowed for seismic application.

3.10 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.

3.11 PIPE MOUNTING PEDESTALS

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

3.12 EQUIPMENT RAILS

A. Use for all roof-mounted equipment, which is not curb mounted. Install bottom of equipment rail flat on roof deck. Insulate exterior of equipment rail.

B. Flashing will be by General Contractor. Provide counter flashing as specified and secure to wood nailer with stainless steel truss head screws.

3.13 CONCRETE ANCHORS

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

3.14 PIPE ROOF PENETRATION PROTECTIONS

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

3.15 PIPE GUIDES

A. Install where shown on drawings.

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

MAXIMUM DISTANCE BETWEEN INTERMEDIATE GUIDES (FT)

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

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

3.16 PIPE ANCHORS

A. Install anchors where shown on drawings or in conjunction with expansion joints, loops and swing joints as required to allow proper expansion and contraction of piping without damage to structure, equipment or piping.

B. Do not anchor piping to concrete block walls, wood, or partition walls.

END OF SECTION

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SECTION 20 05 53
MECHANICAL SYSTEMS IDENTIFICATION

PART 1 – GENERAL
1.1 SUBMITTALS
PART 2 – PRODUCTS
2.1 IDENTIFYING DEVICES
PART 3 – EXECUTION
3.1 GENERAL
3.2 PIPING SYSTEM IDENTIFICATION
3.3 VALVE IDENTIFICATION
3.4 DUCT SYSTEM IDENTIFICATION
3.5 EQUIPMENT IDENTIFICATION
3.6 ACCESS PANEL IDENTIFICATION
3.7 SPRINKLER ZONE CONTROL VALVE IDENTIFICATION
3.8 UNDERGROUND WARNING TAPE

PART 1 - GENERAL

1.1 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 IDENTIFYING DEVICES

A. Marker System:
1. Manufacturers: Brady USA, Marking Services Inc. (MSI), Kolbi, or Seton
2. Manufacturer's standard, preprinted with color coding, lettering size and length of color field according to ASME A13.1.
3. Use pressure-sensitive type, stick on or paint on type.

B. Valve Tags:
1. Minimum 1-1/2” diameter, 0.032” thick, polished brass or 316 stainless steel.

C. Laminated Plastic Nameplates:
1. Nameplates shall be approximately 1-1/2" x 4", 1/16” thick, and have 1/2” high lettering. Face of plastic nameplates shall be black with white letters.
2. Fasteners shall be self-tapping, stainless steel screws or contact type with permanent adhesive.

D. Underground Warning Tape:
1. Manufacturers: Brady USA, Marking Services Inc. (MSI), Kolbi, or Seton
2. Underground warning tape, 5.0 mil overall thickness, 2” width minimum, aluminum foil core where required to be detectable, bonded polyethylene jacket. Brady “Identoline” or equal.
3. Following services shall be provided with warning tape with colors and trace wire as indicated:
   a. Natural Gas: Yellow with black letters, detectable
   b. Fuel Oil: Yellow with black letters, detectable
   c. Water Lines: Blue with black letters, detectable
   d. Sanitary Sewer: Green with black letters, detectable
   e. Storm Sewer: Green with black letters, detectable

PART 3 - EXECUTION

3.1 GENERAL

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

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

3.2 PIPING SYSTEM IDENTIFICATION

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

3.3 VALVE IDENTIFICATION

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

3.4 DUCT SYSTEM IDENTIFICATION

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

3.5 EQUIPMENT IDENTIFICATION

A. Identify major equipment, including unit heaters, heat pumps, split system equipment, exhaust fan systems, supply fan systems, etc.
B. Identify equipment with laminated plastic nameplates.
C. Identify control equipment and panels with laminated plastic nameplates.
D. 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.
E. Locate motor nameplates for easy reading. Relocate or provide new nameplates on motors if original nameplates are not located for easy reading.

3.6 ACCESS PANEL IDENTIFICATION

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

3.7 SPRINKLER ZONE CONTROL VALVE IDENTIFICATION

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

3.8 UNDERGROUND WARNING TAPE

A. Install detectable warning tape 4” to 6” below grade to allow for accurate above surface detection.

B. Install non-detectable warning tape 6” to 12” below grade.
C. Repair and replace existing underground warning tape where disturbed by excavation.

END OF SECTION

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SECTION 20 05 73
MECHANICAL SYSTEMS FIRESTOPPING

PART 1 – GENERAL
1.1 SCOPE
1.2 SYSTEM PERFORMANCE REQUIREMENTS
1.3 SUBMITTALS
1.4 QUALITY ASSURANCE
1.5 DELIVERY, STORAGE, AND HANDLING
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3.1 EXAMINATION
3.2 PREPARATION
3.3 INSTALLATION
3.4 FIELD QUALITY CONTROL
3.5 IDENTIFICATION
3.6 CLEANING AND PROTECTION

PART 1 - GENERAL

1.1 SCOPE

A. Work under this Section includes but is not limited to the following:
   1. Penetrations through fire-resistance-rated floor, roof, walls, partitions, and smoke barriers including openings containing pipes, ducts and other penetrating items.
   2. Penetrations through non-fire-resistance-rated floors where vertical service riser penetrates 3 or more floors.

1.2 SYSTEM PERFORMANCE REQUIREMENTS

A. Firestopping systems shall be UL Classified for the application and correspond to those indicated by reference to designations listed by UL Fire Resistance Directory.
B. Firestop materials and methods shall conform to requirements of Local Code Authority Having Jurisdiction.

1.3 SUBMITTALS

A. Manufacturer's specifications and product data for each type of product including composition and limitations, documentation of UL Certification for firestopping systems to be used and manufacturer's installation instructions.
B. Material safety data sheets provided with product delivered to job-site.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Firm experienced in installing penetration firestopping similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful performance. Qualifications include having necessary experience, staff, and training to install manufacturer's products per specified requirements.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver products to project site in original, unopened containers or packages with intact and legible manufacturers' labels identifying product, type and UL Label where applicable.
B. Store materials to prevent deterioration or damage due to moisture, temperature changes, contaminants or other causes.
C. Handle in accordance with recommended procedures, precautions or remedies described in material safety data sheets as applicable.

1.6 PROJECT CONDITIONS

A. Do not install firestopping when ambient or substrate temperatures are outside limits permitted by firestopping manufacturers or when substrates are wet because of rain, frost, condensation or other causes.

B. Install and cure firestopping per manufacturers' written instructions using natural ventilation or, where this is inadequate, forced-air circulation.

1.7 COORDINATION

A. Coordinate construction of openings and penetrating items to ensure that penetration firestopping is installed according to specified requirements.
B. Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate penetration firestopping.
C. Notify Owner's testing agency at least seven (7) days in advance of penetration firestopping installations; confirm dates and times on day preceding each series of installations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. 3M, Hilti, Tremco, Nelson Firestop Products, Specified Technologies, Inc. (STI), or RectorSeal Corp.
B. Pro-set firestop products may be used for specific applications, provided products meet requirements in this Section.
C. HydroFlame water/firestop sleeves may be used for specific applications provided products meet requirements in this Section.

2.2 MATERIALS

A. Use only firestop products that have been UL 1479, ASTM E814 Tested for specific fire-rated construction conditions conforming to construction assembly type, penetrating item type, annular space requirements and fire-rating involved for each separate instance.
B. VOC Content: Penetration firestopping sealants and sealant primers shall comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
   1. Sealants: 250 g/L
   2. Sealant Primers for Nonporous Substrates: 250 g/L
   3. Sealant Primers for Porous Substrates: 775 g/L
C. Where UL classified systems are indicated, they refer to system numbers in UL's "Fire Resistance Directory" under product Category XHEZ.

2.3 MIXING

A. For those products requiring mixing before application, comply with through-penetration firestop system manufacturer's written instructions for accurate proportioning of materials, water (if required), type of mixing equipment, selection of mixer speeds, mixing containers, mixing time, and other items or procedures needed to produce products of uniform quality with optimum performance characteristics for application indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance of firestopping.
B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Clean out openings immediately before installing firestopping to comply with manufacturer's written instructions.
B. Prime substrates where recommended in writing by manufacturer using that manufacturer's recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.
C. Provide masking and temporary covering to prevent soiling of adjacent surfaces by firestopping materials.

3.3 INSTALLATION

A. Install penetration firestopping to comply with manufacturer's written installation instructions and published drawings for products and applications.

B. Install forming materials and other accessories of types required to support fill materials during application. After installing fill materials and allowing materials to fully cure, remove forming materials and other accessories not indicated as permanent components of firestop systems.

C. Avoid multiple penetrations of common fire barrier opening. Seal each penetration in accordance with manufacturer's UL installation details. When multiple penetrations are unavoidable, seal openings with appropriate UL Classified firestopping systems.

3.4 FIELD QUALITY CONTROL

A. Inspecting Agency: Owner will engage a qualified independent inspecting agency to inspect Through-Penetration Firestop Systems and to prepare test reports.

B. Inspecting agency will state in each report whether inspected Through-Penetration Firestop Systems comply with or deviate from requirements.

C. Provide certification by Installer that all Through-Penetration Firestop Systems have been firestopped in accordance with applicable Building Codes of this State.

D. Proceed with enclosing Through-Penetration Firestop Systems with other construction only after inspection reports are issued.

E. Where deficiencies are found, repair or replace Through-Penetration Firestop Systems so they comply with requirements.

3.5 IDENTIFICATION

A. Identify Through-Penetration Firestop Systems with preprinted metal or plastic labels. Attach labels permanently to surfaces adjacent to and within 6” of firestopping edge so labels will be visible to anyone seeking to remove penetrating items or firestop systems. Use mechanical fasteners or self-adhering type labels with adhesives capable of permanently bonding labels to surfaces on which labels are placed. Include the following information on labels:

1. The words: “Warning--Through-Penetration Firestop System—Do Not Disturb. Notify Building Management of Any Damage.”
2. Contractor’s name, address, and phone number.
3. Designation of applicable testing and inspecting agency.
4. Date of installation.
5. Manufacturer’s name.
6. Installer’s name.

3.6 CLEANING AND PROTECTION

A. Clean surfaces adjacent to sealed holes and joints to be free of excess firestop materials and soiling as Work progresses.

B. Provide final protection and maintain conditions during and after installation that ensure that penetration firestopping is without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, immediately cut out and remove damaged or deteriorated penetration firestopping and install new materials to produce systems complying with specified requirements.

END OF SECTION

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SECTION 20 07 00
MECHANICAL SYSTEMS INSULATION

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1.2 DESCRIPTION
1.3 DEFINITIONS
1.4 SUBMITTALS
1.5 DELIVERY, STORAGE, AND HANDLING
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3.11 TYPE S INSULATION (POLYSTYRENE)
3.12 ENGINE EXHAUST PIPE INSULATION (OVER 1200°F)

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 0529 - Piping and Equipment Supporting Devices
B. Section 23 3114 - Ductwork (Duct Lining)

1.2 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.

1.3 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).

1.4 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

1.5 DELIVERY, STORAGE AND HANDLING

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

B. Coatings, Mastics, Sealants and Adhesives:
   1. Foster, Childers, Vimasco, Miracle or Pittsburgh Corning

2.2 MATERIALS

A. Products used for or related to air conditioning and ventilating systems shall conform to NFPA 90A possessing flame spread index of not over 25 and smoke developed index no higher than 50.

B. Unless otherwise indicated, all products, material itself or on composite basis, shall have flame spread index not more than 25 and smoke developed index not more than 50, when tested in accordance with ASTM E-84 or UL723.

C. Pipe insulation which is not located in air plenum may have flame spread rating not over 25 and smoke developed rating no higher than 450 when tested in accordance with UL 723 and ASTM E84.

D. Outdoor insulation may have flame spread rating not over 75 and smoke developed rating not higher than 450.

E. Insulation applied on stainless steel shall meet requirements of ASTM C795 and NRC 1.36.

2.3 INSULATION

A. Insulation materials shall be fire retardant, moisture and mildew resistant, vermin proof, and suitable to receive jackets, adhesives and coatings as indicated.

B. Glass fiber insulation shall be of inert inorganic material, non-corrosive to mechanical surfaces.

C. Insulating cement shall be Quick-Cote by PK Insulation MFG Co. or Ryder GP, with dry density of no more than 38 lb/ft3 thermal conductivity of 0.96 at 400°F mean temperature, and service temperature to 1200°F.

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

E. Type A Insulation (Closed Cell Elastomeric Thermal Insulation):
   1. Minimum nominal density of 6 lb/ft3, thermal conductivity not more than 0.25 at 75°F mean temperature, maximum water vapor transmission of 0.06 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/ft3 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 EQ Type 75, Knauf Atmosphere Duct Wrap.

G. Type FR Insulation (Fire Resistive Duct Wrap):
   1. Wrap material shall have fire resistive rating of 2 h and shall be Fire Master Fast Wrap XL duct wrap by Thermal Ceramics or similar products by Unifrax or 3M. Wrap shall be 1-1/2" thick, service range up to 2000°F and R-value per ASTM C518, 4.15 per inch at 70°F.
   2. Wrap shall have the following requirements:
      a. Through-penetration firestop systems for air ducts, ASTM E814, 2 h F and T Rating.

b. Non-combustibility, ASTM E136
c. ISO-6944, Fire Resistance Tests - Ventilation Ducts

H. Type G Insulation (Cellular Glass):
1. 100% cellular glass cells with no organic material, noncombustible, 0.00 perm-inch permeability, 7.5 lb/ft3 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.

I. 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.

J. Type P Insulation (Expanded Polyisocyanurate):
1. Continuously molded rigid polyisocyanurate foam insulation meeting requirements of ASTM C-591, with thermal conductivity of not more than 0.19 at 75°F mean temperature, minimum nominal density of 2 lb/ft3, minimum compressive strength of 24 psi, maximum water vapor transmission of 4.0 perm-inch, maximum water absorption of 2% by volume, and suitable for temperature of plus 300°F down to -297°F. Insulation shall have factory-applied jacket with SSL. Trymer 2000 XP by ITW, Dyplast ISO-C1, or approved equal.

K. 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.
2. Pipe insulation shall be premolded type in accordance with ASTM C547 Type I, suitable for temperatures to 850°F, Johns Manville Micro-Lok, Owens Corning Fiberglas ASJ/SSL-II or Knauf Earthwool 1000° pipe insulation.
3. Duct and equipment insulation shall be in accordance with ASTM C612, Type IA and IB, suitable for temperatures to 450°F, Johns Manville Spin-Glas Type 814, Owens Corning Type 703, Knauf Insulation Board.
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.

L. 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. GA4000 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.

M. Type T Insulation (Mineral Fiber Fireproofing):
1. Nominal 8 lb/ft3 density with fire hazard classification flame spread of no more than 15, and smoke development of 0, thermal conductivity of not more than 0.23 at 75°F mean temperature, rated for service temperature to 1200°F. US Gypsum Thermafiber, Roxul or Fibrex duct insulation.

2.4 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 A-1 Jacket (Aluminum Roll Jacketing):
1. Factory fabricated 0.016” thick, ASTM B209, Type 3003 or 3105, stucco embossed aluminum jacket with integrally bonded moisture barrier/retarder consisting of 3 layers of polymer films with total thickness of 3 mil.
2. Fitting covers shall be factory fabricated from not lighter than 0.024" thick, Type 3003 or 1100 aluminum. For large pipes, where factory fabricated fitting covers are not available, Contractor shall fabricate fitting covers from like sheet materials.
3. Jacketing system shall be similar to ITW Pabco/Childers or Insul-Mate by RPR Products, Inc.

C. Type D-1 Jacket:
1. Heavy-duty, fire retardant material with glass fiber reinforcing. Jackets shall have neat, white Kraft finish suitable for painting, with beach puncture resistance of 50 units minimum. Vapor barrier shall be adhered to inner surface of jacket. Permeance shall not exceed 0.02 perm. Owens Corning "ASJ", Johns Manville "AP", Knauf “ASJ”.

D. 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", Knauf “FSK”.

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

F. Type P-2 Jackets:
   1. Jackets shall be minimum 5 ply laminated, weather proofing material with acrylic adhesive capable of installation with no additional mechanical attachments, 0.00 water vapor permeance rating per ASTM E-96, mold inhibitors incorporated and UV stable, Venture Clad 1577 CW or Alumaguard Lite.
   2. Jackets shall have white finish.

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

A. Adhesives and sealants shall comply with the South Coast Air Quality Management District (SCAQMD) Rule #1168; VOC limits shall comply with Indoor Environmental Quality Section, Credit IEQ-4.1.

B. Coatings and mastics shall comply with VOC limits set forth by Green Seal BS-11 and comply with the South Coast Air Quality Management District (SCAQMD) Rule #113; VOC limits shall comply with Indoor Environmental Quality Section, Credit IEQ-4.2.

C. Products shall be compatible with surfaces and materials on which they are applied, and shall be suitable for use at operating temperatures of systems to which they are applied.

D. Products shall be fire retardant, moisture resistant and mildew resistant and vermin proof.

E. Vapor Barrier Mastic: Below ambient insulation. Water vapor permeance shall be less than 0.08 perms at 45 mils dry film thickness per ASTM F1249.
   1. Foster 30-33
   2. Childers CP-33
   3. Vimasco 749

F. Weather Barrier Breather Mastic: Above ambient insulation. Permeance shall be greater than 1.0 perms at 1/16” dry film thickness per ASTM E96.
   1. Foster 46-50 Weatherite
   2. Childers CP-10/CP-11 Vi Cryl
   3. Vimasco WC-5

G. Lagging Adhesive/Coatings: Indoors applications used in conjunction with canvas/glass cloth.
   1. Foster 30-36
   2. Childers CP-50 AMV1
   3. Vimasco 713

H. Metal jacketing sealant for aluminum jacketing:
   1. Foster 95-44 Elastolar
   2. Childers CP-76 Chil Byl
   3. Pittsburgh Corning 727

I. Insulation joint sealant for Type P, Type PP, and Type G insulation:
   1. Foster 95-50 Flextra
   2. Childers CP-76 Chil Byl
   3. Pittsburgh Corning CW Sealant

J. Glass fiber fabric reinforcing shall be 10 x 10 mesh similar to Childers Chil Glas #10 or Foster Mast A Fab.

K. Wire mesh reinforcing shall be 22 ga, 1” galvanized.

L. Insulation cement shall be ANSI/ASTM C195, hydraulic setting mineral wool.

M. Finishing cement shall be ASTM C449.

N. Butt joint and longitudinal joint adhesive for Type A insulation shall be Armstrong 520, Rubatex 373, Childers CP-82 or Foster 85-75.

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

2.6 METAL BANDS AND WIRES

A. Aluminum bands shall be 0.5" x 0.020” 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.

2.7 INSULATION FASTENERS

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

2.8 REMOVABLE INSULATING BLANKETS

A. Custom designed removable, reusable, flexible, blanket thermal insulation system.
B. Acceptable Manufacturers: Thermal Energy Products, Inc., Advanced Thermal Corp., Temptec and Remco Technology, Inc.
C. Removable insulation system shall be custom designed for each individual item to provide close contour fit. Overlapping seams and gaps are not acceptable.
D. Removable insulation shall be designed to overlap adjoining pipe insulation by 2".
E. Insulation: Minimum 2" thick, 2.4 lb/ft3 density, 1000°F continuous service temperature thermal insulating wool; Owens Corning Fiberglass or equal.
F. Interior and Exterior Fabric: Minimum weight 17.5 oz/sq yd silicone rubber coated fiberglass cloth.
G. Securement: Blanket seams shall be closed with buckle and strap assembly (D ring closure).
H. Identification/Tagging: Label each removable insulation device with plastic or 304 stainless steel tag with raised letters. Tag as directed by Owner.

2.9 ACOUSTICAL BARRIER MATERIALS

A. Acoustical barrier material shall be similar to Kinetics Model KNM-100ALQ. Barrier material shall have acoustic ratings of STC-28, 1.0 lb/ft2 nominal density, flame spread index less than 25, smoke developed index less than 50, and minimum continuous operating range from 40°F to 220°F.
B. Minimum sound transmission loss at each octave band shall be as follows:

Sound Transmission Loss (dB) Octave Band Center Frequency (Hz)					
125	250	500	1000	2000	4000
13	16	24	33	43	49

PART 3 - EXECUTION

3.1 APPLICATION

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

Service	Jacket Type	Insulation Type	Piping System: Insulation Thickness According to Pipe Size: 3/4" and less	1" - 1-1/4"	1-1/2" - 3"	4" - 6"	8" and Larger
Refrigerant Suction Lines and Hot Gas By-pass Line if Used (Exterior)	P-2	A	1"	1"	1"	1"	1-1/2"
Cooling Coil Condensate Drain	P-2	A	3/4"	3/4"	3/4"	3/4"	3/4"
Domestic Cold Water	P-1	R	1"	1"	1"	1"	1"
	--	A	3/4"	3/4"	3/4"	3/4"	3/4"
			(Type A Insulation is an option)				
Domestic Hot Water (105-140°F)	P-1	R	1"	1"	1-1/2"	1-1/2"	1-1/2"
	--	A	1"	1"	1-1/2"	1-1/2"	NA
			(Type A insulation is an option.)				
Storm piping including roof drain body.	P-1	R	NA	1"	1"	1"	1"
	--	A	NA	3/4"	3/4"	3/4"	NA
			(Type A insulation is an option.)				

Clearwater Waste	P-1	R	1"	1"	1"	1"	1"
	--	A	3/4"	3/4"	3/4"	3/4"	NA
			(Type A insulation is an option.)				
Piping Provided with Heat Tracing	P-1	R	1"	1-1/2"	2"	2"	2"

Insulation thickness shall be the greater thickness specified for piping system or thickness specified above.

Insulated Exterior Piping Insulated Piping Subject to Abuse as Indicated on Drawings	Unless otherwise indicated, provide protective insulation shield (Type A-1 jacket) in addition to pipe insulation and jacket specified in this schedule. Provide Type H insulation for hot piping and Type P insulation for cold piping with V-1 jacket in lieu of specified insulation/jacket with same insulation thickness.

	Ductwork/Equipment System		
Service	Jacket Type	Insulation Type	Insulation Thickness
OA Ducts Exposed	D-1 or D-2	R	2"
OA Ducts Concealed	D-2	R	2"
Supply Ducts Exposed	D-1	R	1-1/2"
Supply Ducts Concealed	D-2	F	2"
Exhaust or Relief Ducts from Control or BD Damper to Outside Wall or Roof	D-1	R	1-1/2"
Return and Relief Ducts in Equipment Rooms	D-1	R	1-1/2"
Return Ducts in **XXX**	D-2	F	2"
Supply Ducts Exterior	D-3	RR	2"
Return Ducts Exterior	D-3	RR	2"
Ductwork Covered with 2 h Rated Wrap	---	FR	(Refer to Part 2)
Engine Generator Set Exhaust Pipe (up to 1200°F)	A-1	H	4"
Engine Generator Set Muffler (up to 1200°F)	A-1	H	4"

3.2 INSTALLATION - GENERAL

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

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

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

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

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

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

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

H. Where multiple layers of insulation are used, stagger and secure each layer with metal bands.
I. Where penetrations occur through fire-rated walls, partitions, or floors, provide fire seal as specified in Section 20 0000 - General Mechanical Requirements and Section 20 0573 - Mechanical Systems Firestopping.
J. Insulate the following systems for complete vapor barrier protection:
   1. Refrigerant
   2. Cooling coil condensate drain
   3. Storm
   4. Clearwater Waste
   5. Cold Water
   6. All insulated ductwork
   7. All equipment with surface temperature below 65°F
K. Apply Type A insulation for insulation and jackets requiring vapor barrier protection where specified insulations are cut for mounting sensors, control devices, parts of valves, devices or components which extend out from specified insulation to prevent condensation.

3.3 GLASS FIBER FABRIC COVERING (TYPE E-1 JACKET)

A. Glass fiber fabric shall be fitted without wrinkles.
B. Glass fiber fabric shall be sized immediately upon application with lagging adhesive and shall be capable of drying within 6 h.
C. Apply adhesive and coating in accordance with manufacturer's recommendations.
D. All seams shall overlap not less than 2".

3.4 PIPING, VALVE AND FITTING INSULATION

A. Apply insulation to pipe, unions, flanges, fittings, valves and piping specialties with butt joints and longitudinal seams closed tightly. Valve insulation shall cover entire valve body including bonnets and packing nuts.
B. Laps on factory-applied jackets shall be 2" minimum width firmly cemented with lap adhesive, or shall be pressure sealing type lap.
C. Cover joints with factory furnished tape (3" minimum width) to match jacket. Cement firmly with lap adhesive. On systems requiring a vapor barrier (ASJ), vaporseal all longitudinal and butt joints ASJ/Saran seams with 4” wide coat of vapor barrier mastic.
D. Where staples are used, they shall be on 6" maximum centers. When used for systems requiring vapor barrier, cover lap and staples with finish coat of vapor barrier mastic.
E. 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.
F. Stove pipe style insulation on elbows (Detail A on Plate 2-200 of MICA 8th Edition) is not allowed. It may be used for closed cell elastomeric insulation.
G. Where terminations of pipe insulation are required, insulation shall have tapered ends, built up and finished as specified for fittings.
H. For pipes 1-1/2" and smaller, install specified pipe insulation and jacket continuous through hanger or support locations. Install insulation protection shields to protect insulation from compressing.
I. 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.
J. For pre-insulated pipe supports and insulation protection shields, refer to Section 20 0529 - Piping and Equipment Supporting Devices.
K. For Contractor-fabricated anchors, secure insulation directly to pipe surface and extend insulation up anchor for distance of 4 times insulation thickness. For pre-insulated anchors, cover entire surface of anchors with Type A insulation. Where applicable, take special care to assure vapor seal at anchor.
L. Piping, fittings and valves not to be insulated:
   1. Valves furnished with removable insulation/jacket

3.5 EQUIPMENT INSULATION

A. For equipment requiring Type H insulation such as breechings, stacks, exhaust pipes and mufflers, apply insulation to equipment and secure with stainless steel bands with tightly butted joints as recommended by

manufacturer. Where multiple layers of insulation are required, stagger and secure each layer with stainless steel bands.

B. Provide removable insulating blankets on expansion joints.

C. Do not insulate over equipment nameplates or ASME stamps. Bevel and seal insulation at these locations.

D. Equipment not to be insulated:

1. Equipment furnished with factory insulation.

3.6 DUCTWORK AND COMPONENTS

A. Apply duct insulation evenly over duct surface. Unless otherwise indicated, insulation and jacket shall run continuously between duct and duct supports. Maintain insulation thickness specified over duct reinforcing members.

B. For support points of rectangular or oval ducts supported by trapeze hangers, place weight-supporting insulation at bottom of duct over trapeze. Weight supporting insulation inserts shall be minimum 6" long with same thickness as insulation specified and shall be Type G, H or P insulation. Size inserts based on compression strength and weight being supported.

C. Flexible glass fiber insulation (Type F) may be installed outside of support for rectangular or oval ducts having width 60" or smaller and supported with strap hangers, provided that vapor barrier integrity is maintained at strap penetration.

D. For support points of round ducts smaller than 16" diameter, weight-supporting insulation is not required for either rigid or flexible glass fiber insulation.

E. For support points of round ducts 16" diameter and larger, place weight-supporting insulation between duct and strap or trapeze. Weight-supporting insulation shall be minimum 6" long with same thickness as insulation specified and shall be Type G, H or P insulation. Size inserts based on compression strength and weight being supported.

F. Flexible glass fiber insulation (Type F) may be installed outside of support for round ducts 24" diameter or smaller, provided that vapor barrier integrity is maintained at rod penetration.

G. Securing glass fiber insulation (Type F, R, and RR) for rectangular or oval ductwork.

1. Horizontal ductwork:
    a. Secure to bottom of duct where duct width is 24" diameter or greater.
    b. Secure to sides of duct where duct side is 24" diameter or greater.
2. Vertical ductwork:
    a. Secure to all sides where duct width is 18" diameter or greater.
3. Install fasteners as required to secure, but not over 18" on center and within 3" of butt joint or edge.
4. Fastener shall be weld pin mechanical type.

H. Fastening insulation anchors to ductwork with adhesives is not allowed. Where weld pin fasteners are used, install them without damage to interior galvanized surface. Where weld pin fasteners cannot be used, use other type of fasteners such as metal bands.

I. 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.

J. Provide insulation over supply air diffusers, grilles and unlined boots after termination point of flexible ducts or rigid duct insulation to prevent from sweating.

K. Where vapor barrier jackets are specified, pins and staples if used shall be jacketed over with matching material using 4" tape. Where staples are used for systems requiring vapor barrier, cover lap and staples with finish coat of vapor barrier mastic. Vaporseal insulation seams, punctures, and tears with two 4” wide coats of vapor barrier mastic.

L. 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.

M. 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 breather mastic with glass fiber reinforcing fabric after application of insulation cement. Apply coating in accordance with manufacturer's recommended procedure.

N. D-1 jackets:

1. Butt together joints and seams firmly, cover with glass fiber fabric 4" minimum width.

O. D-2 jackets:

1. Butt together joints and seams firmly and cover with 4" wide FSK tape.

P. D-3 jackets:

1. Install jacket in strict accordance with manufacturer's installation requirements.
2. For rectangular ducts, overlap bottom half jacket and top half jacket at each side of duct at least 4" (bottom inside top outside at overlap).

3. For round ducts, wrap duct insulation continuously with spiral shaped overlapping. Overlap at least 4".
4. Use welded stickpins for Type D-3 jacketing wider than 24" in width alongside and bottom surfaces of ducts. Retainers of stick pins shall be covered with Type D-3 patch, minimum 4" square, once retainer cup is in place on stick pin.

Q. Acoustical Barrier Materials:
1. Provide 2" thick Type R insulation with Type D-1 jacket as inner layer. Over insulation install acoustical barrier materials as outer layer in accordance with manufacturer's installation instruction.
2. For ductwork specified with Type F insulation, replace it with insulation specified above.
3. Refer to plans for ductwork requiring acoustical barrier materials.

R. Ductwork not to be insulated:
1. Internally lined ductwork
2. Ductwork components with factory installed insulation
3. Exposed supply and exhaust ductwork in parking ramp.

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

A. Unless otherwise indicated, install shields (A-1 jacket) around insulated pipe and fittings exterior to building. Seal water and vapor tight at terminations.

B. Longitudinal overlap shall be at least 2" wide with vapor barrier sealant.

C. Secure jacketing with 3/4" wide 0.015" stainless steel or 3/4" wide 0.020" aluminum bands and wing seals on maximum 18" centers.

3.8 TYPE FR INSULATION (FIRE RESISTIVE DUCT WRAP)

A. Install Fire Resistive Duct Wrap system in accordance with manufacturer's instructions and referenced Standards.

B. Where duct is specified to have Type FR wrap, and other insulation is indicated in Ductwork/Equipment System Schedule in this Section, other insulation does not need to be provided in addition to Type FR wrap.

3.9 TYPE G INSULATION (CELLULAR GLASS)

A. Install cellular glass insulation system in strict accordance with manufacturer's installation instructions.

3.10 TYPE P INSULATION (POLYISOCYANURATE)

A. Install Type P insulation with specified insulation jacket in accordance with manufacturer's installation recommendations. Insulation shall be tightly butted and free of voids and gaps at joints. Use 3" wide tape at butt joints with minimum 1.25 times circumference wrapping. Apply insulation joint sealant in longitudinal and butt joints.

B. Install pre-fabricated tight fitting insulation pieces on fittings, elbows, tees and valves.

C. Insulation at fittings and valves shall be the same thickness as on pipe section.

D. Replace Type P insulation and jacket with Type R insulation of same thickness with Type P-1 jacket at penetration of fire rated walls and floor slabs where fire stopping system is required.

END OF SECTION

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SECTION 21 00 00

GENERAL FIRE SUPPRESSION REQUIREMENTS

PART 1 – GENERAL
1.1 DESCRIPTION
1.2 RELATED WORK
PART 2 – PRODUCTS (NOT USED)
PART 3 – EXECUTION (NOT USED)

PART 1 - GENERAL

1.1 DESCRIPTION

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

1.2 RELATED WORK

A. Section 20 0000 – General Mechanical Requirements
B. Section 20 0513 – Motors
C. Section 20 0520 – Excavation and Backfill
D. Section 20 0529 – Mechanical Supporting Devices
E. Section 20 0553 – Mechanical Systems Identification
F. Section 20 0573 – Mechanical Systems Firestopping
G. Section 20 0700 – Mechanical Systems Insulation
H. Section 21 0533 – Electrical Heat Tracing (Fire Protection Systems)
I. Section 21 1314 – Automatic Fire Sprinkler System
J. Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables
K. Section 26 0529 – Hangers and Supports for Electrical Systems
L. Section 26 0533 – Raceway and Boxes for Electrical Systems
M. Section 26 0553 – Electrical Systems Identification
N. Section 26 0593 – Electrical Systems Firestopping
O. Section 26 2913 – Enclosed Controllers
P. Section 28 3116 – Multiplexed Fire Detection and Alarm Systems

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

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SECTION 21 05 33
ELECTRICAL HEAT TRACING FOR FIRE PROTECTION

PART 1 – GENERAL
1.1 DESCRIPTION
1.2 RELATED WORK
1.3 REFERENCE
1.4 QUALITY ASSURANCE
1.5 DELIVERY, STORAGE, AND HANDLING
1.6 SUBMITTALS
PART 2 – PRODUCTS
2.1 MATERIALS
2.2 TEMPERATURE MAINTENANCE HEATERS
PART 3 – EXECUTION
3.1 INSTALLATION
3.2 INSPECTION
3.3 TESTING

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies materials and installation methods necessary for permanent electrical heat tracing system which will protect fire protection pipe that feeds wet pipe sprinkler systems.

B. Fire Protection Contractor shall provide complete Listed system of heaters and components. System shall be Listed by a nationally recognized testing laboratory for fire protection pipe heat tracing.

C. System shall be monitored by building's fire alarm panel.

D. Self-regulating heat tracing system shall maintain a temperature of at least 40°F and shall not exceed 120°F.

E. Heat trace origin shall begin at the heated enclosure and extend along fire protection pipe that provides water to wet pipe sprinkler systems identified on engineering drawings.

F. Refer to fire protection drawings for additional information.

1.2 RELATED WORK

A. Section 20 0000 – General Mechanical Requirements
B. Section 20 0529 – Mechanical Supporting Devices
C. Section 20 0553 – Mechanical Systems Identification
D. Section 20 0573 – Mechanical Systems Firestopping
E. Section 20 0700 – Mechanical Systems Insulation
F. Section 21 0000 – General Fire Suppression Requirements
G. Section 21 1314 – Automatic Fire Sprinkler System
H. Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables
I. Section 26 0529 – Hangers and Supports for Electrical Systems
J. Section 26 0533 – Raceway and Boxes for Electrical Systems
K. Section 26 0553 – Electrical Systems Identification
L. Section 26 0593 – Electrical Systems Firestopping
M. Section 28 3116 – Multiplexed Fire Detection and Alarm Systems

1.3 REFERENCE

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

1.4 QUALITY ASSURANCE

A. Applicable Codes, Guidelines and Standards:
   1. This installation shall conform to the following:
      a. NFPA 13, Installation of Sprinkler Systems, 2016 Edition
      b. NFPA 14, Installation of Standpipe and Hose Systems, 2016 Edition
      c. NFPA 70, National Electrical Code, 2011 Edition
      d. NFPA 72, National Fire Alarm and Signaling Code, 2016 Edition
      e. International Building Code (IBC), 2009 Edition
      f. International Fire Code (IFC), 2009 Edition

g. Local and State Building, Mechanical, and Fire Codes
h. Underwriters Laboratories (UL) Fire Protection Equipment Directory
i. Factory Mutual Research Corporation (FMRC) Approval Guide

B. Heat trace system shall conform to ANSI/IEEE Standard 515.1, 2005 Edition.
C. Manufacturer's Quality Assurance program shall be certified by ISO 9000 Standard.

1.5 DELIVERY, STORAGE AND HANDLING

A. Promptly inspect shipments to insure material is undamaged and complies with Specifications.
B. Protect heat trace system from damage.
C. Place accessory kits in individual plastic bags to prevent loss of components.
D. Storage and protection methods must allow inspection to verify products.

1.6 SUBMITTALS

A. Fire Protection Contractor shall be responsible for all submittals.
B. Submit manufacturer's technical data and installation instructions for following:
1. Heat trace cable, voltage, phase, and temperature
2. Heat output chart for each pipe size
3. Circuit isometric riser diagram
4. Circuit schedule with circuit length, breaker panel number, breaker number, and amperage.
5. Contractor certification from heat trace manufacturer.
6. Only licensed fire protection contractors or licensed electricians, who are under direction of manufacturer's representative, are permitted to install and work on heat trace system.
a. Submit document signed by manufacturer's representative indicating that:
1) instruction has been given,
2) proficiency has been demonstrated and,
3) identify those individuals or organizations that are permitted to install heat trace system on fire protection supply pipe.
7. Submit written warranty statement.
C. Submit shop drawings and product data sheets on items specified herein prior to installation. Submit to:
1. Engineer
2. Authority Having Jurisdiction (AHJ)
D. At completion of installation and tests, submit one copy of test reports (e.g. megger readings) and "as built" drawings to:
1. Engineer
2. Owner's representative

PART 2 - PRODUCTS

2.1 MATERIALS

A. Items shall be new and shall be Listed by a nationally recognized testing laboratory for use with automatic fire sprinkler systems.

2.2 TEMPERATURE MAINTENANCE HEATERS

A. Heat Tracing:
1. Heat cable shall consist of two parallel 16 AWG nickel-plated copper wires in a cross-linked polymer core, capable of varying its heat output along its entire length. Cable shall be covered by a modified polyolefin outer jacket, and protected by tinned-copper braid.
2. Heater cable shall operate at 110-120 VAC, single phase without use of transformers.
3. Heat cable cover shall be permanently marked with manufacturer's batch or serial number. Cable jackets shall be continuously marked with manufacturer's name, catalog number, nominal supply voltage and nominal power output in watts per foot in an equally permanent fashion. Use of temporary printing or tags is not allowed.
4. Basis of Design: 6” diameter, nominal pipe size (NPS), metallic fire protection pipe utilizing Raychem Model 8XL1-CR heating cable with 2” of fiberglass thermal insulation using -40°F as anticipated low ambient temperature.
5. Raychem XL-Trace Model C910-485 or equal, power distribution and monitoring panel with thermostat shall be part of heat trace system.
6. When requested, test certificates shall be available from manufacturer to indicate cable type, cable rating in watts/ft., voltage rating, test date, batch number, reel number, length of cable, test voltage and test amperage reading.

B. Accessories:
   1. Include necessary accessories as needed to ensure that complete and fully operational heat trace system is provided. Accessories shall include: power connection kits, tee kits, lighted end seal kits, splice kits, polyester fiber attachment tape, caution labels and transformers.
   2. Accessories shall be by same manufacturer as heat cable.
   3. Include UL Listed fiberglass or closed cell flame-retardant insulation as part of the heat trace system.
   4. Circuit breakers, conduit, power wiring, junction boxes, and other main electrical power accessories shall be provided by Division 26 and Division 28 contractors.
   5. Circuit breakers, supplying power to heat tracing system shall be equipped with 30 mA ground-fault equipment protection. Do not provide a 5mA Ground Fault Interrupter (GFI) since nuisance tripping may result.

C. Manufacturer:
   1. Manufacturer: Raychem or equal
   2. Heat trace cable shall be XL-Trace self-regulating type as manufactured by Raychem or equal, rated to provide 40°F when supplied with 110-120 VAC single-phase power.
   3. Identify cable model, manufacturer and operating temperature, and necessary supply voltage.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install system per manufacturer's installation instructions and Listing.

B. Coordinate installation with Division 26 and Division 28 contractors.

C. Attach heat trace cable to clean, dry pipe with manufacturer approved glass cloth adhesive tape. Secure heat trace cable at 12” intervals as stated in manufacturer's installation instructions. Basis of design: Raychem GT-66 attachment tape or equal.

D. Refer to manufacturer's isometric drawings, which are part of material package for heater locations, heater layout, location of power points, and load chart. Fire Protection Contractor shall obtain these isometrics and submit to Engineer for review and approval prior to installation of heating cable.

E. Attach heat cable per manufacturer's installation instructions to effectively distribute heat along pipe and develop designated temperature. Consult manufacturer's data for sizing and spacing of heat cable strip.

F. Attach electric heat tracing labels to insulation vapor barrier at 10 ft. intervals. Basis of design: Raychem Model ETL caution labels or equal.

G. Install heat cable and appropriate accessories and controls in conformance with applicable sections of Division 26 Specifications and manufacturer's installation instructions.

H. Power wiring, connections, breakers, conduit, and other electrical accessories necessary for heat cable power will be provided by Division 26 and Division 28 contractor. Coordinate with Division 26 and Division 28 contractors.

I. Protect heat trace cable circuits with monitored GFI system installed per manufacturer's installation instructions. Basis of design: Raychem Model C910-485 Controller.

J. Coordinate system's auxiliary contact installation with Division 26 and Division 28 contractors as needed.

3.2 INSPECTION

A. Inspect heat cable installation with manufacturer's representative and electrical inspector prior to insulating piping.

B. Manufacturer's representative shall certify that heat cable is installed per manufacturer's installation instructions and successfully tested. Refer to testing section for additional information.

C. Documentation shall be included in Operation and Maintenance manuals.

3.3 TESTING

A. Electrician shall measure insulation resistance of heat trace cable with 2500 volt DC (VDC) megohmeter (megger):
   1. Prior to installation while cable is still on reel(s).
   2. After installation of heating cable and completion of circuit fabrication kits (including any splice kits) and before thermal insulation has been installed.
   3. After installation of thermal insulation but prior to connection of power.

B. Insulation resistance, measured between braid and either bus wire, should be at least 20 megohms regardless of heat cable length. Record these readings for each circuit.

C. Contractor shall test continuity of both heater bus wires to verify connection of splices or tees.

D. If heat cable circuit fails either insulation resistance test or continuity test, electrician shall notify Fire Protection Contractor. Fire Protection Contractor must repair or replace circuits yielding unacceptable readings.

E. Megger tests may need to be witnessed by Owner's representative and manufacturer's representative. Notify Owner's representative, manufacturer's representative, and Engineer at least 3 days in advance to allow for participation.

END OF SECTION

SECTION 21 13 14

AUTOMATIC FIRE SPRINKLER SYSTEM

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2.3 VALVES
2.4 DRY PIPE VALVE
2.5 TAMPER SWITCH
2.6 FLOW SWITCH
2.7 WATERFLOW ALARM PRESSURE SWITCH
2.8 HIGH/LOW SUPERVISORY PRESSURE SWITCH
2.9 NITROGEN GENERATION SYSTEM
2.10 SPRINKLER HEAD
2.11 FIRE VALVE CABINETS (FVC)
2.12 FIRE DEPARTMENT CONNECTION (FDC)
2.13 ROOF MANIFOLD
2.14 BALL DRIP
2.15 FIRE PUMP (FP)
2.16 CONTROL EQUIPMENT FOR ELECTRIC DRIVE
2.17 JOCKEY PUMP (JP)
2.18 JOCKEY PUMP CONTROLLER
2.19 HANGERS
2.20 PRESSURE GAUGES
2.21 DIELECTRIC FITTINGS
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3.1 DESIGN CRITERIA
3.2 INSPECTION
3.3 INSTALLATION
3.4 FIRE PUMP INSTALLATION
3.5 CLEANING
3.6 TESTING
3.7 FIRE PUMP TESTING

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies materials, methods, and equipment to be used for automatic sprinkler system, standpipe system, fire pump system, and related fire protection piping to 5 ft. outside building.

B. Research indicates there is no documentation or indication that microbiologically influenced corrosion (MIC) exists in the area of the project.

C. NFPA 13's seismic requirements are not part of this project.

D. This is not a Factory Mutual Global (FMG) protected property.

E. As shown on drawings, systems shall consist of:

1. Eleven (11) automatic fire sprinkler zones which consist of:
   a. One (1) wet sprinkler zones
   b. Ten (10) dry sprinkler zones

F. Each wet pipe zone shall begin with:

1. Indicating-type floor control valve with supervisory switch
2. Check valve (required on combined standpipes)
3. Pressure gauge
4. Waterflow switch
5. Inspector's test and drain assembly with integral pressure relief valve

G. Engineer of Record:
1. Contractor shall be Engineer of Record. Contractor shall produce stamped and sealed installation drawings, which are also referred to as shop drawings in this Section, based on design criteria listed in this Section and drawings furnished by Engineer. Contract drawings show zone and main piping layouts of fire protection systems as it relates to architecture, structure, and mechanical/electrical systems.

H. All work shall be installed in conformance with the governing codes, regulations, local ordinances, and requirements of Authorities Having Jurisdiction. It shall be the responsibility of the Fire Protection Contractor to familiarize themselves with all governing codes and requirements and report any noncompliance of the plans or specifications to the Construction Manager/Engineer, prior to entering into the contract. These requirements are minimum criteria and no reductions permitted by Code shall be allowed without written permission of the Engineer.

I. No additional compensation shall be granted for work which must be changed as a result of the work not originally complying with codes and standards or not in accordance with the multiple trade coordination design criteria set forth in the contract documents.

J. If code or other requirements exceed provisions indicated in the Contract Documents, the Construction Manager/Engineer shall be notified in writing. Where the work indicated on the Contract Documents exceeds code requirements, the installation shall be done in accordance with the Contract Documents. Any work done contrary to these requirements shall be removed and replaced at the expense of the responsible Contractor.

K. Fire Protection Contractor shall become familiar with all details of the work, verify dimensions in the field, and advise the Construction Manager/Engineer of any discrepancy prior to entering into the contract.

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

1.2 RELATED WORK

A. Section 20 0000 – General Mechanical Requirements
B. Section 20 0513 – Motors
C. Section 20 0520 – Excavation and Backfill
D. Section 20 0529 – Mechanical Supporting Devices
E. Section 20 0553 – Mechanical Systems Identification
F. Section 20 0573 – Mechanical Systems Firestopping
G. Section 21 0000 – General Fire Suppression Requirements
H. Section 21 0533 – Electrical Heat Tracing (Fire Protection Systems)
I. Section 26 0593 – Electrical Systems Firestopping
J. Section 26 2913 – Enclosed Controllers
K. Section 28 3116 – Multiplexed Fire Detection and Alarm Systems

1.3 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.

1.4 QUALITY ASSURANCE

A. Codes and Standards:
1. This installation shall conform to the following:
a. NFPA 13, Installation of Sprinkler Systems, 2016 Edition
b. NFPA 14, Installation of Standpipe and Hose Systems, 2016 Edition
c. NFPA 20, Installation of Stationary Pumps for Fire Protection, 2016 Edition
d. NFPA 24, Installation of Private Fire Service Mains and Their Appurtenances, 2016 Edition
e. NFPA 25, Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems, 2014 Edition
f. NFPA 37, Installation and Use of Stationary Combustion Engines and Gas Turbines, 2015 Edition
g. NFPA 70, National Electrical Code, 2011 Edition
h. NFPA 72, National Fire Alarm and Signaling Code, 2016 Edition
i. International Building Code (IBC), 2009 Edition
j. International Fire Code (IFC), 2009 Edition
k. Local and State Building, Mechanical, and Fire Codes
l. Underwriters Laboratories (UL) Fire Protection Equipment Directory
m. Factory Mutual Research Corporation (FMRC) Approval Guide

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

C. Electrical Coordination
   1. All relays, wire, conduit, pushbuttons, pilot lights, and other devices required for power side or the control of electrical equipment shall be furnished by Division 26 and Division 28 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, sprinkler 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 sprinkler 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 sprinkler contractor which have been indicated to be wired by Division 26 and Division 28 contractors.

1.5 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 clean, dry space.
D. Promptly inspect shipments to insure 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.

1.6 SUBMITTALS

A. Shop Drawings on Items Specified:
   1. Pipe, Fittings, and Joints
   2. Valves
   3. Tamper Switches
   4. Flow Switches
   5. Pressure Switches
   6. Sprinkler Heads
   7. Sprinkler Head Cabinet
   8. Dry Pipe Valve and Accessories
   9. Nitrogen Generation System and Accessories
   10. Hanger Assemblies
   11. Pressure Gauges
   12. Fire Department Connection (FDC)
   13. Double Check Backflow Prevention Assembly (DCBP)
   14. Fire Department Valves (FDV)
   15. Fire Pump and Accessories
   16. Fire Pump Test Connection
   17. Fire Pump Controller with Automatic Transfer Switch
   18. Jockey Pump and Accessories
   19. Jockey Pump Controller

20. Drawings
21. Hydraulic Calculations

B. Submit fire pump certified shop test curves showing pressure rating and rated horsepower to Engineer.
C. Submit Material Safety Data Sheet (MSDS) for corrosion inhibitive paint.
D. Include items listed in product section and additional items required to provide complete installation.
E. Indicate by red marking or arrow, items that are to be provided, where more than 1 item appears on manufacturer's catalog sheet.
F. Submit stamped and sealed drawings, product datasheets, hydraulic calculations, and a signed copy of the Owner's certificate to City of Madison Fire Department, Engineer, and State of Wisconsin Department of Safety and Professional Services (DSPS) prior to installation or fabrication of system components.
G. Include copies of City of Madison Fire Department and State of Wisconsin Department of Safety and Professional Services (DSPS) plan review letters in submission to Engineer.
H. Review of submittals does not relieve Contractor from coordinating installation of work with other trades, or from compliance with Codes and Standards.
I. At completion of acceptance tests:
   1. Send copy of test log to Engineer
   2. Send copy of Contractor's Material and Test Certificates and fire pump test results to:
      a. Engineer
      b. Owner
      c. Authority Having Jurisdiction
   3. Provide Owner with following:
      a. Manufacturer's literature and instructions describing operation and maintenance of equipment and devices installed.
      b. Typewritten chart with identification and location of all access panels serving equipment and valves. Incorporate into Operation & Maintenance (O&M) manual.
      c. Typewritten valve schedule indicating valve number, fixture/equipment or areas served by each numbered valve. Incorporate into O&M manual.
      d. For additional O&M manual requirements, refer to Section 20 0000 – General Mechanical Requirements.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials and Equipment:
   1. Materials and equipment in system shall be new and current products of manufacturer regularly engaged in production of such materials and equipment.
   2. Where 2 or more pieces of equipment are required to perform interrelated functions, they shall be products of same manufacturer.
   3. Clean and cap pipe after fabrication and prior to placing pipe in building.
   4. Mark pipe with tags that can be removed during installation so no permanent markings remain on pipe.
B. Approval Guides:
   1. Unless otherwise shown, 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.

2.2 PIPE

A. Below Ground:
   1. Pipe: Ductile iron, Class 52, American Water Works Association (AWWA) C151, 150 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, cement mortar lined, Class 250, AWWA C110
   3. Encasement: Polyethylene encasement, 8 millimeters 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, A53, or A135
      b. Fittings:
         1) Malleable iron, threaded, Class 125, 175 psi Cold Water Pressure (CWP) rating, ANSI 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, ASTM 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. Galvanized Steel, 2” and smaller:
a. Pipe: Galvanized steel pipe, Schedule 40, ASTM A795, ASTM A53, or A135
b. Fittings:
1) Malleable iron, threaded, galvanized coating, Class 125, ANSI B16.3
2) Forged steel, threaded, galvanized coating, ANSI 16.11
3) Ductile iron or malleable iron, cut grooved for mechanical coupling, 175 psi CWP rating, malleable iron conforming to ASTM A47, hot dipped galvanized to ASTM A153 or zinc electroplating to ASTM B633
   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) Tapered pipe threads, ANSI B1.20.1
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.

4. Galvanized Steel, larger than 2":
   a. Pipe: Galvanized steel pipe, Schedule 40, ASTM A795, ASTM A53, or A135
   b. Fittings:
      1) Cast iron, threaded, galvanized coating, Class 125, ANSI B16.4
      2) Forged steel, threaded, galvanized coating, ANSI 16.11
      3) Ductile iron or malleable iron, cut grooved for mechanical coupling, 175 psi CWP rating, malleable iron conforming to ASTM A47, hot dipped galvanized to ASTM A153 or zinc electroplating to ASTM B633
         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) Tapered pipe threads, ANSI B1.20.1
      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.
         f) Type 316 stainless steel, ASTM A351, equal to Victaulic Style 489
5. Chlorinated Polyvinyl Chloride (CPVC):
   a. Pipe: CPVC fire sprinkler pipe:
      1) Shall not be used on the project.
6. 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) Straight Hose Assembly Lengths: 2 ft. length, Model #2024; 3 ft. length, Model #2036; 4 ft. length, Model #2048; 5 ft. length, Model #2060; 6 ft. length, Model #2072
      4) Elbow Hose Assembly lengths: 2 ft. length, Model 2024E; 3 ft. length, Model #2036E; 4 ft. length, Model #2048E; 5 ft. length, Model #2060E; 6 ft. length, Model #2072E
   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
7. Provide metal pipe's exposed threads with corrosion inhibitive paint, equal to Rust-Oleum.
8. 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.
9. Plain end couplings (Roust-A-Bouts, Plainloks or similar couplings) are not allowed on either new or existing sprinkler systems.
10. Adjustable drop nipples are not allowed on either new or existing sprinkler systems.
11. Expansion joints:
    a. Provide AnvilStar Tri-Flex Loop, MetraFlex FireLoop, or swing joints with flexible grooved couplings, pipe nipples, and grooved elbows installed per manufacturer's installation instructions.
    b. Refer to structural drawings for location of expansion joints.

c. Provide high pressure expansion joints and mechanical couplings where pressures exceed 175 psi water working pressure.

12. 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.

2.3 VALVES

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

B. Check Valve:
1. Acceptable manufacturers: Reliable, Tyco Fire Products, Victaulic, Viking, or equal.
2. Iron body, bronze seat, stainless steel clapper with a replaceable rubber seal, Tyco Fire Products CV-1F, Viking Model G-1, or equal.
3. Provide high pressure valves and fittings when pressures exceed 175 psi water working pressure.

C. 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 78FP or equal.
3. Provide high pressure valves and fittings where pressures exceed 175 psi water working pressure.

D. Ball Valve:
1. Acceptable manufacturers: Milwaukee Valve Co., Mueller, Nibco, Stockham, Victaulic, or equal.
2. Provide high pressure valves and fittings when pressures exceed 175 psi water working pressure.

E. Butterfly Valve:
1. Acceptable manufacturers: Kennedy, Milwaukee Valve Co., Mueller, Nibco, Stockham, Tyco Fire Products, Victaulic, or equal.
2. Milwaukee Valve Co. Series BB for valve sizes 1” to 2-1/2” or equal.
3. 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.
4. Provide high pressure valves and fittings when pressures exceed 175 psi water working pressure.

F. 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 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 C510-97.
5. Double check valve shall be selected based on minimal pressure drop to allow maximum available pressure to sprinkler system.
6. Provide high pressure DCBP assembly and fittings when pressures exceed 175 psi.

G. Test and Drain Valves:
1. Acceptable manufacturers: AGF, Victaulic, or equal.
2. AGF TESTanDRAIN, Victaulic Style 720 TestMaster II, or equal.
3. Test and drain valve shall include integral pressure relief valve. Pressure relief valve shall be set to operate at 175 psi or 10 psi in excess of the maximum system pressure, whichever is greater.
4. Provide high pressure valves and fittings where pressures exceed 175 psi water working pressure.

H. Drain Valves:
1. Acceptable manufacturers: Kennedy, Nibco, or equal.
2. Thread-in bonnet bronze globe valves, rated to 175 psi non-shock water working pressure, Nibco KT-65 Series for valve sizes 1/2” to 1”, KT-211 Series 1-1/4” to 2”, or equal.
3. Provide high pressure valves and fittings when pressures exceed 175 psi water working pressure.

I. Pressure Regulating Valves:
1. Acceptable manufacturers: Croker, Elkhart Brass, Potter-Roemer, or equal.
2. Valve shall be able to regulate inlet pressure up to 400 psi, brass body with brass and stainless steel internal parts, field adjustable indicating scale, non-rising stem, red handwheel, tamper-proof monitor switch adapter, Potter-Roemer Model 4036-MSA or equal for in-line applications and Model 4021-MSA or equal for end-of-line applications.

J. Fire Department Valve (FDV):
1. Acceptable manufacturers: Croker, Elkhart Brass, Potter-Roemer, or equal.

2. Fire Department valve shall be 2½" angle valve, cast brass body, polished chrome plated finish, equal to Potter-Roemer Model 4065. Valve cap for 2½" valve shall be 2½" cap with chain, Potter-Roemer Model 4625 or equal. Cap and chain finish shall match finish of valve body. Threads shall match Fire Department Standards.

K. Fire Department Valve (FDV - Pressure Regulating type)
1. Acceptable manufacturers: Croker, Elkhart Brass, Potter-Roemer, or equal.
2. Fire Department valve shall be 2½" angle valve, able to regulate inlet pressure up to 400 psi, cast brass body with brass and stainless steel internal parts, indicating scale, non-rising stem, red handwheel, tamper-proof monitor switch adapter. Finish shall be polished chrome plated. Valve shall be equal to Potter-Roemer Model 4023 for end-of-line applications. Valve cap for 2½" valve shall be 2½" cap with chain, Potter-Roemer Model 4625 or equal. Cap and chain shall match finish of valve body. Threads shall match Fire Department Standards.

L. Riser Manifold:
1. Acceptable manufacturers: Tyco Fire Products, Victaulic, Viking, or equal.
2. Ductile iron or fabricated steel pipe body; threaded or grooved connections; rated to 175 psi non-shock water working pressure; includes test and drain valve with integral pressure relief valve kit, flow switch with optional cover tamper kit, and pressure gauge; Tyco Fire Products Model 513 or equal.
3. Provide high pressure valves and fittings when pressures exceed 175 psi water working pressure.

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

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

O. Valves in galvanized piping shall be bronze.

2.4 DRY PIPE VALVE

A. Acceptable manufacturers: Reliable, Tyco Fire Products, Victaulic, Viking, or equal.

B. Dry pipe valve shall assembly shall include accelerator.

C. Include standard trimmings, such as gauges, drain valve, test valve, compressed gas connection and maintenance device, and low/high supervisory pressure switch.

D. Provide nitrogen generation system for supervisory gas source.

2.5 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 with 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 with optional cover tamper kit. For areas identified as hazardous locations, provide "EX" Model. Potter Electric Signal Co. PIBV series or equal.

D. Ball valve supervisory switch, NEMA 4 rated enclosure, provided with SPDT (Form C) contacts rated at 2 Amps at 30 VDC and 10 Amps at 125/250 VAC. Provide without optional cover tamper kit. Potter Electric Signal Co. RBVS series or equal.

E. 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.

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

2.6 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 with optional cover tamper kit. Potter Electric Signal Co. VS series or equal.

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

2.7 WATERFLOW ALARM PRESSURE SWITCH

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

B. Pressure actuated switch for use in dry sprinkler systems, 300 psi service pressure rating, adjustable between 4-15 psi, 2 sets of SPDT (Form C) contacts rated at 2 Amps at 30 VDC and 10.1 Amps at 125/250 VAC. Provide with optional cover tamper kit. Potter Electric Signal Co. PS series or equal.

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

2.8 HIGH/LOW SUPERVISORY PRESSURE SWITCH

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

B. Pressure actuated switch to detect a decrease from normal system pressure in dry sprinkler systems, 300 psi service pressure rating, set to operate at a pressure decrease of 10 psi at 30 psi, 2 sets of SPDT (Form C) contacts rated at 2 Amps at 30 VDC and 10.1 Amps at 125/250 VAC. Provide with optional cover tamper kit. Potter Electric Signal Co. PS series or equal.

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

2.9 NITROGEN GENERATION SYSTEM

A. Acceptable manufacturers: Engineered Corrosion Solutions, Potter Corrosion Solutions, South-Tek Systems, or equal.

B. Nitrogen generation system:

1. System shall be designed to achieve a nitrogen concentration of 98% or greater in the supplied piping system within 14 days of start-up and maintain that concentration continuously.
2. System shall be skid mounted and include an oil-less air compressor that is sized appropriately for the application and capable of achieving system air pressure within 30 minutes in accordance with NFPA 13 requirements.
3. System shall have a dedicated un-switched power source that is sized as directed by the product manufacturer.
4. Include an automatic drain valve capable or removing all liquid moisture from the air storage tank that is piped to drain.
5. Air maintenance device:
   a. System shall include a dedicated air maintenance device for each system supplied by the nitrogen generation system.
6. Basis of Design: Engineered Corrosion Solutions Pre-Engineered Nitrogen Generator PGEN-10 or PGEN-20.

C. Nitrogen system purge valve and gas analyzer.

1. System shall include a dedicated automatic purge valve for each system supplied by the nitrogen generation system.
2. Purge valve shall include a sensor to sample the exiting gas and automatically shut off the purge valve to prevent continuous venting after a minimum 98% nitrogen concentration has been achieved.
3. The purge valve shall include an alarm relay (Form C dry contacts) to indicate a trouble condition on the Building Management System (BMS) if nitrogen purity drops below 97%.
4. Valve assembly shall include an isolation ball valve, Y-type strainer, and FM Approved float-type purge valve.
5. Basis of Design: Engineered Corrosion Solutions Protector Dry SMART Vent (PSV-D) and Protector SMART Gas Analyzer (SGA-1).

2.10 SPRINKLER HEAD

A. Manufacturers:

B. Unless otherwise noted below, shall be manufactured by Reliable, Tyco Fire Products, Viking, or equal.

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

D. Light hazard occupancies shall utilize quick-response type sprinkler heads.

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

F. Provide the following type of sprinkler heads.

1. Type A: Unfinished areas such as mechanical spaces.
   a. Standard Coverage, Brass Upright or Pendent, ordinary temperature class (155°F), Tyco Fire Products Model TY-FRB, Viking Microfast, or equal.
2. Type B: In the parking garage, areas exposed to the weather, or areas with corrosive conditions.
   a. Standard Coverage, White Polyester Upright or Pendent, intermediate temperature class (200°F), Tyco Fire Products Model TY-FRB, Viking Microfast, or equal.

3. Type C: In areas with ceilings.
    a. Standard Coverage, Concealed Pendent, ordinary temperature class (155°F), 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).
4. Type D: In areas where ceiling conditions do not permit installation of pendent head or finished area where sidewall head provides better coverage of hazard.
    a. Standard Coverage, standard bright white finish, ordinary temperature class (155°F), Tyco Fire Products Model TY-FRB, Viking Microfast horizontal (HSW) or vertical (VSW) sidewall with Viking Microfast Model F-1 adjustable escutcheon, or equal.
5. Type E: In walk-in coolers, freezers, and areas subject to temperatures at or below 40°F.
    a. Standard Coverage, standard chrome finish dry pendent or dry horizontal sidewall, intermediate temperature class (200°F), adjustable recessed chrome escutcheon, Tyco Fire Products Model DS-1 or equal.
    b. Provide compatible wire cage sprinkler head guard where sprinklers are subject to impact damage.
6. Type F: In unfinished areas where conditions do not permit installation of upright or pendent head.
    a. Standard Coverage, Brass Sidewall, ordinary temperature class (155°F), Tyco Fire Products Model TY-FRB, Viking Microfast horizontal (HSW) or vertical (VSW) sidewall or equal.

G. Submit samples for examination and approval when appearance is different than sprinkler head specified.

H. Temperature class of sprinkler heads shall vary if installed close to heat sources, under skylights or in special hazard areas. Refer to NFPA 13 for requirements.

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

J. Sprinkler Cabinets:
1. Shall be complete with required number of spare sprinkler heads 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.

2.11 FIRE VALVE CABINETS (FVC)

A. Manufacturers:
1. Acceptable Manufacturers: American Fire Hose & Cabinet, Badger-Powhatan, Croker Corp., Elkhart Brass, Fire End, Guardian Fire Equipment, Potter-Roemer, or equal.

B. Fire Valve Cabinets:
1. FVC-1:
    a. Cabinet: recessed, Potter-Roemer Series 1810 or equal.
    b. Door Style: Full Glass, white polyester coating with identifying decal.
    c. Angle Valve: Female x Male, 2½" cast brass body, polished chrome plated finish, equal to Potter-Roemer Model 4065. Valve cap for 2½" valve shall be 2½" cap with chain, Potter-Roemer Model 4625 or equal. Cap and chain finish shall match finish of valve body. Threads shall match Fire Department Standards.
2. FVC-2:
    a. Cabinet: surface mounted, Potter-Roemer Series 1815 or equal.
    b. Door Style: Full Glass, white polyester coating with identifying decal.
    c. Angle Valve: Female x Male, 2½" cast brass body, polished chrome plated finish, equal to Potter-Roemer Model 4065. Valve cap for 2½" valve shall be 2½" cap with chain, Potter-Roemer Model 4625 or equal. Cap and chain finish shall match finish of valve body. Threads shall match Fire Department Standards.

2.12 FIRE DEPARTMENT CONNECTION (FDC)

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

B. Fire Department Connection:
1. Provide flush type, cast brass body with drop clappers, faceplate shall be polished chrome plated finish, with lettering reading AUTOSPKR STANDPIPE.
2. Unit shall include four 2-1/2" snoots with rigid end threading to match local fire department standards by pin-lug hose thread swivels, pin-lug plugs and chains. Finish of snoots shall match faceplate finish. Provide Elkhart Brass or equal.

2.13 ROOF MANIFOLD

A. Acceptable Manufacturers: Croker Corp., Elkhart Brass, Potter-Roemer, or equal.

B. Two-way connection, cast brass body with female NPT inlet and 2-1/2" male NPT outlets, Croker Corp. 6860 Series or equal.

2.14 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.

2.15 FIRE PUMP (FP)

A. Acceptable Manufacturers: A-C Fire Pump, Aurora, Fairbanks Nijhuis, Patterson Pump, Peerless Pump, or equal.

B. Fire pump shall meet following criteria:
   1. Deliver rated flow at rated pressure
   2. Deliver not less than 65% of rated pressure at 150% rated capacity
   3. Not exceed 140% of rated pressure at shutoff

C. Pump Type: Electric Driven

D. Pump Configuration: Horizontal Split Case

E. Rated Flow: 1000 gpm

F. Rated Pressure: 140 psi

G. Pump casing shall be pressure rated to handle system pressure.

H. Pump and motor shall be mounted on common steel baseplate.

I. Motor:
   1. Provide open drip proof, high-efficiency, foot-mounted.
   2. 460 VAC, 3 Ph, 60 Hz, and 1770 rpm
   3. 125 hp
   4. Locked rotor current shall not exceed values specified in NFPA 20.

J. Accessories to be provided with each fire pump are as follows:
   1. Fire Pump Test Connection:
      a. Test connection shall be flush type, cast brass body, polished chrome plated with lettering reading "PUMP TEST CONNECTION".
      b. Unit shall include four 2½", polished chrome plated caps with chains.
      c. Potter-Roemer Model 5864-6-D or equal.
   2. Discharge pressure gauge and compound suction gauge shall be liquid-filled type.
   3. Circulation Relief Valve: 3/4" Cla-Val Model 55L pressure relief valve or equal.
   4. Automatic Air Release Valve.

K. Basis of Design: Aurora Model 6-485-17A

2.16 CONTROL EQUIPMENT FOR ELECTRIC DRIVE

A. Acceptable Manufacturers: Eaton, Firetrol, Joslyn Clark, Metron, or equal.

B. Fire Pump Controller:
   1. Shall be completely assembled, wired and tested by control manufacturer before shipment from factory.
   2. Shall be labeled "Fire Pump Controller".
   3. Shall be located as close as practical and within sight of motor.
   4. Shall be located and protected such that it will not be damaged by water escaping from pump or connections.
   5. Shall be combined manual and automatic
   6. Heavy gauge formed steel, NEMA Type 2 enclosure with top drip hood.
   7. Provide complete with following:
      a. Starter: Reduced Voltage Solid State
      b. Isolating Switch: Externally operable, quick-break type
      c. Circuit breaker: Rated at 42 KAIC at 480 VAC
      d. Locked rotor protector for drive motor
      e. Pilot light to show circuit breaker closed and power available
      f. Ammeter and voltmeter displays on front of panel
      g. Alarm relay to energize audible or visible alarm
      h. Pressure recording device
      i. With Automatic Transfer Switch

j. Voltage surge protection
k. Contacts for remote alarm of:
1) Pump Running
2) Loss of Line Power in any phase
3) Phase Reversal
4) Controller Connected to Alternate Source
l. Provide remote fire pump alarm panel in a location of constant attendance.
1) Remote pump alarm panel shall be key lockable enclosure consisting of audible or visible alarms.
2) Alarms shall show: “Pump Running”; “Supervisory Power Failure”; “Phase Reversal” and, when required by NFPA 20, “Controller Connected to Alternate Source”.

C. Basis of Design: Eaton FT90 LMR Soft Start Transfer Switch Controller.

2.17 JOCKEY PUMP (JP)

A. Acceptable manufacturers: A-C Fire Pump, Fairbanks Nijhuis, Patterson Pump, Peerless Pump, or equal
B. Jockey pump shall be:
1. Same manufacturer as main fire pump.
2. Centrifugal jockey pump rated for 10 gpm at 150 psig.
C. Pump casing shall be pressure rated to handle system pressure.
D. Motor shall be:
1. 5 hp
2. 3500 rpm
3. 460 VAC
4. 3 Ph, Jockey pump shall be close-coupled.
5. Open Drip Proof (ODP)
6. Pump and motor shall be integrally mounted on common steel baseplate.
E. Basis of Design: Aurora Model JP-346-10

2.18 JOCKEY PUMP CONTROLLER

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

2.19 HANGERS

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

2.20 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.

2.21 DIELECTRIC FITTINGS

A. Acceptable manufacturers: Epco Sales, Lochinvar, Watts Regulator Co., Wilkins, or equal.
B. Insulating nipple, metal casing, inert thermoplastic lining, Clearflow dielectric fitting by Perfection Corporation or equal.

C. 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. Provide high pressure type when pressures exceed 175 psi water working pressure.

PART 3 - EXECUTION

3.1 DESIGN CRITERIA

A. Flow Test:
1. Static Pressure: 62 psig
2. Residual Pressure: 56 psig with 1140 gpm flowing
3. Pressure-test hydrant is located on the northeast corner of the intersection of East Doty Street and South Pinckney Street.
4. Test Date: November 2, 2016
5. Test Time: 2:25 p.m.
6. Test conducted by or information supplied by: Madison Water Utility

B. Sprinkler Contractor, prior to preparation of installation drawings and hydraulic design calculations, shall conduct a hydrant flow test within the last 12 months.

C. Send current hydrant flow test data to Engineer.

D. Fire pump shall be designed to meet fire protection system demand.

E. Hydraulically calculated system shall be designed to a minimum of 10% or 5 psi below available water flow curve, whichever is greater.

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

G. 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. Penthouse and other mechanical equipment areas shall be hydraulically designed to provide minimum density of 0.15 gpm per sq. ft. over most hydraulically remote 1500 sq. ft. Maximum spacing shall not exceed 130 sq. ft. per head.
3. Parking garage areas shall be hydraulically designed to provide minimum density of 0.15 gpm per sq. ft. over most hydraulically remote 1500 sq. ft. Maximum spacing shall not exceed 130 sq. ft. per head.
4. Mercantile areas 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.
5. General storage areas 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.

H. Hose Streams:
1. Add 100 gpm hose stream to sprinkler zone hydraulic calculations, at the point of connection to the municipal water supply, for Light Hazard Occupancies.
2. Add 250 gpm hose stream to sprinkler zone hydraulic calculations, at the point of connection to the municipal water supply, for Ordinary Hazard Occupancies.
3. Add 500 gpm hose stream to sprinkler zone hydraulic calculations, at the point of connection to the municipal water supply, for Extra Hazard Occupancies.

I. Fire Protection System Layout and Installation Drawings:
1. Contractor shall review Design Drawings and Specifications, and shall provide installation drawings, calculations, and product datasheets.
2. Layout of fire protection system has been established as it relates to structure and mechanical/electrical/piping systems in the building, and must be adhered to. Other layouts shall be produced by Contractor in coordination with building components.
3. Conceal sprinkler piping above ceilings where possible.
4. Contractor shall consult with Architect during development of piping layout to avoid conflicts with general appearance. Pipe routing is a critical issue due to attributes of this building.
5. Submit stamped and sealed installation drawings, calculations and product data sheets for coordination review to: City of Madison Fire Department, Engineer, Architect, State of Wisconsin Department of Safety and Professional Services (DSPS), and other Authorities Having Jurisdiction prior to installation (see submittals).
6. Contractor shall be responsible to have examined "Reflected Ceiling" drawings as well as Mechanical, Electrical, Piping, Information Technology, Structural and Architectural building plans prior to system layout.

7. Contractor shall coordinate routing of piping with other trades and Architect.
8. Contractor shall participate in coordination process and shall not install piping prior to coordination with other trades.

3.2 INSPECTION

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

3.3 INSTALLATION

A. Install hydraulically designed sprinkler system and associated accessories according to requirements of NFPA 13 and as shown on drawings.
B. Install hydraulically designed standpipe system and associated accessories according to requirements of NFPA 14 and as shown on drawings.
C. Install pipe, fittings, couplings, and valves according to requirements of manufacturer.
D. Keep materials within listed temperature range to assure jointing in accordance with manufacturer's requirements.
E. Pipe and fittings shall be of corresponding materials when assembled.
F. Below Ground Pipe:
   1. Anchors and tie rods can be provided in lieu of thrust blocks. Tie rods shall be 3/4” diameter steel rod. Clamps shall be 3/8” thick by 2” wide steel. Each clamp shall be secured with four 5/8” diameter bolts.
   2. Apply asphaltum or approved corrosion inhibitive paint, to tie rods, clamps and bolts of underground pipe.
   3. 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.
G. 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.
H. Provide readily removable fittings at end of cross-mains. Minimum size of flushing connection shall be 2”.
I. Provide test connection for each flow switch.
J. Discharge test connections inside building to receptacles provided as part of plumbing system or to standpipe’s drain riser. Outside discharge is preferred.
K. 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.
L. Provide auxiliary drains at low points of systems per requirements of NFPA 13.
M. Identify valve with brass tag denoting which flow switch is being tested, when test valves are located remote from flow switch.
N. 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.
O. 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.
P. Piping and fittings between dry pipe valves and sprinkler heads and test/auxiliary drain piping of dry sprinkler systems shall be galvanized steel. Provide dielectric fittings between dissimilar pipe materials.
Q. Feed sprinkler heads, installed in finished ceilings, with FlexHead, swing joint, or return bend arrangement for final positioning in ceiling grid pattern during construction phases.
R. Sprinklers are required to be installed in the center of ceiling tiles.
S. Provide minimum 1” outlets with sprigs or drops for sprinklers located in shelled spaces.
T. Install tamper switch on each shutoff valve.
U. Install sprinkler heads 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 heads beneath obstruction.
V. Make joints of threaded pipe by cutting pipe square and reaming inside.
W. Use joint compound sparingly.
X. Install joints for mechanical coupled pipe according to manufacturer's recommendations. Use manufacturer’s gasket lubricant sparingly.
Y. Pipe grooving shall be per coupling manufacturer’s instructions.
Z. Welded joints shall be made in fabrication shop. No welding allowed at project site.

AA. 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.
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.

BB. Install flexible fitting at building's expansion joints per manufacturer's instructions.

CC. Install pressure gauges as shown on engineering drawings, as required in manufacturer's installation instructions, and as required per NFPA standards.

3.4 FIRE PUMP INSTALLATION

A. Install fire pump, jockey pump and their controllers per manufacturer's installation instructions, as shown on drawings and as required in NFPA 20.

B. Grout base–mounted pumps after securely anchoring to structure.

C. Coordinate installation with Division 26 and Division 28 contractors.

3.5 CLEANING

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

B. Clean systems after installation is complete.

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

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

3.6 TESTING

A. Refer to testing paragraph of Section 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. In addition to hydrostatic test, dry pipe systems shall be air pressure tested at 40 psi for 24 h. Leakage in excess of 1½ psi during 24 h will not be permitted.

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

I. 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.

J. 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 forms from NFPA 13 and NFPA 14

K. Operate flow and pressure switches to test that signals are transmitted to Fire Alarm Control Panel.

L. Include test for tamper switches.

3.7 FIRE PUMP TESTING

A. Test fire pump, jockey pump and their controllers per manufacturer's installation instructions and as required in NFPA 20.

B. Furnish test certificate indicating suction pipe has been flushed and suction and discharge pipe has been hydrostatically tested in accordance with NFPA 20, prior to fire pump acceptance test.

C. Coordinate fire pump acceptance test so Local Authorities, Owner's representatives, and Insurance Company representatives can witness the test.

D. 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.

E. Representatives from following shall be present for fire pump field acceptance test:
1. Pump manufacturer
2. Controller manufacturer
3. Transfer switch manufacturer
4. Coordinate fire pump test with local utilities to verify acceptable method for disposal of water.
5. Provide equipment to perform fire pump test, including:
   a. Calibrated test gauges
   b. Calibrated tachometer
   c. Hoses
   d. Nozzles
   e. Valves

END OF SECTION

SECTION 22 00 00
GENERAL PLUMBING REQUIREMENTS

PART 1 – GENERAL
1.1 DESCRIPTION
1.2 RELATED WORK
PART 2 – PRODUCTS (NOT USED)
PART 3 – EXECUTION (NOT USED)

PART 1 - GENERAL

1.1 DESCRIPTION

A. Specification requirements defined in Division 20 of this Specification apply to, and are in addition to the work associated with equipment, systems, materials, and installation requirements specified in Division 22. Contractor shall provide the requirements specified in Division 20 to obtain complete systems, tested, adjusted, and ready for operation.

1.2 RELATED WORK

A. Section 20 0000 - General Mechanical Requirements
B. Section 20 0513 - Motors
C. Section 20 0514 - Variable Frequency Drives
D. Section 20 0520 - Excavation and Backfill
E. Section 20 0529 - Mechanical Supporting Devices
F. Section 20 0549 - Seismic Anchorage and Restraints
G. Section 20 0553 - Mechanical Systems Identification
H. Section 20 0573 - Mechanical Systems Firestopping
I. Section 20 0700 - Mechanical Systems Insulation

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

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SECTION 22 05 33
ELECTRICAL HEAT TRACING

PART 1 – GENERAL
1.1 DESCRIPTION
1.2 RELATED WORK
1.3 SUBMITTALS
1.4 SHIPPING
PART 2 – PRODUCTS
2.1 MATERIALS
2.2 FREEZE PROTECTION HEATERS
PART 3 – EXECUTION
3.1 INSTALLATION
3.2 INSPECTION
3.3 TESTING

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies materials and installation methods necessary for electrical heat tracing system for freeze protection.

B. Freeze protection systems shall be maintained at 40°F.

1.2 RELATED WORK

A. Section 20 0529 - Mechanical Supporting Devices.

B. Section 20 0700 - Mechanical Systems Insulation.

C. Section 26 0533 - Raceway and Boxes for Electrical Systems.

D. Section 26 0519 - Low-Voltage Electrical Power Conductors and Cables.

1.3 SUBMITTALS

A. Manufacturer's technical data and installation instructions for the following:

1. Heat trace cable, voltage, phase, and temperature.
2. Heat output chart for each pipe size.
3. Circuit riser diagram.
4. Circuit schedule with circuit length, breaker panel number, breaker number, and amperage.
5. Contractor certification from heat trace manufacturer.
6. Written warranty statement.

B. Shop drawings on items specified herein.

1.4 SHIPPING

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

PART 2 - PRODUCTS

2.1 MATERIALS

A. Items shall be new, UL Listed or FM approved for their intended use.

2.2 FREEZE PROTECTION HEATERS

A. Heaters:

1. Self-regulating type, 2 tinned-copper bus wires, self-regulating polymer core maintaining temperature of pipe above freezing. Cover heater with polyolefin dielectric jacket, tinned-copper braid jacket and outer polyolefin jacket. Heater shall be compatible with 208, 220, 240 or 277 V, single phase electrical power without transformers. XL-Trace by Raychem.

B. Accessories:

1. Include power connection kits, tee kits, end seal kits, splice kits, and transformers by same manufacturer as heater. Include fiberglass tape or cable ties to fasten heater to pipe.

C. Control:
   1. Automatic control by means of an ambient sensing thermostat with the following features:
      a. Stainless steel air temperature sensor
      b. Set point of 35°F with adjustable range of 25° to 325°F
      c. Electrical rating of 22 amp with voltage from 125 to 480V AC
      d. NEMA - 4X metal enclosure
      e. Raychem ECW-GF or equal
   2. Manufacturers: Chromalox, Dekoron, Pentair Thermal Management, or Thermon.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Attach heater to clean, dry pipe with glass tape or nylon cable ties as stated in manufacturer's installation instructions and terminate at as shown on drawings.

B. Manufacturer's representative shall instruct Contractor in proper installation techniques and certify in writing that instruction has been given and proficiency demonstrated by Contractor in installation fabrication. Only those individuals so certified shall be permitted to work on system. Certification document signed by manufacturer's representative and certified individuals shall be submitted with product shop drawings. No shop drawings will be processed without this documentation.

C. Manufacturer shall supply isometric drawings as part of material package including heater layout, location of power points, and load chart. Plumbing contractor shall obtain these isometrics and submit to engineer for review and approval prior to installation of heating cable. One set of "as built" drawings shall be turned over to Engineer upon completion of installation and testing.

D. Attach heat cable linearly or spirally to pipe as required to effectively distribute heat along pipe and develop proper temperature. Consult manufacturer's data for sizing and spacing of heat cable strip.

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

F. Power wiring, connections, GFI breakers, conduit, and other electrical accessories necessary for heat cable will be provided by Electrical Contractor.

G. Protect heat trace cable circuits with Ground Fault Interrupt (GFI). Coordinate with Electrical Contractor.

3.2 INSPECTION

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

3.3 TESTING

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

B. Contractor shall test continuity of both heater bus wires to verify connection of splices or tees.

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

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

END OF SECTION

SECTION 22 11 18
WATER DISTRIBUTION SYSTEM

PART 1 – GENERAL
1.1 DESCRIPTION
1.2 RELATED WORK
1.3 QUALITY ASSURANCE
1.4 DELIVERY, STORAGE AND HANDLING
1.5 SUBMITTALS
PART 2 – PRODUCTS
2.1 MATERIALS
2.2 PIPE, FITTINGS, AND JOINTS
2.3 UNIONS AND FLANGES
2.4 VALVES
2.5 WATER METERS
2.6 DIELECTRIC FITTINGS
2.7 WATER HAMMER ARRESTORS
PART 3 – EXECUTION
3.1 INSTALLATION
3.2 COPPER TUBING
3.3 WATER METERS
3.4 WATER HAMMER ARRESTORS
3.5 DIELECTRIC UNIONS AND FLANGES
3.6 CLEANING
3.7 TESTING
3.8 DISINFECTION
3.9 BACTERIOLOGICAL TESTING

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section covers interior domestic cold water, domestic hot water (120°F), to a point 5 ft outside building wall.

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

1.2 RELATED WORK

A. Section 20 0513 - Motors
B. Section 20 0514 - Variable Frequency Drive (VFD) Systems
C. Section 20 0520 - Excavation and Backfill
D. Section 20 0529 - Mechanical Supporting Devices
E. Section 20 0553 - Mechanical Systems Identification
F. Section 20 0700 - Mechanical Systems Insulation
G. Section 22 0533 - Electric Heat Tracing
H. Section 22 2114 - Plumbing Specialties
I. Section 26 2913 - Enclosed Controllers

1.3 QUALITY ASSURANCE

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

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

1.4 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.

1.5 SUBMITTALS

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

B. Shop Drawings on items specified herein.

PART 2 - PRODUCTS

2.1 MATERIALS

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

2.2 PIPE, FITTINGS, AND JOINTS

A. Above Ground:
1. Copper (2-1/2" and Smaller):
a. Pipe: Copper tube, Type L, hard drawn, ASTM B88
b. Fittings:
1) Cast copper alloy, solder joint, pressure rated, ANSI B16.18
2) Wrought copper, solder joint, pressure rated, ANSI B16.22
c. Joints:
1) Lead free (<0.2%) solder, ASTM B32, flux, ASTM B813
d. Nipples: Red brass pipe, threaded
2. Copper (3" and Larger):
a. Pipe: Copper tube, Type L, hard drawn, ASTM B88
b. Fittings:
1) Wrought copper, ASTM B75 or ASTM B152 and ASME B16.22, roll grooved.
2) Copper alloy CDA 836(85-5-5-5), sand cast per ASTM B584 and ASME B16.18, roll grooved.
3) Manufactured to copper tube dimensions with factory grooved ends. Flaring of tube and fitting ends to IPS dimensions is not permitted.
c. Joints: Roll grooved with ductile iron couplings, ASTM A536. Coupling housing shall be cast with off-setting, angle-pattern bolt pads. Heat-treated carbon steel bolts, ASTM A449 and A183, pressure responsive EPDM gasket UL Classified in accordance with NSF-61, and enamel coated. Victaulic Style 607H.
3. Owner reserves right to require destructive testing on 3 joints to ensure quality of joints.

2.3 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

2.4 VALVES

A. Shutoff Valves:
1. Ball Valves (2 ½" and smaller):
a. Acceptable manufacturers: Apollo, Hammond, Milwaukee, Nibco, Stockham and Watts with indicated features and equal to model listed. Note that not all manufacturers make all sizes.

b. Full Port, 2 Piece: Bronze body, ASTM B584, stainless steel ball and stem, teflon seats, stem extension with length according to installed system insulation thickness, 600 psi CWP pressure rating, Apollo Series 77CLF-240-01.
c. Full Port, 3 Piece: Bronze body, ASTM B584, stainless steel ball and stem, teflon seats, stem extension with length according to installed system insulation thickness, 600 psi CWP pressure rating, Apollo Series 82LF-240.

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. Threaded or Solder Ends: Bronze body, stainless steel disc and stem, viton disk seal, Milwaukee Series BB2.
   c. Lug Type: Ductile iron body, aluminum bronze disc mounted without pins or bolts, EPDM liner, stainless steel stem, brass bushings (lower, upper and collar), 200 psi CWP pressure rating, 10 position lever handle through 6", gear operator 8" and larger, Apollo LD141.
   d. Wafer Type: Ductile iron body, aluminum bronze disc mounted without pins or bolts, EPDM liner, stainless steel stem, brass bushings (lower, upper and collar), 200 psi CWP pressure rating, 10 position lever handle through 6", gear operator 8" and larger, Apollo WD141.
   e. 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 461.

3. Gate Valves:
   a. Acceptable Manufacturers: Crane, Hammond, Kennedy, Milwaukee, Nibco, and Stockham with indicated features and equal to model listed. Note that not all manufacturers make all sizes.
   b. Size 2-1/2" and Smaller: Lead-free bronze body, bronze trim, 150 psi steam pressure rating, union bonnet, rising stem, Hammond UP635/UP640.
   c. Size 3" 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.

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.
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, Powell 559P.

C. Spring Check Valves:
1. Valves 2" and Smaller:
   a. Bronze body, ASTM B62, in-line lift type with spring, Buna-N disc, 250 psi CWP rating, Apollo 61LF-60D-01.
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 101MAT
   b. Ductile iron body, aluminum bronze or elastomer encapsulated ductile iron disc, stainless steel spring and shaft, welded-in nickel or EPDM synthetic rubber seat, vertical or horizontal installation, grooved ends, 300 psi CWP rating, Victaulic Series 716.
3. Size 1/2" thru 2":
   a. Stainless steel body, in-line pattern, stainless steel seats, spring and valve disc. DFT, Inc. Basic Check, Model BSS, rated for 300 psi WSP.
   b. Manufacturers: Nibco, Watts, Mission, DFT, Inc., Circle Seal, Milwaukee, Stockham.

D. Pressure Reducing Valve – Main System
1. Manufacturers: Cla-Val, Fisher, and Watts.
2. Pilot operated valve with low flow bypass, bronze body, globe pattern, stainless steel trim, Buna-N disc, stainless steel stem and spring, Class 150 Flanged ends, maximum service temperature 160°F.
3. Refer to Schedules on drawings for performance requirements.

2.5 WATER METERS

A. Compound Flow Meter
1. Acceptable Manufacturers: Badger, Neptune, Sensus Metering Systems or approved equal.
2. Meter shall be in-line compound meter type consisting of one positive displacement chamber and one turbine chamber. Meter shall have integral or remote converter with graphic display and keypad. Meter shall be factory sized and programmed for its specific application and flow range. Meter shall be reprogrammable using converter keypad without use of special interface device or computer.
3. Meter body shall be lead-free bronze construction with stainless steel trim. Meter shall have thermoplastic piston, turbine chamber and turbine. Meter materials and finish shall meet AWWA Standard C700.
4. Meter shall be provided with ANSI Class 150 flanges.
5. Meter shall be selected for 10:1 turndown. Meter shall be wet-calibrated and accurate to within ±1.5% of reading. Meter shall be shipped with certification of calibration.
6. Meter shall have 4-20 mA and programmable pulse output signals.
7. Meter shall have integral lead-free bronze or stainless steel plate type strainer. Strainer shall have access cover for cleaning of strainer grid.
8. Meter shall provide totalized flow in gal.
9. Basis of Design is Badger Recordall Compound Series capable of flow range 0.5 gpm to 25 gpm with maximum pressure drop of 4 psig.

2.6 DIELECTRIC FITTINGS

A. Insulating nipple, metal casing, inert thermoplastic lining, Clearflow dielectric fitting by Perfection Corporation or Victaulic Style 47.

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

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

2.7 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.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Maintain piping system in clean condition during installation. Remove dirt and debris from assembly of piping as work progresses. Cap open pipe ends where left unattended or subject to contamination.

C. Include connections to plumbing fixtures, to equipment by others, and to equipment requiring water. Provide proper backflow and back siphonage protection to safeguard potable water system from contamination.

D. Lay out water system so as to conform to intent of drawings. Coordinate piping with building features and work of other trades. Install water piping plumb and square with building. Plans indicate, general routing, provide additional offsets as required. Install piping with necessary swing joints and offsets to allow for expansion.

E. Install shut-off valves on branch lines near mains to avoid long dead-leg branches when valves are closed.

F. Install shut-off valves where indicated and at base of risers to allow isolation of portions of system for repair.

G. Do not install water piping within exterior walls.

H. Provide drain valves at base of risers and at low points of trapped piping 2” and larger where trapped water volume exceeds 5 gallons.

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

3.2 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. 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.

3.3 WATER METERS

A. Provide minimum of 10 pipe diameters of straight pipe on inlet of meter and minimum of 5 pipe diameters of straight pipe on outlet of meter.
B. Provide strainer on inlet to meter.

3.4 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, quick-closing valves, and at branch main risers serving more than 1 fixture.
C. Provide access panels when water hammer arrestors are installed in non-accessible concealed locations.

3.5 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.

3.6 CLEANING

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

3.7 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 [100 psi] for 2 h. No decrease in pressure allowed. Provide pressure gauge with shutoff and bleeder valve at highest point of system tested. Inspect joints in system under test.

C. Defective work or material shall be replaced or repaired as necessary and inspection and test repeated. Repairs shall be made with new materials. No caulking of threaded joints or holes will be allowed.

D. Do not conceal pipe until satisfactorily tested.

E. Testing with air will not be allowed.

3.8 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.

3.9 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 22 13 14

SANITARY WASTE AND STORM DRAINAGE SYSTEMS

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PART 1 - GENERAL

1.1 DESCRIPTION

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

1.2 RELATED WORK

A. Section 20 0513 - Motors
B. Section 20 0520 - Excavation and Backfill
C. Section 20 0529 - Mechanical Supporting Devices
D. Section 20 0549 - Seismic Anchorage and Restraints
E. Section 20 0700 - Mechanical Systems Insulation
F. Section 22 1114 - Exterior Services
G. Section 22 2114 - Plumbing Specialties
H. Section 22 4000 - Plumbing Fixtures
I. Section 26 2913 - Enclosed Controllers

1.3 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.

1.4 QUALITY ASSURANCE

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

1.5 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.

1.6 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 boots
7. Downspout nozzles
8. Air gap fittings
9. Backwater valves
10. Discharge check valves
11. Discharge isolation valves
12. Trench drains
13. Traps
14. Sump pumps
15. Sewage ejectors
16. Fiberglass sump basins
17. Concrete sump basins
18. Epoxy coating of concrete sump pits
19. Sump cover
20. Precast sand/oil interceptor

PART 2 - PRODUCTS

2.1 MATERIALS

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

2.2 PIPE, FITTINGS, AND JOINTS

A. Interior Underground 15” and Smaller:

1. Polyvinyl Chloride (PVC):
   a. Pipe:
      1) Schedule 40, Class 12454-B (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-B (PVC 1120), ASTM D1785.
   b. Fittings: Socket fitting patterns, ASTM D3311.
   c. Joints: Primer, low VOC, ASTM F656; solvent cement, low VOC, ASTM D2564.
2. Copper:
   a. Pipe: Type K copper tube, H (drawn) temper, ASTM B88.
   b. Fittings:
      1) Cast copper drainage fittings (DWV), ANSI B16.23.
      2) Wrought copper drainage fittings (DWV), ANSI B16.29.
   c. Joints: Lead free (<0.2%) solder, ASTM B32; flux, ASTM B813.

C. Interior Above Ground:

1. Polyvinyl Chloride (PVC):
   a. Pipe: Schedule 40, Class 12454-B (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.

D. Pressurized Interior Above Ground:
1. Copper (2" and smaller):
a. Pipe: Type L copper tube, hard drawn temper, ASTM B88.
b. Fittings:
1) Cast copper drainage fittings (DWV), ANSI B16.23.
2) Wrought copper drainage fittings (DWV), ANSI B16.29.
c. Joints: Lead free (<0.2%) solder, ASTM B32; flux, ASTM B813.
2. Copper (3" and larger):
a. Pipe: Type L copper tube, hard drawn temper, ASTM B88.
b. Fittings:
1) Wrought copper, ASTM B75 or ASTM B152, ASME B16.22, roll grooved.
2) Copper alloy CDA 836*85-5-5-5), sand cast per ASTM B584 and ASME B16.18, roll grooved.
c. Joints: Roll grooved with ductile iron couplings, ASTM A536. Heat-treated carbon steel bolts, ASTM A183, EPDM gasket and enamel coated. Victaulic Style 606.
3. Galvanized steel
a. Pipe: Schedule 40, Type F, Grade A, ASTM A53.
b. Fittings: Cast iron threaded drainage fittings, ASTM B16.12.
4. PVC (3" and smaller):
a. Pipe: Schedule 40, Class 12454-B (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.

E. Adaptor 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. Adaptor couplings shall be specifically designed for pipe materials being joined.
3. 8" through 27" diameter: Fernco 1000 Series flexible coupling with elastomeric PVC or neoprene gasket and stainless steel clamping bands. Adaptor couplings shall be specifically designed for pipe materials being joined.

2.3 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] [Hammond Series 8303/8513] [Nibco 585-70-66].
2. Butterfly Valves:
a. Acceptable Manufacturers: Crane or Nibco with indicated features and equal to model listed
b. Size 4" and larger:
1) Wafer Type: Ductile iron body, aluminum bronze disc, EPDM liner, 316 4106 stainless steel stem, brass collar bushings, copper upper and lower bushings, (lower, upper and collar), 200 psi CWP pressure rating, lever handle through 6", gear operator 8" and larger, [Nibco WD2000] [Crane Quartermaster 42-B-S-Z].

3. Discharge valve assembly:
   a. Grooved pipe, Victaulic 318 Series that includes Victaulic 365 plug valve, 317 check valve and couplings. For sizes 3" and larger.
4. 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.

2.4 CLEANOUTS

A. Josam, Mifab, Smith, Wade, Watts or Zurn, equal to number listed in Drains and Cleanout Schedule.
B. Provide recessed, solid brass, cleanout plugs where fittings are used as cleanouts. Provide taper-thread plug with Teflon tape thread wrap.

2.5 FLOOR AND AREA 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.

2.6 AIR GAP FITTINGS

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

2.7 TRAPS

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

2.8 SEWAGE EJECTOR PUMPS (AIR FILLED)

A. Acceptable pump manufacturers: ABS, Ebera, KSB, Paco, and Weil.
B. Acceptable control manufacturers: See Water, SJE-Rhombus and Weil.
C. Pump shall be [simplex] [duplex] submersible sewage ejector type constructed of epoxy or enamel coated cast iron shell and volute, ASTM A48, Class 30, multi-vane semi-open non-clog cast iron impeller capable of passing 2" solids, stainless steel shaft, stainless steel fasteners, stainless steel impeller hardware, double sealed upper and lower ball bearings permanently lubricated, and ceramic mechanical seal.
D. Motors shall be NEMA 6, submersible, air filled, hermetically sealed with Class F insulation. Motors shall meet requirements of Section 20 0513 - Motors.
E. Pump shall be of capacity and motors shall be of electrical service as indicated in equipment schedules on drawings.
F. Pump Removal System:
   1. Removal System shall permit removal and re-installation of pump without disturbing discharge piping and without personnel entering wet well.
   2. Lifting cable shall be braided stainless steel.
   3. Pump shall be provided with lifting bail to permit attachment of cable to pump.
   4. Pump shall be guided by two guide poles provided with system.
   5. The guide poles shall be mounted on floor elbow and 304 stainless steel upper guide bracket.
   6. Pump sliding bracket shall be constructed of heavy duty bronze.
   7. Floor elbow shall be constructed of ASTM A48-83, Class 30, close grain cast iron.
   8. Pump sliding bracket shall act as wedge type coupling between pump and floor elbow to insure metal to metal, water tight fit.
   9. Systems that require gaskets, diaphragms, or O-rings to ensure watertight fit shall not be acceptable.
G. Pump controls shall include:
   1. 4 UL Listed float switches (Lead pump On, Lag pump On, Pumps Off, High water level alarm).
   2. Pump alternator and alarm panel with HOA switch, run light and resettable overload heaters for each pump; warning light; horn; silent switch; test switch; labeled terminal switch and devices; auxiliary dry contacts for remote alarm; NEMA 1, enclosure.
   3. Class 1, Group D, Division 1 explosion proof rated controls and switches.
   4. Elapsed run time meters.
   5. Refer to Section 26 2913 - Enclosed Controllers for starter requirements.
H. Pump accessories shall include:
   1. Power cord length, as required.

2. NEMA 4 junction box.
3. Dual mechanical seals, seal leak detector probe and warning light in control panel.
4. Dual stainless steel lift out guide rails, stainless steel wall, pump, and sump brackets, bronze and neoprene quick disconnect fitting, corrosion resistant pull chain or cable.
5. Explosion proof, Class 1, Group D, Division 1 motor.
6. Unions.

2.9 ELEVATOR SUMP PUMPS

A. Acceptable manufacturers: Aurora/Hydromatic; Liberty, Stancor, Inc., Weil, Zoeller.
B. Pump shall be submersible type constructed of epoxy coated cast iron shell, cast iron volute, two vane enclosed semi-open 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

2.10 CONCRETE SUMP BASINS

A. Pre-cast reinforced concrete manhole sections, ASTM C478. Seal between sections with rubber ring gaskets, ASTM C443, or plastic preformed gasket material.
B. Coat interior of sump with water- proof epoxy coating.
C. Base shall be constructed of 6” thick pre-cast reinforced concrete or 8” thick cast in place concrete.
D. Seal pipe penetrations with flexible watertight rubber gasketed seals.
E. Sump cover shall be bolted aluminum with gasket, inspection access plate and non-skid coating. Access plate to have discharge pipe flange for each pump and vent pipe, and hole for control cabling.

2.11 PRECAST SAND/OIL INTERCEPTOR

A. Acceptable manufacturers: Highland Tank; Jensen Precast; McTighe; Mid-State Concrete Products; Old Castle Precast or equal.
B. Reinforced precast concrete in accordance with AASHTO M-199 with gaskets in accordance with ASTCM C923.
C. Mortar and Grout: Type S.
D. Wall Sections to meet ASTM C858 with AASHTO HS-20 loading.
E. Interceptor shall be constructed of pre-cast concrete with base and walls poured monolithically. Concrete shall have minimum compressive strength of [3000 psi] [4000 psi] at 28 days and conforming to ASTM C150.
F. Wall thickness of at least [3”] [4”] [6”], except if engineered analysis can justify lesser thickness.
G. Steel reinforcement in both directions shall be in accordance with ACI 318-89 and placement location to comply with ACI 318-89.
H. Interior walls finished smooth and impervious. Voids, pits or protrusions exterior and interior are prohibited.
I. Interceptor shall have two compartments. Inlet compartment shall be not less than two-thirds of total required capacity with minimum volume of 200 gal and in all cases shall be longer than maximum interior width of interceptor. Outlet compartment shall be minimum capacity of not less than one-third of total interceptor capacity. Liquid depth not less than 2’-6” not more than 6 ft.
J. Free surface area of liquid shall be 1 sq ft for every 45 gal of liquid capacity.
K. Access to tanks via two [20”] [24”] diameter ring and H-20 covers at inlet and outlets. Cast iron covers shall have words SAND/OIL cast into it.
L. See schedule on drawings for capacity required.

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

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

B. 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.

3.2 UNDERGROUND WARNING TAPE

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

3.3 COPPER TUBING

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

3.4 STEEL PIPE

A. Threaded Pipe Joints:
1. Make threaded pipe joints with square cut and reamed pipe. Provide tapered pipe threads in conformance with ANSI B1.20.1.
2. Cut threads so that exposed threads at joint are less than 3. Coat exposed threads with corrosion inhibiting paint. Use joint compounds or teflon tape on pipe threads to achieve leak free joint.

B. Grooved Steel Pipe Joints:
1. Grooved joint piping systems shall be installed in accordance with manufacturer's guidelines and recommendations.
2. Gasket style and elastomeric material shall be verified as suitable for intended service as specified. Gaskets shall be supplied by grooved coupling manufacturer.
3. Grooved end shall be clean and free from indentations, projections, and roll marks in area from pipe end to groove for proper gasket sealing.
4. 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.

3.5 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.

3.6 PRECAST SAND/OIL INTERCEPTORS

A. Minimum slope for tank inlet and outlet piping is 1%.

B. Precast unit shall be inspected by local Authority prior to being set into ground.

C. Install in dry excavation. Dewatering is permitted to maintain dry conditions. Inspect for leakage upon completion of backfilling.

D. Precast units shall be placed on level undisturbed soil, or approved compacted fill. Two 2" x 6" redwood grade boards shall be placed below tank side walls along length.

E. Covers shall be set to grade within 1/4" from finish surface or as directed by Engineer.

F. Sidewall backfill which required to pass 2" screen material made up of dry soil, sand or gravel. Minimum 12" sides, from base to top. No parallel backfilling or compaction along length of sidewalls is permitted. No wheel or track loading on sidewalls.

3.7 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.

END OF SECTION

SECTION 22 14 14
BUILDING SUBSOIL DRAINAGE

PART 1 – GENERAL
1.1 DESCRIPTION
1.2 RELATED WORK
1.3 SUBMITTALS
PART 2 – PRODUCTS
2.1 PIPE, FITTINGS, AND JOINTS
2.2 VALVES
2.3 FILTER FABRIC
2.4 STONE
2.5 CLEANOUT
2.6 SUMP PUMPS (AIR FILLED)
2.7 CONCRETE SUMP BASINS
PART 3 – EXECUTION
3.1 INSTALLATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies pipe and materials to provide subsoil drainage system for building.

1.2 RELATED WORK

A. Section 20 0520 - Excavation and Backfill.

1.3 SUBMITTALS

A. Shop drawings on items specified herein.

PART 2 - PRODUCTS

2.1 PIPE, FITTINGS AND JOINTS

A. Interior Underground
   1. Plastic Corrugated Tubing:
      a. Pipe: Polyethylene corrugated drainage and footing type, ASTM F405 or AASHTO M252, ASTM F405, Type C similar to product by Advanced Drainage System (ADS).
      b. Joints: Plastic snap coupling meeting soil tightness requirements of AASHTO M252 or M294.
      c. Cover: Polypropylene filter fabric, design flow rate range from 110 to 330 gpm per square foot when tested according to ASTM D4491.

B. Pressurized Interior Above Ground.
   1. Polyvinyl Chloride(PVC):
      a. Pipe: Schedule 40, Class 12454-B (PVC 1120), ASTM D1785.
      b. Fittings: Socket fitting patterns, ASTM D3311.
      c. Joints: Primer, ASTM F656; solvent cement, ASTM D2564.

2.2 VALVES

A. Ball Valves:
   1. Acceptable manufacturers: Asahi, Chemtrol, Ipex, Plast-O-Matic, Spears.
   2. Size 4” and smaller: PVC body, full port, true union, Teflon seats, EPDM seals, socket ends. Ipex VX Series.

B. Check Valves:
   1. Acceptable manufacturers: Asahi, Chemtrol, Hayward, Ipex, Spears.
      a. Size 4” and smaller: PVC body, ball check, EPDM seals, socket ends.

2.3 FILTER FABRIC

A. Filter fabric shall be non-woven polypropylene fiber bonded at crossing points. Equivalent opening size (EOS) shall be 70 to 100 U.S. Standard sieve size, ASTM D4751. Fabric shall have water flow rate of 55 gal/min/sq ft, ASTM D4491.

B. Fabric shall be Typar, Style 3401 by DuPont or Mirafi 140 by Celanese.

2.4 STONE

A. Drainage stone shall be washed rock or gravel evenly graded with stone smaller than 2" size and larger than 3/4" size.

2.5 CLEANOUT

A. Manufacturers: Josam, Wade, Zurn or Smith equal to item listed on Cleanouts and Drains schedule on drawings.

2.6 SUMP PUMPS (AIR FILLED)

A. Acceptable pump manufacturers: Ebera, KSB, Paco, and Weil.

B. Acceptable control manufacturers: See Water, SJE-Rhombus and Weil.

C. Pump shall be duplex submersible type constructed of epoxy or enamel coated cast iron shell, and cast iron volute, ASTM A48, Class 30, multi-vane enclosed semi-open non-clog bronze or cast iron impeller, stainless steel shaft, stainless steel fasteners, upper sleeve and lower ball bearings permanently lubricated, and ceramic mechanical seal.

D. Motors shall be NEMA 6, submersible, air-filled, hermetically sealed with Class F insulation. Motors shall meet requirements of Section 20 0513 - Motors.

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

F. Pump Removal System:

1. Removal system shall permit removal and re-installation of pump without disturbing discharge piping and without personnel entering wet well.
2. Lifting cable shall be braided stainless steel.
    a. Pump shall be provided with lifting bail to permit attachment of cable to pump.
3. Pump shall be guided by two guide poles provided with system.
    a. The guide poles shall be mounted on floor elbow and 304 stainless steel upper guide bracket.
4. Pump sliding bracket shall be constructed of heavy duty bronze.
5. Floor elbow shall be constructed of ASTM A48-83, class 30, close grain cast iron.
6. Pump sliding bracket shall act as wedge type coupling between pump and floor elbow to insure metal to metal, water tight fit.
7. Systems that require gaskets, diaphragms, or O-rings to ensure a watertight fit shall not be acceptable.

G. Pump controls shall include:

1. Four UL Listed float switches (Lead pump On, Lag pump On, Pumps Off, High water level alarm).
2. Refer to Section 26 2913 – Enclosed Controllers for starter requirements.
3. Electrical pump alternator and alarm panel with HOA switch, run light and resettable overload heaters for each pump; warning light; horn; silent switch; test switch; labeled terminal switch and devices; auxiliary dry contacts for remote alarm; NEMA 1, enclosure.

H. Pump accessories shall include:

1. Power cord length, as required.
2. NEMA 4 junction box.
3. Dual mechanical seals, seal leak detector probe and warning light in control panel.
4. Dual stainless steel lift out guide rails, stainless steel wall, pump, and sump brackets, bronze and neoprene quick disconnect fitting, corrosion resistant pull chain or cable.
5. Unions.

2.7 CONCRETE SUMP BASINS

A. Pre-cast reinforced concrete manhole sections, ASTM C478. Seal between sections with rubber ring gaskets, ASTM C443, or plastic preformed gasket material.

B. Base shall be constructed of 6" thick pre-cast reinforced concrete or 8" thick cast in place concrete.

C. Seal pipe penetrations with flexible watertight rubber gasketed seals.

D. Sump cover shall be bolted galvanized steel with gasket, inspection access plate and non-skid coating. Access plate to have discharge pipe flange for each pump and vent pipe, and hole for control cabling.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install subsoil drainage system as shown on drawings and details. Placement of drainage stone shall be carefully done to prevent tearing of filter fabric. Pipe shall be pitched at grade of 2” per 100 ft..

B. Install jointing systems for pipe to accomplish proper pipe alignment and pitch.

C. Handle and store filter fabric according to manufacturer's recommendations.

D. Only pipe in stone bedding shall be perforated. Extensions to cleanouts shall be solid pipe material.

E. Install filter fabric as envelope around pipe and stone as follows:

1. Lay fabric in trench.
2. Place stone in filter fabric.
3. Level stone to proper grade and set perforated pipe on stone.
4. Place remaining stone on side and top of pipe.
5. Wrap filter fabric around and close with minimum 6” lap.

F. Components (fabric, stone, pipe) form subsoil drain conduit.

G. Where subsoil drains are required to penetrate foundation work, sleeve subsoil drains and use non-perforated sections of piping and place prior to foundation work.

H. Install basin base on undisturbed soil with setting pad of level concrete to bed base, build up basin with standard sections and epoxy based concrete mortar joints. Adjust cover slab and access frame to align with poured floor level.

END OF SECTION

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SECTION 22 21 14
PLUMBING SPECIALTIES

PART 1 – GENERAL
1.1 DESCRIPTION
1.2 RELATED WORK
1.3 SUBMITTALS
PART 2 – PRODUCTS
2.1 MATERIALS
2.2 THERMOMETERS
2.3 THERMOMETER SOCKETS AND TEST WELLS
2.4 PRESSURE GAUGES
2.5 STRAINERS
2.6 BACKFLOW PREVENTERS
2.7 IN-LINE TRAP SEALER
2.8 FLEXIBLE CONNECTIONS
2.9 AIR VENTS
2.10 FLASHINGS
2.11 SAFINGS
PART 3 – EXECUTION
3.1 INSTALLATION
3.2 TESTING

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section covers material specialties for piping systems.

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

1.2 RELATED WORK

A. Section 22 1118 - Water Distribution System.

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

1.3 SUBMITTALS

A. Manufacturer's technical data for the following:
1. Thermometers
2. Pressure gauges
3. Pressure relief valves
4. Strainers
5. Flexible connections
6. Air vents
7. In-line trap sealer
8. Flashings
9. 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

2.1 MATERIALS

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

2.2 THERMOMETERS

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

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

2.3 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.

2.4 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. Provide with No. 301 Series maximum registering pointer.

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

2.5 STRAINERS

A. Manufacturers: Conbraco, Hoffman, Keckley, Metraflex, Mueller, or Wheatley.

B. Strainers shall be comparable to regulator or control valve specified. Strainers shall be "Y" type for liquid service to 400 lbs WOG at 210°F, with 40 mesh stainless steel screen. Body material shall be compatible with installed piping, stainless steel, or FDA approved, heat fused, epoxy coated interior.

2.6 BACKFLOW PREVENTER

A. Reduced Pressure Zone Backflow Preventers:

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

2.7 IN-LINE TRAP SEALER

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

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.

2.8 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.

2.9 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.

2.10 FLASHINGS

A. Elastomer Membrane Roofing:

1. Pipe clamps, Fernco Series 1056 flex coupling with Series 300 stainless steel clamps.

2.11 SAFINGS

A. 4 lb/ft2 sheet lead, to 18” beyond edge of drain on all sides.

B. Chlorinated polyethylene (CPE) as manufactured by Noble Company under trade name Chloraloy 240.

C. Polyvinyl Chloride (PVC) shower pan line, 40 mil thickness, ASTM D4551.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide thermometers where indicated on drawings. Thermometers shall be easily read from floor or maintenance platforms. Calibrate thermometers to 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 flexible connections for base mounted pumps and other vibrating equipment.

F. Install air vents at high points in water systems where air may collect.

G. 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. 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.

H. 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. Roof penetrations for corrosive or acid vent systems shall be preformed EPDM vent pot with flex coupling pipe clamp collar.

3.2 TESTING

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

END OF SECTION

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SECTION 22 33 14
WATER HEATING EQUIPMENT

PART 1 – GENERAL
1.1 QUALITY ASSURANCE
1.2 SUBMITTALS
PART 2 – PRODUCTS
2.1 MATERIALS
2.2 STORAGE TYPE ELECTRIC WATER HEATER
PART 3 – EXECUTION
3.1 INSTALLATION

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

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

1.2 SUBMITTALS

A. Shop drawings on items specified herein.

PART 2 - PRODUCTS

2.1 MATERIALS

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

2.2 STORAGE TYPE ELECTRIC WATER HEATER

A. Manufacturers: A. O. Smith, Bock, Bradford White, Lochinvar, Rheem, Ruud, State

B. Water heater shall be electric storage type heater. Water heater shall be UL listed and have minimum 5 yr tank warranty and 1 yr parts warranty.

C. Heating element(s) shall be zinc plated copper sheaths. Temperature control shall be adjustable from 110° to 170°F for single heating element.

D. Water heater design shall include electronic controls for element sensing low water cut off and economy made with programmable operating set points.

E. Tank shall be glass lined steel rated for 150 psi. Tank shall have removable magnesium anode rod, pressure and temperature relief valve, drain valve, polyurethane insulation and painted steel jacket.

F. Provide thermometers on inlet and outlet to heater.

G. Refer to Water Heater Schedule for water heater capacity required.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Initial startup service shall be provided by representative of manufacturer.

END OF SECTION

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SECTION 22 40 00
PLUMBING FIXTURES

PART 1 – GENERAL
1.1 DESCRIPTION
1.2 RELATED WORK
1.3 SUBMITTALS
PART 2 – PRODUCTS
2.1 MATERIALS
2.2 MANUFACTURERS
2.3 CARRIERS AND SUPPORTS
2.4 WATER CLOSETS
2.5 LAVATORIES
2.6 SINKS
2.7 JANITOR'S SINKS
2.8 HOSE BIBBS
2.9 WALL HYDRANTS
PART 3 – EXECUTION
3.1 INSTALLATION
3.2 PROTECTION
3.3 CLEANING

PART 1 - GENERAL

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

1.2 RELATED WORK
A. Section 22 1118 - Water Distribution System
B. Section 22 1314 - Sanitary Waste and Storm Drainage Systems

1.3 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

2.1 MATERIALS
A. Vitreous china fixtures shall be of highest quality, non-absorbent, hard-burned, and vitrified throughout.
B. 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.
C. 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.
D. Precast receptors and shower basins shall be "terrazzo" concrete. Receptor and basin colors shall be standard colors unless otherwise noted. Assembly of drain to waste piping shall be made from floor level on which basin or receptor is installed.
E. Insulation for traps and supplies shall be molded closed cell vinyl insulation and shall meet ASTM E84 for flame and smoke spread. Insulation shall be vandal resistant and be color as listed.

2.2 MANUFACTURERS
A. Water closets, urinals, and lavatories: American Standard, Kohler, or Zurn equal to number listed
B. Water Closet Seats: Bemis, Beneke, Centoco, Olsonite or Zurn equal to number listed
C. Stainless Steel Sinks: Advance Tabco, Elkay or Just equal to number listed
D. Mop Basins (Janitor Sinks): Fiat, Mustee, Stern-Williams, or Zurn equal to number listed
E. Manual Faucets: Chicago Faucet, T and S Brass, or Zurn equal to number listed
F. Fixture Traps: Engineered Brass Company, Kohler, McGuire, or Zurn equal to number listed

G. Insulated Traps and Supplies: McGuire, ProFlo, or True-Bro equal to model listed
H. Supplies and Stops: Chicago Faucet, Kohler, McGuire or Zurn equal to number listed

2.3 CARRIERS AND SUPPORTS

A. Carrier manufacturers shall be Josam, J.R. Smith, Wade, 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.

2.4 WATER CLOSETS

A. WC-1 Water Closet (floor mounted, flush tank, pressure assist)
1. Fixture: Kohler "Kingston" Model #K-3493-0, white vitreous china, floor mounted pressure assist flush tank, elongated bowl, 1.6 gal per flush. Locate trip lever on open side of stall/room.
2. Fixture Fittings and Accessories: Gaskets, bolts with chromium plated caps, nuts, and washers
3. Seat: Bemis #1955-SS/C, heavy duty, elongated bowl, open front, plastic seat, less cover, white color, with stainless steel self-sustaining check hinge
4. Stops and Supplies: Kohler K-7639-CP angle pattern, lock shield cap, loose key handle, with copper alloy control valve bodies, stems, and gland nuts, 1/2” NPT inlet x 3/8” compression outlet

2.5 LAVATORIES

A. L-1 Lavatory (wall-hung, barrier free)
1. Fixture: Kohler "Greenwich" K-2032 20” x 18” vitreous china, wall hung, 4” centers, drilled for carrier support, mount at 34” above finished floor to rim
2. Faucet: Chicago Faucet 2200-4, single handle, E12 aerator
3. Mixing Valve: Symmons 7-225-CK, exposed lead-free mixing valve, check/strainers on inlets, tamper resistant cap, 0.5 gpm minimum flow
4. In-line Check Valve: Brass or bronze body, stainless steel spring, Buna-N o-ring, straight through flow. Circle Seal 2200 Series or approved equal.
5. Drain: McGuire 155WC, offset grid drain, 1-1/4” tailpiece
6. Trap: McGuire B8902, 1-1/4” x 1-1/2” cast brass P-trap with cleanout, 17 ga tubing outlet
7. Stops and Supplies: Kohler K-7608-CP angle pattern, lock shield cap, loose key handle, with copper alloy control valve bodies, stems, and gland nuts, 1/2” NPT inlet x 3/8” compression outlet
8. Traps, Stops and Supplies Insulation: True-Bro “Lav Guard 2”, offset strainer, p-trap and angle stop and supply cover, white
9. Carrier: J.R. Smith 700-M31, concealed arms, rectangular steel uprights

2.6 SINKS

A. S-1 Sink (counter mounted, double bowl)
1. Fixture: Elkay "Lustertone" #LR-3322, Type 302 stainless steel, 18 ga, self-rimming, double compartment, satin finish, fully undercoated, each compartment dimension 13.5” x 16” x 8.5” deep, 3 faucet holes
2. Faucet: Chicago Faucet #201-215424AB, mixing valve faucet, 8” swing gooseneck, lever handles, 1.5 gpm flow control, 8” faucet centers, cast or copper alloy construction with renewable or replaceable operating mechanisms, polished chrome finish
3. Drain: Elkay #LK-99 1-1/2” diameter drain with conical strainer basket, stainless steel construction, continuous drain and waste fitting for double sinks, chrome plate brass
4. Trap: Kohler K-9000, 1-1/2” x 1-1/2” p-trap, cleanout plug, adjustable with connected elbow and nipple to wall, chrome plated
5. Stops and Supplies: Chicago Faucet #1006-ABCP, angle pattern, lock shield cap, loose key handle, with copper alloy control valve bodies, stems, and gland nuts, 1/2” NPT inlet x 1/2” compression outlet

2.7 JANITOR’S SINKS

A. JS-1 Janitor’s Sink:
1. Fixture: Fiat #TSB-200 pre-cast terrazzo, 24” x 24” x 12” with integral stainless steel grid strainer outlet
2. Faucet: Chicago Faucet 911-IS, cast or wrought copper alloy, combination faucet mounted 36” above finished floor. Spout shall have pail hook, 3/4” hose connection, top or bottom wall brace. Handles on faucets shall be cast, formed, or drop forged copper alloy. Escutcheons shall be either forged copper alloy or CRS. Valves shall include concealed integral stops, 8” centers. Elevated vacuum breaker mounted 7’-6” above finished floor. Exposed parts shall be polished chrome plated.

3. Trap: 3” p-trap to match piping system.
4. Accessories: Fiat #832-AA hose and hose bracket, 30” long, 5/8” rubber hose, and stainless steel hose bracket. Mount bracket at least 18” above finished floor and 6” left of faucet center. Fiat #MSG. Stainless steel wall guards on two walls, Type 304, 20 ga, and 12” high.

2.8 HOSE BIBBS

A. HB-1 Hose Bibbs:
1. Fixture: Woodford Model 24CP with stem lock and key operator for vandal resistance, polished chrome, 3/4” inlet and model 50HF backflow preventer

B. HB-2 Hose Bibbs:
1. Fixture: Woodford Model 24CP, polished chrome, 3/4” inlet with metal wheel handle and Nidel Model 34HF vacuum breaker

2.9 WALL HYDRANTS

A. WH-1 Wall Hydrant (Freeze-less):
1. Fixture: Woodford Model 65, chrome plated, back-flow protected, with loose key operator

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Support fixtures with proper carrier for each use. 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. Install each fixture with trap easily removable for servicing and cleaning. Install fixture stops in readily accessible location for servicing.

E. Install barrier free fixtures in compliance with local code and Federal ADA Accessibility Guidelines. Install barrier free lavatory traps parallel and adjacent to wall and supplies and stops elevated to 27” above finished floor to avoid contact by wheelchair users.

F. Return fixture waste and supply piping into wall as high as practical under fixture. Provide accessible shutoff in fixture supply. Protect "barrier free" supply and drain piping with white colored wrap neatly trimmed to prevent contact with hot or sharp surfaces by user.

G. 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.

3.2 PROTECTION

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

3.3 CLEANING

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

END OF SECTION

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SECTION 23 00 00

GENERAL HVAC REQUIREMENTS

PART 1 – GENERAL
1.1 DESCRIPTION
1.2 RELATED WORK
PART 2 – PRODUCTS (NOT USED)
PART 3 – EXECUTION (NOT USED)

PART 1 - GENERAL

1.1 DESCRIPTION

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

1.2 RELATED WORK

A. Section 20 0000 - General Mechanical Requirements
B. Section 20 0513 - Motors
C. Section 20 0514 - Variable Frequency Drives
D. Section 20 0520 - Excavation and Backfill
E. Section 20 0529 - Mechanical Supporting Devices
F. Section 20 0553 - Mechanical Systems Identification
G. Section 20 0573 - Mechanical Systems Firestopping
H. Section 20 0700 - Mechanical Systems Insulation

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

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SECTION 23 05 13
MOTORS

PART 1 – GENERAL
1.1 RELATED WORK
1.2 SUBMITTALS
1.3 PRODUCT CRITERIA
PART 2 – PRODUCTS
2.1 MATERIALS
2.2 MOTORS
PART 3 – EXECUTION
3.1 INSTALLATION

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 0514 - Variable Frequency Drive (VFD) System
B. Section 26 2913 - Enclosed Controllers

1.2 SUBMITTALS

A. Shop Drawings including, but not limited to, the following:
   1. Manufacturer
   2. hp, voltage, phase, hertz, rpm
   3. Motor type
   4. Enclosure type
   5. Frame type
   6. Insulation class
   7. NEMA design designation
   8. Service factor
   9. Nominal efficiency at full load
   10. Power factor at full load
   11. Full load amperes
   12. Bearings
   13. Mountings
   14. Dimensions
   15. Weight
   16. Shaft grounding brush for motors driven by Variable Frequency Drives (VFD)

1.3 PRODUCT CRITERIA

A. Motors covered by this Specification shall conform to applicable requirements of NEMA, IEEE, ANSI, and NEC Standards and shall be UL Listed where applicable for service specified.
B. Motors shall be designed for conditions in which they will be required to perform; i.e., general purpose, splash proof, explosion proof, standard duty, high torque or other special type as required by equipment manufacturers.
C. Select motors so they do not exceed nameplate rating nor operate into service factor to meet specified duty.
D. Motors located in exposed locations 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.

PART 2 - PRODUCTS

2.1 MATERIALS

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

2.2 MOTORS

A. Voltage Ratings
   1. Refer to equipment schedules and specification sections for voltages required.
   2. Unless otherwise indicated, motors 1/3 hp and smaller shall be rated 115 V for operation on 120 V, 1 Ph, 60 Hz service.
   3. Unless otherwise indicated, motors 1/2 hp and larger shall be rated:
      a. 460 V for operation on 480 V, 3 Ph, 60 Hz service.
      b. 200 V for operation on 208 V, 3 Ph, 60 Hz service.
      c. 230 V for operation on 240 V, 3 Ph, 60 Hz service.

B. Motors shall be 4 pole (approximately 1750 rpm) unless otherwise noted.

C. Single-phase motors shall be furnished with built-in thermal overload protection.

D. Use NEMA Design B motors, normal starting torque with regreasable ball bearings, and Class B insulation unless specified otherwise or unless manufacturer of equipment on which motor is being used has more stringent requirements.
   1. Bearings shall be rated for minimum AFBMA 9, L-10 life of 26,280 hours (belted) and 200,000 hours (direct-coupled) at full-load.

E. Motors shall be rated continuous duty and have 1.15 service factor unless otherwise noted.

F. Motors Driven by Variable Frequency Drives (VFD)
   1. Motors shall comply with the latest NEMA MG-1, Section IV, Part 31.
   2. Motors shall have service factor not less than 1.0 at rated load.
   3. Insulation shall be Class F or H.
   4. Furnish each motor with shaft grounding ring utilizing conductive microfiber similar to AEGIS SGR to protect motor bearings from electrical damage.

G. Vibration shall not exceed 0.15” per second, unfiltered peak unless otherwise noted.

H. Motors (180 frames and larger) shall have provisions for lifting eyes or lugs capable of safety factor of 5.

I. Full load nominal efficiency of motors 1 hp and larger, except special-purpose motors including 2-speed or multi-speed motors, and 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
60 hp	94.5	95.0	93.6	94.5	95.0	93.6
75 hp	94.5	95.0	93.6	94.5	95.4	93.6
100 hp	95.0	95.4	93.6	95.0	95.4	94.1

J. Single-phase motors for hard starting applications (including interior locations exposed to atmosphere) shall be capacitor start type. Motors for fans and pumps located indoors may be split phase or permanent split-capacitor. Motors shall be equipped with permanently lubricated and sealed ball bearings and shall be selected for quiet operation. Motors 1/8 hp and below may be shaded pole type.

K. Refer to individual equipment section for additional requirements or specific type of motors.

L. 3 Ph, 2-speed motors shall be one winding, consequent pole, variable torque type and 1 Ph, 2-speed motors shall be capacitor start capacitor run type.

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

PART 3 - EXECUTION

3.1 INSTALLATION

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

END OF SECTION

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SECTION 23 05 50
VIBRATION ISOLATION

PART 1 – GENERAL
1.1 RELATED WORK
1.2 DESIGN CRITERIA
1.3 SUBMITTALS
1.4 SUPERVISION, INSPECTION AND CERTIFICATION
PART 2 – PRODUCTS
2.1 MATERIALS
2.2 MANUFACTURERS
2.3 TYPE 1 MOUNTS (NEOPRENE PAD)
2.4 TYPE 2 MOUNTS (NEOPRENE PAD)
2.5 TYPE 3 MOUNTS (UNHOUSED SPRING WITH NEOPRENE)
2.6 TYPE 4 MOUNTS (RESTRAINED SPRING WITH NEOPRENE)
2.7 TYPE 5 HANGERS (SPRING HANGER WITH NEOPRENE)
2.8 TYPE 6 HANGERS (PRECOMPRESSED SPRING HANGER WITH NEOPRENE)
2.9 TYPE AG PIPE ANCHORS/GUIDES
2.10 TYPE T THRUST RESTRAINTS
2.11 FLEXIBLE PIPING CONNECTORS
2.12 PERFORMANCE
PART 3 – EXECUTION
3.1 INSTALLATION
3.2 FLEXIBLE PIPING CONNECTIONS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 0529 - Mechanical Supporting Devices
B. Section 23 3314 - Ductwork Specialties (Duct Flexible Connections)
C. Section 23 1214 – Liquid Fuel Systems (Fuel System Flexible Connections)

1.2 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.

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 over 25 hp shall be balanced in accordance with the following maximum rms velocity levels:
   1. Fans: 0.15 inch/sec

1.3 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

B. Provide seismic restraints for all vibration-isolated equipment. Restraints shall not be in contact with the equipment during its normal operation, but shall be capable of withstanding loads imposed by seismic acceleration of the equipment in any direction during seismic event.

C. Refer to Section 20 0550 - Seismic Anchorage and Restraints for additional requirements.

1.4 SUPERVISION, INSPECTION AND CERTIFICATION

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

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials used shall retain their isolation characteristics for life of equipment served. Elastomeric materials shall comply with ASTM D2240 and shall be oil-resistant industrial grade neoprene.

B. Isolators shall be treated to resist corrosion.

C. Isolation devices subject to weather shall have either hot-dip or cold-dip galvanized, cadmium plated, or neoprene coated finish after fabrication and be furnished with limit stops to resist wind.

D. Vibration isolator springs shall have minimum additional travel to solid equal to 50% of rated deflection.

E. Ratio of lateral to vertical stiffness of vibration isolators shall not be less than 0.8 or greater than 2.0.

F. Coordinate selection of devices with isolator and equipment manufacturer.

2.2 MANUFACTURERS

A. Mason Industries, Amber/Booth Co., Aeroflex-VMC-Korfund. Vibration Eliminator, Vibro-Acoustics, 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.

2.3 TYPE 1 MOUNTS (NEOPRENE PAD)

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

2.4 TYPE 2 MOUNTS (NEOPRENE PAD)

A. Mason Type ND or rails Type RND, double deflection neoprene mounts with cast-in metal inserts for bolting to equipment.

B. Both surfaces shall be rib molded for skid resistance. On equipment such as small vent sets steel rails shall be used above mountings to compensate for overhang.

2.5 TYPE 3 MOUNTS (UNHOUSED SPRING WITH NEOPRENE)

A. Mason Type SLF, combination spring and neoprene with rib molded base. Spring type isolators shall be free standing and laterally stable without any housing and complete with 1/4" neoprene acoustical friction pads between baseplate and support.

B. Mountings shall have leveling bolts rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of compressed height of spring at rated load.

2.6 TYPE 4 MOUNTS (RESTRAINED SPRING WITH NEOPRENE)

A. Mason Type SLR, combination spring and neoprene with rib molded base similar to Type 3 above, but shall have 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.

2.7 TYPE 5 HANGERS (SPRING HANGER WITH NEOPRENE)

A. Mason Type 30N, vibration hangers with steel spring and neoprene element in series. Neoprene element shall be molded with rod isolation bushing that passes through hanger box. Spring diameters and hanger box lower hole sizes shall be large enough to permit hanger rod to swing through 30° arc before contacting hole and short circuiting spring.

B. Mason Type DNHS may be used where load rating and specified deflection cannot be accommodated by Type 30N.

2.8 TYPE 6 HANGERS (PRECOMPRESSED SPRING HANGER WITH NEOPRENE)

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

2.9 TYPE AG PIPE ANCHORS/GUIDES

A. Mason Type ADA all-directional acoustical pipe anchors and Type VSG guides for vertical piping consisting of telescopic arrangement of 2 sizes of steel tubing separated by minimum 1/2" thickness of heavy duty neoprene and neoprene isolation material. Vertical restraints shall prevent vertical travel in either direction. Allowable loads on isolation materials shall not exceed 500 psi and design shall be balanced for equal resistance in any direction.

B. Submittals shall include supporting calculations by registered mechanical or civil engineer indicating anchor/guide loads and isolator selection.

2.10 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.

2.11 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 (in)	Minimum Live Length (in)
2-1/2” and smaller	12”
3” and 4”	18”
5” and larger	24”

D. Refrigerant System:

1. Where manufacturer recommends flexible connection, provide 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.

2.12 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)
Air-Cooled Condensers:	-	-	1	0.75	1	1.5	1	2.5	1	3.5
Emergency Generator Muffler Suspended:	-	-	5	1.5	5	1.5	5	2.0	5	2.0

, 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, Heat Pump Units — Type 5 with minimum deflection of 0.5" for 600 cfm or less and 0.75" for over 600 cfm. Use Type 1 between wall and Fan Coil Unit for wall amounted application.

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.

Vertical Pipe Risers: Use Type 6 hangers, Type AG anchors and guides. Refer to Section 20 0529 - Mechanical Supporting Devices for additional riser support requirements.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install and adjust vibration isolation devices as specified, as shown on drawings and according to manufacturer's recommendations.
   1. Adjust isolators after piping system is at operating weight.
   2. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
   3. Adjust active height of spring isolators.
   4. Adjust restraints to permit free movement of equipment within normal mode of operation.
   5. Adjust air-spring leveling mechanism.

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

3.2 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. Install flexible connections on equipment side of shut off valves and horizontal and parallel to equipment shafts where applicable.

D. For non-metallic flexible piping connections, 2-1/2" and larger, use flange type recommended by manufacturer.

END OF SECTION

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SECTION 23 05 95
AIR SYSTEMS TEST ADJUST BALANCE

PART 1 – GENERAL
1.1 RELATED WORK
1.2 DESCRIPTION
1.3 SUBMITTALS
1.4 REFERENCE STANDARDS
PART 2 – PRODUCTS
2.1 INSTRUMENTATION
2.2 INSTRUMENT TEST HOLE PLUGS
PART 3 – EXECUTION
3.1 GENERAL
3.2 PLANNING PHASE
3.3 SET-UP PHASE
3.4 FINAL BALANCE PHASE

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 0901 - Control Systems Integration
B. Section 23 0993 - Control Sequences
C. Section 23 3314 - Ductwork Specialties

1.2 DESCRIPTION

A. This Contractor shall be responsible for providing complete testing, adjusting and balancing (TAB) work for air systems, such as supply fans, exhaust fans, air terminal devices, diffusers, grilles and other air moving processes included in this project.
B. Work required shall consist of setting volume flow rates and adjusting speed controls, recording data, making tests, and preparing reports, as specified herein.
C. Scope of work includes TAB of new work specified herein and includes all equipment, distribution systems, and terminal units connected.
D. TAB work shall be performed by persons trained in TAB work and certified by Associated Air Balance Council (AABC), National Environmental Balancing Bureau (NEBB), or Testing, Adjusting and Balancing Bureau (TABB). Procedures shall be in accordance with the latest edition of AABC, NEBB or TABB Standards, ASHRAE - 2015 HVAC Application Chapter 38, and as detailed herein.
E. Mechanical Contractors who are members of AABC or NEBB and who have qualified personnel available to perform work may submit Quality Assurance Submittal for approval. Mechanical Contractors who cannot meet these requirements shall subcontract with independent TAB Contractor who meets these requirements. TAB subcontractor shall prepare Quality Assurance Submittal for Contractor to submit for approval.
F. TAB Contractor shall perform ductwork leakage tests. Refer to Section 23 3114 - Ductwork. Test equipment will be provided by Mechanical Contractor.
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 fan sheaves, motor sheaves and/or drive belts.
H. TAB work shall not proceed until assigned personnel have been approved by Architect/Engineer via Quality Assurance Submittal. Coordinate each phase of TAB work with overall project schedule. Each phase of TAB work shall be done in timely manner as detailed herein. Fieldwork must be completed before occupancy. Certificate of Substantial Completion shall not be issued until after Final Report is accepted by Architect/Engineer.

1.3 SUBMITTALS

A. General:
1. Make submittals in accordance with project submittal procedure. Submit minimum of 5 copies of submittals unless more 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. All information sheets shall be 8-1/2" x 11" white bond paper. Use preprinted forms of NEBB, AABC or TABB 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

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

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

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

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

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

PART 2 - PRODUCTS

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

2.2 INSTRUMENT TEST HOLE PLUGS
A. Center-pull plugs similar to CPW Series by Mocap. Plug material shall be low-density polyethylene.

PART 3 - EXECUTION

3.1 GENERAL

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

B. Unless otherwise specified, maximum acceptable offset tolerance is plus or minus 10% of the design flow rates as indicated on drawings and/or as scheduled.

C. For areas such as the generator room where supply airflow rates and return/exhaust airflow rates are used to maintain specific pressure relationships, higher airflow rate of either supply or return/exhaust air shall be balanced to 0 to +10% of design flow rate. Lower airflow rate of either supply or return/exhaust air shall be balanced to provide negative space pressure.

3.2 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 requirements.
   a. Samples: Provide copies of all forms to be used.
   b. General narratives: Furnish written narratives of all procedures used. Include separate narratives for each fan and air handling system. Identify flow-measuring devices to be used at each fan, air terminal device, and air outlet. Narrative shall include statement that every air outlet shall be measured and adjusted. Provide different narratives for constant and variable flow systems. Narratives shall include references to published standards of NEBB or AABC. Narratives shall include measuring instruments to be used and ranges required for each procedure. Narratives shall include specified adjustment tolerances.
   c. Air system narratives: Provide narratives for each air system which shall include procedures for measuring static pressures at each component of air handling system to generate a static pressure profile. Measurements shall be made to measure performance of system in all operating modes including economizer mode using 100% outside air where applicable. Differentiate between constant and variable flow systems.
   d. 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.
   e. Branch duct and air outlet measurements: Indicate on preprinted forms all measurements to be taken in field. Include branch duct or air outlet identification, system, space served, location, and design flow rates (include zone and system summaries). Indicate duct or air outlet neck size, make, model number, and design velocities.
   f. Pressure relationship test narrative: Narratives shall describe how to obtain and measure pressure relationships between spaces as per schedule or as listed below.
      1) Generator rooms .
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 including shutoff and bypass dampers
   n. Set up of controls and control devices

3. Measuring Instrument List - list what measuring instruments will be used for each procedure. Indicate ranges required for each procedure. Provide data on each measuring instrument to be used. This data shall include:
   a. Manufacturer name and model number
   b. Measurement range
   c. Pressure/temperature limits
   d. Date put into service
   e. Date of last calibration
   f. Include certificate from calibration firm
4. Architect/Engineer reserves the right to request adjustments in any procedure and/or ask for recalibration of any measuring instrument, which has not been recalibrated within past year.

3.3 SET-UP PHASE

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

3.4 FINAL BALANCE PHASE

A. Procedure:
   1. Perform all procedures as per Planning Phase narrative. Correct all deficiencies and redo procedures as required before submitting Final Report.
B. Final Report:
   1. Submit report to Architect/Engineer and Mechanical Contractor indicating all data and measurements as per requirements herein and per Planning Phase narrative. Do not submit partial or incomplete reports.
C. Final Report Adjustments:
   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 23 09 01A

CONTROL SYSTEMS

PART 1 – GENERAL
1.1 RELATED WORK
1.2 SECTION INCLUDES
1.3 QUALITY ASSURANCE
1.4 SUBMITTALS
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PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 0902 Control Valves and Dampers
B. Section 23 0903 Control Instrumentation
C. Section 23 0905 Instrument Point List
D. Section 23 0993 Control Sequences

E. Section 26 0519 Low-Voltage Electrical Power Conductors and Cables
F. Section 26 0533 Raceway and Boxes for Electrical Systems

1.2 SECTION INCLUDES

A. Complete System of Automatic Controls.
B. Controls Components, Wiring and Material.

1.3 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum five years' experience.
B. TCC: Company specializing in the work of this section with minimum five years temperature control experience.
C. Technician: Minimum five years' experience installing commercial temperature control systems.
D. TCCs are limited to firms regularly employing a minimum of five full-time temperature control technicians within 100 miles of the job site.

1.4 SUBMITTALS

A. Equipment Coordination:
   1. The Controls Contractor shall obtain approved equipment submittals from other contractors to determine equipment wiring connections, to choose appropriate controllers, and to provide programming.
   2. Control valve selections shall be based on flow rates shown in approved shop drawings.
   3. Coordinate the control interface of all equipment with the equipment manufacturers prior to submittal submission.
B. Shop Drawings:
   1. Submit shop drawings per Division 01. In addition, submit an electronic copy of the shop drawings in Adobe Acrobat (.pdf) format to the Owner for review.
   2. Cross-reference all control components and point names in a single table located at the beginning of the submittal with the identical nomenclature used in this section.
   3. Submittal shall also include a trunk cable schematic diagram depicting operator workstations, control panel locations and a description of the communication type, media and protocol.
   4. System Architecture: Provide riser diagrams of wiring between central control unit and all control panels. This shall include specific protocols associated with each level within the architecture. Identify all interface equipment between CPU and control panels. The architecture shall include interface requirements with other systems including, but not limited to, security systems, lighting control, fire alarm, elevator status, and power monitoring system.
   5. Diagrams shall include:
      a. Wiring diagrams and layouts for each control panel showing all termination numbers.
      b. Schematic diagrams for all control, communication, and power wiring. Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturers' model numbers and functions. Show all interface wiring to the control system.
      c. Identification of all control components connected to emergency power.
      d. Schematic diagrams for all field sensors and controllers.
      e. A schematic diagram of each controlled system. The schematics shall have all control points labeled. The schematics shall graphically show the location of all control elements in the system.
      f. A schematic wiring diagram for each controlled system. Each schematic shall have all elements labeled. Where a control element is the same as that shown on the control system schematic, label it with the same name. Label all terminals.
      g. A tabular instrumentation list for each controlled system. The table shall show element name, type of device, manufacturer, model number and product data sheet number.
      h. All installation details and any other details required to demonstrate that the system will function properly.
      i. All interface requirements with other systems.
   6. The network infrastructure shall conform to the published guidelines for wire type, length, number of nodes per channel, termination, and other relevant wiring and infrastructure criteria as published. The number of nodes per channel shall be no more than 80% of the defined segment (logical or physical) limit in order to provide future system enhancement with minimal infrastructure modifications.

7. Sequences: Submit a complete description of the operation of the control system, including sequences of operation. The description shall include and reference a schematic diagram of the controlled system. The wording of the control sequences in the submittal shall match verbatim that included in the construction documents to ensure there are no sequence deviations from that intended by the Architect/Engineer. Clearly highlight any deviations from the specified sequences on the submittals.
8. Points List Schedule: Submit a complete points list of all points to be connected to the TCS and FMCS. The points list for each system controller shall include both inputs and outputs (I/O), point number, the controlled device associated with the I/O point, the location of the I/O device, and reference drawings. Where a control point is the same as that shown on the control system schematic, label it with the same name. Points list shall specifically identify alarms, trends, event history, archive, totalization, graphic points, and all mapped points from other systems (security systems, lighting control, fire alarm, etc.). Provide points lists, point naming convention, and factory support information for systems provided and integrated into the FMCS.
9. Damper Schedule: Schedule shall include a separate line for each damper and a column for each of the damper attributes:
    a. Damper Identification Tag.
    b. Location.
    c. Damper Type.
    d. Damper Size.
    e. Duct Size.
    f. Arrangement.
    g. Blade Type.
    h. Velocity.
    i. Pressure Drop.
    j. Fail Position.
    k. Actuator Identification Tag.
    l. Actuator Type.
    m. Mounting.
10. Valve Schedule: Valve manufacturer shall size valves and create a valve schedule. Schedule shall include a separate line for each valve and a column for each of the valve attributes:
    a. Valve Identification Tag.
    b. Location.
    c. Valve Type.
    d. Valve Size.
    e. Pipe Size.
    f. Configuration.
    g. Flow Characteristics.
    h. Capacity.
    i. Valve CV.
    j. Design Pressure Drop.
    k. Pressure Drop at Design Flow.
    l. Fail Position.
    m. Close-off Pressure.
    n. Valve and Actuator Model Number and Type.
11. Airflow Measuring Station Schedule:
    a. The manufacturer's authorized representative shall prepare the airflow measuring station submittal, or review and approve in writing the submittal prepared by the TCC prior to submission to the Architect/Engineer and prior to installation. The representative shall review air handling equipment submittals and duct fabrication drawings to ensure that all AFMS locations meet the appropriate parameters to achieve proper installation and the specified accuracy. Comply with all manufacturer's installation requirements including straight up and downstream duct lengths. Install airflow straighteners if required by the manufacturer based on installation constraints. The Architect/Engineer shall be notified for approval of any deviations.
    b. Submit product data sheets for airflow measuring devices indicating minimum placement requirements, sensor density, sensor distribution, and installed accuracy to the host control system.
    c. Submit installation, operation, and maintenance documentation.

12. Product Data Sheets: Required for each component that includes: unique identification tag that is consistent throughout the submittal, manufacturer's description, technical data, performance curves, installation/maintenance instructions, and other relevant items. When manufacturer's literature applies to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawings shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cutsheets to fulfill submittal requirements.
13. Provide PICS files indicating the BACnet® functionality and configuration of each device.
14. Provide documentation of submitted products that have been tested and listed by the BACnet Testing Laboratory (BTL), or provide a letter on the manufacturer's company letterhead indicating the anticipated date by which testing is expected to be completed. If, for any reason, BTL testing and listing has not been completed, a written commitment to upgrade installed controls to a version that meets BTL testing and listing requirements in the event that problems are found during BTL testing is required.
15. Graphic Display: Include a sample graphic of each system and component identified in the points list with a flowchart (site map) indicating how the graphics are to be linked to each other for system navigation.
16. Software: A list of operating system software, operator interface software, color graphic software, and third-party software.
17. Control System Demonstration and Acceptance: Provide a description of the proposed process, along with all reports and checklists to be used.
18. Clearly identify work by others in the submittal.
19. Quantities of items submitted may be reviewed but are the responsibility of the Contractor to verify.

C. Operation and Maintenance Manual:
1. In addition to the requirements of Section 23 05 00, submit an electronic copy of the O&M manuals in PDF format.
2. Provide three complete sets of manuals.
3. Each O&M manual shall include:
   a. Table of contents with indexed tabs dividing information as outlined below.
   b. Definitions: List of all abbreviations and technical terms with definitions.
   c. Warranty Contacts: Names, addresses, and 24-hour telephone numbers of contractors installing equipment and controls and service representatives of each.
   d. Licenses, Guarantees, and Warranties: Provide documentation for all equipment and systems.
   e. System Components: Alphabetical list of all system components, with the name, address, and telephone number of the vendor.
   f. Operating Procedures: Include procedures for operating the control systems; logging on/off; enabling, assigning, and reporting alarms; generating reports; collection, displaying, and archiving of trended data; overriding computer control; event scheduling; backing up software and data files; and changing setpoints and other variables.
   g. Programming: Description of the programming language (including syntax), statement descriptions (including algorithms and calculations used), point database creation and modification, program creation and modification, and use of the editor.
   h. Engineering, Installation, and Maintenance: Explain how to design and install new points, panels, and other hardware; recommended preventive maintenance procedures for all system components, including a schedule of tasks (inspection, cleaning, calibration, etc.), time between tasks, and task descriptions; how to debug hardware problems; and how to repair or replace hardware. A list of recommended spare parts.
   i. Original Software: Complete original issue CDs for all software provided, including operating systems, programming language, operator workstation software, and graphics software.
   j. Software: One set of CDs containing an executable copy of all custom software created using the programming language, including the setpoints, tuning parameters, and object database.
   k. Graphics: A glossary or icon symbol library detailing the function of each graphic icon and graphics creation and modification. One set of CDs containing files of all color graphic screens created for the project.

D. Training Manual:
1. Provide a course outline and training manuals for each training class.

E. Record Documents:
1. Submit record documentation per Division 01.

2. Provide a complete set of "as-built" drawings and application software on CDs. Provide drawings as AutoCAD™ or Visio™ compatible files. Provide two copies of the "as-built" drawings with revisions clearly indicated in addition to the documents on compact disk. All as-built drawings shall also be installed on the FMCS server in a dedicated directory. Provide all product data sheets in PDF format.
3. Submit two hard copies and one electronic copy of as-built versions of the shop drawings, including product data and record drawings with revisions clearly indicated. Provide floor plans showing actual locations of control components including panels, thermostats, sensors, and hardware.
4. Provide all completed testing and commissioning reports and checklists, along with all trend logs for each system identified in the points lists.
5. Submit printouts of all graphic screens with current values (temperatures, pressures, etc.) to the A/E verifying completion and proper operation of all points.

1.5 DELIVERY, STORAGE AND HANDLING

A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons through shipping, storage, and handling as required to prevent equipment damage. Store equipment and materials inside and protected from weather.

B. Factory-Mounted Components: Where control devices specified in this section are indicated to be factory mounted on equipment, arrange for shipping control devices to unit manufacturer.

1.6 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Control Valves.
B. Flow Switches.
C. Temperature Sensor Sockets.
D. Gauge Taps.
E. Automatic Dampers.
F. Flow Meters.

1.7 AGENCY AND CODE APPROVALS

A. All products shall have the following agency approvals. Provide verification that the approvals exist for all submitted products with the submittal package.
1. UL-916; Energy Management Systems.
2. C-UL listed to Canadian Standards Association C22.2 No. 205-M1983 "Signal Equipment."
3. EMC Directive 89/336/EEC (European CE Mark)
4. FCC, Part 15, Subpart J, Class A Computing Devices

1.8 ACRONYMS

A. Acronyms used in this specification are as follows:

B-AAC	BACnet Advanced Application Controller
B-ASC	BACnet Application Specific Controller
BTL	BACnet Testing Laboratories
DDC	Direct Digital Controls
FMCS	Facility Management and Control System
GUI	Graphic User Interface
IBC	Interoperable BACnet Controller
IDC	Interoperable Digital Controller
LAN	Local Area Network
NAC	Network Area Controller
ODBC	Open Database Connectivity
OOT	Object Oriented Technology
OPC	Open Connectivity via Open Standards
PICS	Product Interoperability Compliance Statement
PMI	Power Measurement Interface
POT	Portable Operator's Terminal
TCC	Temperature Control Contractor
TCS	Temperature Control System
WAN	Wide Area Network

1.9 SUMMARY

A. Provide new standalone FMCS for this project with connection to city server system.

B. TCC shall furnish all labor, materials, equipment, and service necessary for a complete and operating Temperature Control System (TCS) and Facility Management and Control System (FMCS) using Direct Digital Controls as shown on the drawings and as described herein.

C. All labor, material, equipment and software not specifically referred to herein or on the plans that is required to meet the intent of this specification shall be provided without additional cost to the Owner.

D. The Owner shall be the named license holder of all software associated with any and all incremental work on the project.

1.10 SYSTEM DESCRIPTION

A. The entire TCS shall be comprised of a network of interoperable, standalone digital controllers communicating via the following protocol to an NAC. Temperature Control System products shall be as specified below.

B. The FMCS shall include Network Area Controller or Controllers (NAC) within each facility. The NAC shall connect to the Owner's local or wide area network, depending on configuration. Provide access to the system, either locally in each building or remotely from a central site or sites, through standard Web browsers, via the Internet, and/or via local area network.

C. Provide materials and labor necessary to connect factory supplied control components.

D. Provide central and remote hardware, software, and interconnecting wire and conduit.

E. The FMCS shall include automated alarming software capable of calling e-mail compatible cellular telephones and pagers. The e-mail alarm paging system shall be able to segregate users, time schedules, and equipment and be capable of being programmed by the Owner.

F. For the dedicated configuration tool provided, it is preferable that it be launched from within the applicable Network Management Software. If not, include any software required for controller configuration as a leave-behind tool with enough license capability to support the installation.

1.11 SOFTWARE LICENSE AGREEMENT

A. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s). In addition, the Owner shall receive ownership of all job-specific configuration documentation, data files, configuration tools, and application-level software developed for the project. This shall include, but is not limited to, all custom, job-specific software code and documentation for all configuration and programming that is generated for a given project and/or configured for use with the NAC, FMCS Server(s), and any related LAN/WAN/intranet and/or Internet connected routers and devices. Provide the Owner with all required IDs and passwords for access to any component or software program. The Owner shall determine which organizations shall be named in the SI organization ID ("orgid") of all software licenses. Owner shall be free to direct the modification of the "orgid" in any software license, regardless of supplier.

1.12 JOB CONDITIONS

A. Cooperation with Other Trades: Coordinate the Work of this section with that of other sections to ensure that the Work will be carried out in an orderly fashion. It is this Contractor's responsibility to check the Contract Documents for possible conflicts between the Work of this section and that of other crafts in equipment location; pipe, duct and conduit runs; electrical outlets and fixtures; air diffusers; and structural and architectural features.

1.13 WARRANTY

A. Refer to Section 23 05 00 for warranty requirements.

B. Within the warranty period, any defects in the work provided under this section due to faulty materials, methods of installation or workmanship shall be promptly (within 48 hours after receipt of notice) repaired or replaced by this Contractor at no expense to the Owner.

C. Warranty requirements include furnishing and installing all FMCS software upgrades issued by the manufacturer during the one-year warranty period.

D. Update all software and back-ups during warranty period and all user documentation on the Owner's archived software disks.

1.14 WARRANTY ACCESS

A. The Owner shall grant to this Contractor reasonable access to the TCS and FMCS during the warranty period.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

Acceptable Manufacturers	BACnet Protocol
Honeywell WEBs-AX	●

2.2 SYSTEM ARCHITECTURE

A. General:

1. The Temperature Control System (TCS) and Facility Management Control System (FMCS) shall consist of a network of interoperable, standalone digital controllers, a computer system, graphic user interface software, printers, network devices, valves, dampers, sensors, and other devices as specified herein.
2. The installed system shall provide secure password access to all features, functions and data contained in the overall FMCS.
3. The FMCS shall be based on Tridium's Niagara Framework and adhere to the open NICS licensing. The FMCS shall be comprised of Java Application Control Engine or Controllers (JACE) within each facility. The system shall support JACE Version 3.8. The JACE shall connect to the local area network, depending on configuration. Access to the system, either locally in each building, or remotely from a central site or sites, shall be accomplished through standard Web browsers, via the Internet and/or local area network. Each JACE is capable communicate to LonMark/LonTalk (ILC) and/or BACnet (IBC) controllers and other open and legacy protocol systems/devices.
4. The FMCS shall be based on the NiagaraAX Framework (or "NiagaraAX"), a Java-based framework developed by Tridium. NiagaraAX provides an open automation infrastructure that integrates diverse systems and devices (regardless of manufacturer, communication standard or software) into a unified platform that can be easily managed in real time over the Internet using a standard Web browser. Systems not developed on the NiagaraAX Framework platform are unacceptable.
5. The entire Temperature Control System (TCS) shall be comprised of a network of interoperable, stand-alone digital controllers communicating via LonMark/LonTalk and/or BACnet communication protocols to Java Application Control Engines (JACE) which communicate BACnet TCP/ IP or OBIX TCP/IP to the Niagara AX Server. Niagara AX Supervisor Software to be installed on owner provided server.
6. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s). All Niagara AX software licenses shall have the "accept.station.in=*" and "accept.station.out=*"and "accept.wb.in=*" and "accept.wb.out=*" section of the software licenses. The intent is to insure that the installed Niagara AX products may be completely open for integrations. Owner shall be free to direct the modification of any software license, regardless of supplier. In addition, the owner shall receive ownership of all job specific software configuration documentation, data files, and application-level software developed for the project. This shall include all custom, job specific software code and documentation for all configuration and programming that is generated for a given project and/or configured for use with Niagara Framework (Niagara AX) based controllers and/or servers and any related LAN / WAN / Intranet and Internet connected routers and devices. Any and all required I.D.'s and passwords for access to any component or software program shall be provided to the owner. Provide all software necessary for developing software algorithms in all supervisory, programmable and application specific direct digital controllers which is licensed to the Owner.

B. Open, Interoperable, Integrated Architectures:

1. All components and controllers supplied under this Division shall be true "peer-to-peer" communicating devices. Components or controllers requiring "polling" by a host to pass data are not acceptable.
2. The supplied system must be able to access all data using standard Web browsers without requiring proprietary operator interface and configuration programs. An Open Database Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on a supplier-installed server for all database access. Systems requiring proprietary database and user interface programs are not acceptable.
3. Hierarchical or "flat" topologies are required to have system response times as indicated below and to manage the flow and sharing of data without unduly burdening the customer's internal intranet network.
    a. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces.

b. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote or dial-up connected user interfaces.

2.3 NETWORKS

A. The Local Area Network (LAN) shall be a 100 megabits/sec Ethernet network supporting BACnet, Java, XML, HTTP, and SOAP. Provide support for multiple Network Area Controllers (NACs), user workstations and, if specified, a local server.

B. Local area network minimum physical and media access requirements:
   1. Ethernet; IEEE Standard 802.3.
   2. Cable; 100 Base-T, UTP-8 wire, Category 6.
   3. Minimum throughput; 100 Mbps.

C. Communication conduits shall not be installed closer than six feet from 110VAC or higher transformers or run parallel within six feet of electrical high power cables. Route the cable as far from interference generating devices as possible. Where communication wire must cross 110VAC or higher wire, it must do so at right angles.

D. Ground all shields (earth ground) at one point only to eliminate ground loops. Provide all shield grounding at the controller location, with the shield at the sensor/device end of the applicable wire being left long and "safed" off in an appropriate manner.

E. There shall be no power wiring in excess of 30 VAC rms run in conduit with communications wiring. In cases where signal wiring is run in conduit with communication wiring, run all communication wiring and signal wiring using separate twisted pairs (24awg) in accordance with the manufacturer's wiring practices.

2.4 REMOTE NETWORK ACCESS

A. For Local Area Network installations, provide access to the LAN from a remote location via the Internet. The Owner shall provide a connection to the Internet to enable this access via high speed cable modem, asynchronous digital subscriber line (ADSL) modem, ISDN line, T1 Line or via the customer's intranet to a corporate server providing access to an Internet Service Provider (ISP). Customer agrees to pay monthly access charges for connection and ISP.

2.5 NETWORK AREA CONTROLLER (NAC)

A. The TCC shall supply one or more Network Area Controllers (NAC) as part of this contract. Number of NACs required depends on the type and quantity of devices provided under Divisions 23 and 26. The TCC shall determine the quantity and type of devices.

B. Each NAC shall provide the interface between the LAN or WAN and the field control devices and shall provide global supervisory control functions over the control devices connected to the NAC. It shall execute application control programs to provide:
   1. Calendar functions.
   2. Scheduling.
   3. Trending.
   4. Alarm monitoring and routing.
   5. Time synchronization.
   6. Integration of all controller data.
   7. Network Management functions.

C. The Network Area Controller shall provide the following hardware features as a minimum:
   1. One Ethernet Port – 10/100 Mbps.
   2. One RS-232 port.
   3. One LonWorks Interface Port – 78KB FTT-10A (for LonWorks systems only).
   4. One RS-485 port.
   5. Battery backup.
   6. Flash memory for long-term data backup. (If battery backup or flash memory is not supplied, the controller shall contain a hard disk with at least 1 gigabyte storage capacity.)
   7. The NAC must be capable of operation over a temperature range of 32°F to 122°F.
   8. The NAC must be capable of withstanding storage temperatures of between 0°F and 158°F.
   9. The NAC must be capable of operation over a humidity range of 5% RH to 95% RH, non-condensing.

D. The NAC shall provide multiple user access to the system and support for ODBC or SQL. Databases resident on the NAC shall be ODBC-compliant or must provide an ODBC data access mechanism to read and write data stored within it.

E. The NAC shall support standard Web browser access via the Internet or an intranet and a minimum of five (5) simultaneous users.

F. Event Alarm Notification and Actions:
   1. The NAC shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.
   2. The NAC shall be able to route any alarm condition to any defined user location whether connected to a LAN, remote via dial-up telephone connection, or WAN.
   3. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including, but not limited to:
      a. Alarm
      b. Normal
   4. Provide for the creation of a minimum of eight alarm classes with different routing and acknowledgement properties, e.g. security, HVAC, Fire, etc.
   5. Provide timed (scheduled) routing of alarms by class, object, group, or node.
   6. Provide alarm generation from binary object “runtime” and/or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.

G. Treat control equipment and network failures as alarms and annunciated.

H. Annunciate alarms in any of the following manners as defined by the user:
   1. Screen message text.
   2. E-mail of the complete alarm message to multiple recipients. Provide the ability to route and e- mail alarms based on:
      a. Day of week.
      b. Time of day.
      c. Recipient.
   3. Pagers via paging services that initiate a page on receipt of e-mail message.
   4. Graphic with flashing alarm object(s).
   5. Printed message, routed directly to a dedicated alarm printer.

I. The FMCS shall record the following for each alarm:
   1. Time and date.
   2. Location (building, floor, zone, office number, etc.).
   3. Equipment tag.
   4. Acknowledge time, date, and user who issued acknowledgement.
   5. Number of occurrences since last acknowledgement.

J. Give defined users proper access to acknowledge any alarm.

K. A log of all alarms shall be maintained by the NAC and/or a server (if configured in the system) and shall be available for review by the user.

L. Provide a “query” feature to allow review of specific alarms by user-defined parameters.

M. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.

N. An error log to record invalid property changes or commands shall be provided and available for review by the user.

2.6 BACNET FMCS

A. The intent of this specification is to provide a peer-to-peer networked, standalone, distributed control system with the capability to integrate ANSI/ASHRAE Standard 135-2001 BACnet, MODBUS, OPC, and other open and proprietary communication protocols in one open, interoperable system.

B. The supplied computer software shall employ object-oriented technology (OOT) for representation of all data and control devices in the system. Adherence to industry standards including the latest ANSI/ASHRAE Standard 135 (BACnet) to assure interoperability between all system components is required. For each BACnet device, the device supplier must provide a PICS document showing the installed device’s compliance level. Minimum compliance is Level 3; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via Ethernet (BACnet Ethernet/IP) and/or RS-485 (BACnet MSTP).

C. Interoperable BACnet Controller (IBC):
   1. Controls shall be microprocessor based Interoperable BACnet Controllers (IBC) in accordance with the latest ANSI/ASHRAE Standard 135. Provide IBCs for unit ventilators, fan coils, heat pumps, terminal air boxes (TAB) and other applications. The application control program shall reside in the same enclosure as the input/output circuitry that translates the sensor signals. Provide a PICS document showing the installed system’s compliance level to ANSI/ASHRAE Standard 135. Minimum compliance is Level 3.

2. The IBCs shall be listed by the BACnet Testing Laboratory (BTL) as follows:
   a. BACnet Building Controller(s) (B-BC).
   b. BACnet Advanced Application Controller(s) (B-ACC).
   c. BACnet Application Specific Controller(s) (B-ASC).
3. The IBCs shall communicate with the NAC via an Ethernet connection at a baud rate of not less than 10 Mbps.
4. Each IBC sensor shall connect directly to the IBC and shall not use any of the I/O points of the controller. The IBC Sensor shall provide a two-wire connection to the controller that is polarity and wire type insensitive. The IBC sensor shall provide a communications jack for connection to the BACnet communication trunk to which the IBC controller is connected. The IBC sensor, the connected controller, and all other devices on the BACnet bus shall be accessible by the POT.
5. All IBCs shall be fully application programmable and shall at all times maintain their BACnet Level 3 compliance. Controllers offering application selection only (non-programmable) require a 10% spare point capacity to be provided for all applications. Store all control sequences within or programmed into the IBC in non-volatile memory that does not depend on a battery to be retained.
6. The Contractor supplying the IBCs shall provide documentation for each device, with the following information at a minimum:
   a. BACnet Device; MAC address, name, type and instance number.
   b. BACnet Objects; name, type and instance number.
7. It is the responsibility of the Contractor to ensure that the proper BACnet objects are provided in each IBC.

D. Object Libraries
1. A standard library of objects shall be included for development and setup of application logic, user interface displays, system services, and communication networks.
2. The objects in this library shall be capable of being copied and pasted into the user's database and shall be organized according to their function. In addition, the user shall have the capability to group objects created in their application and store the new instances of these objects in a user-defined library.
3. In addition to the standard libraries specified here, the system supplier shall maintain an on-line accessible (over the Internet) library, available to all registered users, to provide new or updated objects and applications as they are developed.
4. All control objects shall conform to the control objects specified in the BACnet specification.
5. The library shall include applications or objects for the following functions, at a minimum:
   a. Scheduling Object: The schedule must conform to the schedule object as defined in the BACnet specification, providing seven-day plus holiday and temporary scheduling features and a minimum of 10 on/off events per day. Data entry to be by graphic sliders to speed creation and selection of on-off events.
   b. Calendar Object: The calendar must conform to the calendar object as defined in the BACnet specification, providing 12-month calendar features to allow for holiday or special event data entry. Data entry to be by graphic "point-and-click" selection. This object must be "linkable" to any or all scheduling objects for effective event control.
   c. Override Object: Provide override object that is capable of restarting equipment turned off by other energy saving programs to maintain occupant comfort or for equipment protection.
   d. Start-Stop Time Optimization Object: Provide a start-stop time optimization object to start equipment just early enough to bring space conditions to desired conditions by the scheduled occupancy time. Also, allow equipment to be stopped before the scheduled unoccupied time just far enough ahead to take advantage of the building's "flywheel" effect for energy savings. Provide automatic tuning of all start-stop time object properties based on historical performance.
   e. Demand Limiting Object: Provide a demand-limiting object that is capable of controlling demand for any selected energy utility (electric, oil, gas, etc.). The object shall be able to monitor a demand value and predict (using a sliding window prediction algorithm) the demand at the end of the user-defined interval period (1 to 60 minutes). This object shall also accommodate a utility meter time sync pulse for fixed interval demand control. Upon a prediction that will exceed the user-defined demand limit (supply a minimum of 6 per day), the demand limiting object shall issue shed commands to either turn off user specified loads or modify equipment setpoints to provide the desired energy reduction. If the list of sheddable equipment is not enough to reduce the demand to below the setpoint, display a message on the user's screen (as an alarm) instructing the user to take manual actions to maintain the desired demand. The shed lists are specified by the user and shall be selectable to be shed in either a fixed or rotating order to control which equipment is shed the most often. Upon suitable reductions in demand, the demand- limiting object shall restore the equipment that

was shed in the reverse order in which it was shed. Each sheddable object shall have a minimum and maximum shed time property to provide both equipment protection and occupant comfort.

6. The library shall include control objects for the following functions:
   a. Analog Input Object: Minimum requirement is to comply with the BACnet standard for data sharing. Allow high, low and failure limits to be assigned for alarming. Also, provide a time delay filter property to prevent nuisance alarms caused by temporary excursions above or below the user defined alarm limits.
   b. Analog Output Object: Minimum requirement is to comply with the BACnet standard for data sharing.
   c. Binary Input Object: Minimum requirement is to comply with the BACnet standard for data sharing. The user must be able to specify either input condition for alarming. This object must also include the capability to record equipment runtime by counting the amount of time the hardware input is in an “on” condition. The user must be able to specify either input condition as the “on” condition.
   d. Binary Output Object: Minimum requirement is to comply with the BACnet standard for data sharing. Properties to enable minimum on and off times for equipment protection as well as start-to-start delay must be provided. Incorporate the BACnet Command Prioritization priority scheme to allow multiple control applications to execute commands on this object with the highest priority command being invoked. Provide 16 levels of priority as a minimum. Systems not employing the BACnet method of contention resolution are not acceptable.
   e. PID Control Loop Object: Minimum requirement is to comply with the BACnet standard for data sharing. Each individual property must be adjustable to allow proportional control only, or proportional with integral control, or proportional, integral and derivative control.
   f. Comparison Object: Allow a minimum of two analog objects to be compared to select either the highest, lowest, or equality between the two linked inputs. Also, allow limits to be applied to the output value for alarm generation.
   g. Math Object: Allow a minimum of four analog objects to be tested for the minimum or maximum, or the sum, difference, or average of linked objects. Also, allow limits to be applied to the output value for alarm generation.
   h. Custom Programming Objects: Provide a blank object template for the creation of new custom objects to meet specific user application requirements. This object must provide a simple BASIC-like programming language that is used to define object behavior. Provide a library of functions including, but not limited to, math and logic functions and string manipulation. Also, provide a comprehensive on-line debug tool to allow complete testing of the new object. Allow new objects to be stored in the library for reuse.
   i. Interlock Object: Provide an interlock object that provides a means of coordination of objects within a piece of equipment, such as an air handler or other similar types of equipment. An example is to link the return fan to the supply fan such that, when the supply fan is started, the return fan object is also started automatically without the user having to issue separate commands or to link each object to a schedule object. In addition, the control loops, damper objects, and alarm monitoring (such as return air, supply air, and mixed air temperature objects) will be inhibited from alarming during a user-defined period after startup to allow for stabilization. When the air handler is stopped, the interlocked return fan is also stopped, the outside air damper is closed, and other related objects within the air handler unit are inhibited from alarming, thereby eliminating nuisance alarms during the off period.
   j. Temperature Override Object: Provide an object whose purpose is to override a binary output to an “on” state in the event a user-specified high or low limit value is exceeded. Link this object to the desired binary output object as well as to an analog object for temperature monitoring to cause the override to be enabled. This object will execute a start command at the Temperature Override level of start/stop command priority, unless changed by the user.
   k. Composite Object: Provide a container object that allows a collection of objects representing an application to be encapsulated to protect the application from tampering or to more easily represent large applications. This object must have the ability to allow the user to select the appropriate parameters of the “contained” application that are represented on the graphic shell of this container.
7. The object library shall include objects to support the integration of devices connected to the Network Area Controller (NAC). Provide the following as part of the standard library included with the programming software:
   a. LonMark/LonWorks Devices: These devices shall include, but not be limited to, devices for control of HVAC, lighting, access, and metering. Provide LonMark manufacturer- specific objects to facilitate simple integration of these devices. Support all network variables defined

in the LonMark profile. The device manufacturer shall provide information (type and function) regarding network variables not defined in the LonMark profile.

b. For devices not conforming to the LonMark standard, provide a dynamic object that can be assigned to the device based on network variable information provided by the device manufacturer. Device manufacturer shall provide an XIF file, resource file, and documentation for the device to facilitate device integration.

c. For BACnet devices, provide the following objects:
   1) Analog In.
   2) Analog Out.
   3) Analog Value.
   4) Binary.
   5) Binary In.
   6) Binary Out.
   7) Binary Value.
   8) Multi-State In.
   9) Multi-State Out.
   10) Multi-State Value.
   11) Schedule Export.
   12) Calendar Export.
   13) Trend Export.
   14) Device.

d. For each BACnet object, provide the ability to assign the object a BACnet device and object instance number.

e. For BACnet devices, provide the following support at a minimum:
   1) Segmentation.
   2) Segmented Request.
   3) Segmented Response.
   4) Application Services.
   5) Read Property.
   6) Read Property Multiple.
   7) Write Property.
   8) Write Property Multiple.
   9) Confirmed Event Notification.
   10) Unconfirmed Event Notification.
   11) Acknowledge Alarm.
   12) Get Alarm Summary.
   13) Who-has.
   14) I-have.
   15) Who-is.
   16) I-am.
   17) Subscribe COV.
   18) Confirmed COV notification.
   19) Unconfirmed COV notification.
   20) Media Types.
   21) Ethernet.
   22) BACnet IP Annex J.
   23) MSTP.
   24) BACnet Broadcast Management Device (BBMD) function.
   25) Routing.

2.7 TERMINAL AIR BOX (TAB) CONTROLLERS

A. FMCS Volume Controller: Electronic, furnished and installed by TCC. Boxes shall have pressure independent control to maintain constant air volume regardless of duct pressure changes up to 6 inches w.c. Provide velocity and static sensor at box inlet for use by unit controller. Set boxes for maximum and minimum settings shown on the drawings. Refer to Section 23 36 00 for additional information.

B. The controller shall support various digital and analog inputs and outputs as needed for damper control, control valves, electric coils, airflow sensors, remote heating, occupancy sensors, etc. and shall be capable of independent occupancy scheduling.

C. Controller shall provide continuous zone temperature histories internal to device for up to 24 hours and perform its own limit and status monitoring and alarms to limit unnecessary communications.

D. Operator interface to any ASC point data or programs shall be through network resident programs or portable

E. operator's terminal connected to the specific controller.
F. Store all system setpoints, proportional bands, control algorithms, and other programmable parameters such that a power failure of any duration does not necessitate reprogramming of the controller.
G. BACnet TAB controllers shall either be B-AAC devices or B-ASC devices as required to meet the performance and BTL listing.

2.8 DATA COLLECTION AND STORAGE (TRENDING REQUIREMENTS)

A. The NAC shall be able to collect data for any property of any object and store resident in the NAC that shall have, at a minimum, the following configurable properties:
   1. Designating the log as interval or deviation.
   2. For interval logs, configure the object for time of day, day of week and the sample collection interval.
   3. For deviation logs, configure the object for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object.
   4. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full or rollover the data on a first-in, first-out basis.
   5. Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.
B. Store all log data in a relational database in the NAC that is accessible from a server (if the system is so configured) or a standard Web browser.
C. All log data, when accessed from a server, shall be capable of being manipulated using standard SQL statements.
D. All log data shall be available to the user in ALL the following data formats:
   1. HTML.
   2. XML.
   3. Plain text.
   4. Comma or tab separated values.
E. The NAC shall archive its log data either locally (to itself) or remotely to a server or other NAC on the network. Provide the ability to configure the following archiving properties:
   1. Archive on time of day.
   2. Archive on user-defined number of data stores in the log (buffer size).
   3. Archive when log has reached its user defined capacity of data stores.
   4. Provide ability to clear logs once archived.

2.9 AUDIT LOG

A. Provide and maintain an audit log that tracks all activities performed on the NAC. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached its user-defined buffer size. Provide the ability to archive the log locally (to the NAC), to another NAC on the network, or to a server. For each log entry, provide the following data:
   1. Time and date.
   2. User ID.
   3. Change or activity: i.e., change setpoint, add or delete objects, commands, etc.

2.10 DATABASE BACKUP AND STORAGE

A. The NAC shall automatically backup its database on a user-defined time interval.
B. Store copies of the current database and, at the most, the recently saved database in the NAC. The age of the most recently saved database shall depend on the user-defined database save interval.
C. Store the NAC database in XML format to allow viewing and editing. Other formats are acceptable as long as XML format is supported.

2.11 GRAPHIC USER INTERFACE SOFTWARE

A. Operating System:
   1. Provide computer with the most current Microsoft-based operating system with which the GUI has proven compatibility.
B. The GUI shall employ browser-like functionality for ease of navigation. It shall include a tree view (similar to Windows Explorer) for quick viewing of, and access to, the hierarchical structure of the database. In addition, menu pulldowns and toolbars shall employ buttons, commands and navigation to permit the operator to perform tasks with basic computing skills. These shall include, but are not limited to, forward/backward buttons, home button, and a context sensitive locator line (similar to a URL line) that displays the location and the selected object identification.
C. Point Organization: Organize points by equipment categories, location, or other means acceptable to Owner.

D. Real-Time Displays: The GUI shall support the following graphic features and functions:
   1. Graphic screens shall be developed using any drawing package capable of generating a GIF, BMP, or JPG file. Use of proprietary graphic file formats is not acceptable. In addition to, or in lieu of, a graphic background, the GUI shall support the use of scanned pictures.
   2. Graphic screens shall be able to contain objects for text, real-time values, animation, color spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URLs, and links to other graphic screens.
   3. Graphics shall support layering, and each graphic object shall be configurable for assignment to a layer. A minimum of six layers shall be supported.
   4. Modifying common application objects, such as schedules, calendars, and setpoints, shall be accomplished graphically.
      a. Schedule times shall be adjusted using a graphic slider without requiring any keyboard entry from the operator.
      b. Holidays shall be set by using a graphic calendar without requiring any keyboard entry from the operator.
   5. Commands to start and stop binary objects shall be made by selecting the object and the appropriate command from a pop-up menu. No text entry shall be required.
   6. Adjustments to analog objects, such as setpoints, shall be made by selecting the object and using a graphic slider to adjust the value. No text entry shall be required.

E. System Configuration: At a minimum, the GUI shall include the necessary software and components to enable the operator to perform the following tasks with proper password access:
   1. Create, delete or modify control strategies.
   2. Add/delete objects.
   3. Tune control loops by adjusting control loop parameters.
   4. Enable or disable control strategies.
   5. Generate hard copy records or control strategies on a printer.
   6. Select alarm points and define the alarm state.
   7. Select points to be trended and initiate the recording of values automatically.
   8. View any trend as a graph.

F. On-Line Help: Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext. All system documentation and help files shall be in HTML format.

G. Security: Each operator shall be required to log on to that system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system administrator shall be able to set passwords and security levels for all other operators. Each operator password shall be able to restrict the operator's access for viewing and/or changing each system application, full screen editor, and object. Each operator shall be automatically logged off the system if no keyboard or mouse activity is detected. This auto log-off time shall be set per operator password. Store all system security data in an encrypted format.

H. System Diagnostics: The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers. Annunciate the failure of any device to the operator.

I. Alarm Console:
   1. The system shall have a dedicated alarm window or console. This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and to acknowledge the alarm.
   2. When the alarm console is enabled, a separate alarm notification window will supersede all other windows on the desktop and shall not be capable of being minimized or closed by the operator. This window will notify the operator of new alarms and un-acknowledged alarms. Alarm notification windows or banners that can be minimized or closed by the operator are not acceptable. The use of the alarm console can be enabled or disabled by the system administrator.

2.12 WEB BROWSER CLIENTS

A. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™, Firefox™, or Chrome. Systems requiring additional software to enable a standard Web browser to reside on the client machine, or manufacturer-specific browsers, are not acceptable.

B. The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphic User Interface. Systems that require different views or that require different means of interacting with objects, such as schedules or logs, are not permitted.

C. The Web browser client shall provide:
1. User log-on identification and password shall be required. If an unauthorized user attempts access, display a blank web page. Implement security using Java authentication and encryption techniques to prevent unauthorized access.
2. Graphic screens developed for the GUI shall be the same screens used for the Web browser client. The web browser interface shall support all animated graphic objects supported by the GUI.
3. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.
4. Store all graphic screens in the Network Area Controller (NAC) without requiring any graphics storage on the client machine.
5. Real-time values displayed on a Web page shall update automatically without requiring a manual
6. "refresh" of the Web page.
7. Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:
   a. Modify common application objects, such as schedules, calendars, and setpoints, graphically.
      1) Schedule times shall be adjustable using a graphic slider, without requiring any keyboard entry from the operator.
      2) Holidays shall be set using a graphic calendar, without requiring any keyboard entry from the operator.
   b. Commands to start and stop binary objects shall be made by right-clicking the selected object and selecting the appropriate command from a pop-up menu. No text entry shall be required.
   c. View logs and charts.
   d. View and acknowledge alarms.
   e. Setup and execute SQL queries on log and archive information
8. The system shall be able to specify a user's (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to just his/her defined home page. From the home page, links to other views or pages in the system shall be possible, if allowed by the system administrator.
9. Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on intranet sites by specifying the Uniform Resource Locator (URL) for the desired link.

2.13 UNINTERRUPTIBLE POWER SUPPLY (UPS)

A. A UPS shall be provided for all controllers including FMCS workstations and servers.
B. Provide a 120 volt 60 Hz line-interactive uninterruptible power supply with backup battery capacity for 5 minutes at 100% load. UPS shall have hot swappable batteries, automatic battery self-test and start-on-battery capabilities. Batteries shall be valve regulated, sealed lead acid type. UPS shall have sine wave shape output waveform. UPS shall be UL 1778 list and comply with FCC Part 15, Class A.
C. Acceptable Manufacturers: Sola/Hevi-Duty, Eaton Powerware, APC.

2.14 OPERATOR'S WORKSTATION HARDWARE

A. Workstations shall communicate with BAS on as-needed basis such that other executionable programs may be processed without affecting control functions of BAS.
B. Provide operator's workstations for operating interface to BAS for monitoring, control, and database management. Each workstations shall consist of the following at a minimum:
1. Case and 250 watt power supply.
2. Motherboard with Pentium 17 microprocessor
3. BIOS in flash memory
4. Sufficient expansion slots to be properly configured for intended use
5. 8 GB RAM
6. 101 key, keyboard with 12 function keys
7. 17" color SVGA monitor with SVGA interface card with 128 MB video SDRAM
8. (3) USB ports and (2) Ethernet ports.
9. 48X max variable speed CD-ROM drive
10. 1 TB hard disk drive
11. Network interface card and associated hardware
12. All required cables for connecting to network and other remote devices
13. Mouse and mouse pad
14. Surge Protector and UPS
15. 8 page per minute letter size laser printer with direct network interface port.

2.15 SYSTEM PROGRAMMING

A. The GUI software shall perform system programming and graphic display engineering. Access to the GUI software shall be through password access as assigned by the system administrator.

B. Provide a library of control, application, and graphic objects to enable creation of all applications and user interface screens. Applications shall be created by selecting the control objects from the library, dragging or pasting them on the screen, and linking them together using a built-in graphic connection tool. Completed applications may be stored in the library for future use. GUI screens shall be created in the same fashion. Data for the user displays shall be obtained by graphically linking the user display objects to the application objects to provide “real-time” data updates. Any real-time data value or object property may be connected to display its current value on a user display. Provide all software tools or processes to create applications and user interface displays.

C. Programming Methods

1. Provide the capability to copy objects from the supplied libraries or from a user-defined library to the user’s application. Link objects with a graphic linking scheme by dragging a link from one object to another. Object links will support one-to-one, many-to-one, or one-to-many relationships. Linked objects shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to objects on other pages for easy identification. Links will vary in color depending on the type of link; e.g., internal, external, hardware, etc.
2. Configuration of each object shall be done through the object’s property sheet using fill-in-the- blank fields, list boxes, and selection buttons. Use of custom programming, scripting language, or a manufacturer-specific procedural language for configuration is not acceptable.
3. The software shall provide the ability to view the logic in a monitor mode. When on-line, the monitor mode shall provide the ability to view the logic in real time for easy diagnosis of the logic execution. When off-line (debug), the monitor mode shall allow the user to set values to inputs and monitor the logic for diagnosing execution before it is applied to the system.
4. All programming shall be done in real time. Systems requiring the uploading, editing, and downloading of database objects are not allowed.
5. The system shall support object duplication in a customer’s database. An application, once configured, can be copied and pasted for easy reuse and duplication. All links, other than to the hardware, shall be maintained during duplication.

2.16 DDE DEVICE INTEGRATION

A. The NAC shall support the integration of device data via Dynamic Data Exchange (DDE) over the Ethernet network. The NAC shall act as a DDE client to another software application that functions as a DDE server.

B. Provide the required objects in the library included with the Graphic User Interface programming software to support the integration of these devices into the FMCS. Objects provided shall include, at a minimum:

1. DDE Generic AI Object.
2. DDE Generic AO Object.
3. DDE Generic BO Object.
4. DDE Generic BI Object.

2.17 MODBUS SYSTEM INTEGRATION

A. The NAC shall support integration of device data from Modbus RTU, ASCII, and TCP control system devices. Connect to the Modbus system via an RS-232, RS485, or Ethernet IP as required by the device.

B. Provide the required objects in the library included with the GUI programming software to support the integration of the Modbus system data into the FMCS. Objects provided shall include, at a minimum:

1. Read/Write Modbus AI Registers.
2. Read/Write Modbus AO Registers.
3. Read/Write Modbus BI Registers.
4. Read/Write Modbus BO Registers.

C. The NAC shall perform all scheduling, alarming, logging and global supervisory control functions of the Modbus system devices.

D. The FMCS supplier shall provide a Modbus system communications driver. The equipment system vendor that provided the equipment using Modbus shall provide documentation of the system’s Modbus interface and shall provide factory support at no charge during system commissioning.

2.18 SOFTWARE

A. IDC/IBCs shall operate totally standalone and independent of a central computer for all specified control applications.

B. Software shall include a complete operating system (OS), communications handler, point processing, energy management application packages as specified herein, standard control algorithms and specific control sequences (IDC/IBC) and an Owner/user custom control calculation package complete with interpreter.

C. OS software shall be PROM resident, operate in real time, provide prioritized task scheduling, control time programs, monitor and manage communications, and scan inputs and outputs.

D. Each IDC/IBC panel shall include the following energy management routines:
   1. Time of day scheduling.
   2. Optimum start/stop.
   3. Peak demand limiting.
   4. Economizer control.
   5. PID control.
   6. Supply air reset.
   7. Outdoor air reset.

E. Input/output point processing software shall include:
   1. Update of all connected input and output points at least once per second.
   2. Analog to digital conversion, scaling and offset, correction of sensor non-linearity, sensing no response or failed sensors, and conversion of values to 32-bit floating point format. Retain both the maximum and minimum values sensed for each analog input in memory. It shall be possible to input subsets of standard sensor ranges to the A/D converter and assign gains to match the full- scale 32-bit conversion to achieve high accuracy readout.
   3. A reasonability check on all analog inputs against previous values and discarding of values falling outside preprogrammed reasonability limits.
   4. Assignment of proper engineering units and status conditions to all inputs and outputs.
   5. Analog input alarm comparison with the ability to assign two individual sets of high and low limits (warning and alarm) to an input or to assign a set of floating limits (alarm a reset schedule or FMCS control point) to the input. Assign each alarm a unique differential to prevent a point from oscillating in and out of alarm. Make alarm comparisons of each scan cycle.
   6. Adjustment of timing from two seconds to two minutes in one-second increments to eliminate nuisance alarms on startup.

F. Command Control software shall manage the receipt of commands from the server and from control programs.
   1. Provide command delay to prevent simultaneous energizing of loads. Delay must be programmable from 0 to 30 seconds.
   2. Assign each command a command and residual priority to manage conflicts created by multiple programs having access to the same command point. Allow only outputs with a higher command priority to execute. Whenever a command is allowed to execute, its assigned residual priority shall replace the existing residual priority.
   3. A "fixed mode" option (override) shall allow inputs to and outputs from control programs to set to a fixed state or value. When in the "fixed mode", assign inputs and outputs high residual command priority to prevent override by application programs.

G. Alarm lockout software shall prevent nuisance alarms. On initial start-up of mechanical equipment, assign a "timed lockout" period to analog points to allow them to reach a stable condition before activating alarm comparison logic. Lockout period shall be programmable for each point from 0 to 90 minutes in one-minute increments.

H. A "hard lockout" shall also be provided to positively lock out alarms when equipment is turned off or when a true alarm depends on the condition of an associated point. Hard lockout points and lockout initiators shall be operator programmable.

I. Runtime shall be accumulated based on the status of a digital input point. It shall be possible to totalize either on time or off time up to 10,000 hours with one-minute resolution. Runtime counts shall reside in non-volatile memory and have DCP resident runtime limits assignable through the operator's terminal.

J. A transition counter shall count the number of times a device is cycled on or off. Counter shall be non-volatile and capable of counting 600,000 cycles. Limits shall be assignable to counts to provide maintenance alarm printouts.

K. Custom IDC/IBC programs shall meet the control strategies called for in the sequence of operation of these specifications. Each IDC/IBC shall have resident in its memory and available to the programs a full library of IDC/IBC algorithms, intrinsic control operators, arithmetic, logic, and relational operators. Provide the following features:
   1. Proportional Control, Proportional plus Integral (PI), Proportional plus Integral plus Derivative (PID), and Adaptive Control (self-learning). Use Adaptive Control where the controlled flow rate is variable (such as TAB units and variable flow pumping loops). The adaptive control algorithm shall monitor the loop response to output corrections and adjust the loop response characteristics in accordance with the time constant changes imposed by variable flow rates. The algorithm shall operate in a

continuous self-learning manner and shall retain in memory a stored record of the system dynamics so that, on system shutdown and restart, the learning process starts from where it left off. Standard PID algorithms are not acceptable substitutes for variable flow applications since they will provide satisfactory control at only one flow rate and will require continued manual fine tuning.

2. All IDC/IBC setpoints, gains and time constants associated with IDC/IBC programs shall be available to the operator for display and modification via the operator workstation.
3. The execution interval of each IDC/IBC loop shall be adjustable from 2 to 120 seconds in one-second increments.
4. IDC/IBC control programs shall assign initialization values to all outputs so controlled devices assume a failsafe position on start-up.

L. Provide time and event programming (TEP) capability to initiate a controlled sequence of events for execution at a specific time or upon the occurrence of an event. Minimum program features required are:
1. Analog points commandable to a specific value.
2. Digital points commandable to a specific state; e.g. on or off; fast, slow or off.
3. Initiator to be a specific day and time or a specific event; e.g. an alarm.
4. Manual initiation via operator's command.
5. Commands must honor command delays (to prevent current surges), and assigned minimum ON and OFF times.
6. Commands must honor command and residual priority structures allowing higher priority commands (like smoke control) to override lower priority commands (like time of day scheduling) and residual priority.
7. Ability to chain TEPs.
8. Ability to enable and disable TEPs individually.
9. Ability to enable/disable TEP initiators.

M. Store Energy Management application programs and associated data files in non-volatile or 72-hour battery backed RAM memory. Individual programs shall be accessible from the operator workstation for enabling/disabling and program parameter modification and shall include:
1. Time Programs:
   a. Provide an independent start and stop program time for each system identified in the points list.
   b. It shall be possible to assign two independent start and stop times/days to any equipment connected to a controller.
2. Exception Day Scheduling:
   a. Provide an Exception Day program for holiday and other planned exceptions to time programs. Exception schedules shall be DSC resident and operator programmable up to one year in advance.
   b. The program shall allow definition of up to 32 exception time spans. Define each span by calendar start day and calendar stop day.
3. An IDC/IBC resident temporary scheduler shall allow operators to modify present time program control of equipment. Minimum feature set required is:
   a. Ability to alter time schedules as much as six days in advance.
   b. Ability to alter either start time, stop time or both for each day.
   c. Temporary schedule shall be in effect for all days specified.
   d. Automatically delete the temporary schedule and restore program to normal schedule after execution.
   e. Ability to assign schedule changes as permanent as well as temporary.

N. The IDC/IBC shall have built-in, non-descriptive, self-test procedure for checking the indication lights, digital display, and memory. It shall display advisories for maintenance, performance, and/or software problems.

O. All electronics shall be:
1. Standard locally stocked modular boards.
2. Plug-in type.
3. Furnish all ROM programs unlocked.

2.19 ACTUATORS

A. Actuators for control dampers and valve actuators shall be electronic type

2.20 CONDUIT

A. Raceway and boxes for electrical systems: Refer to Electrical Section 26 05 33 for materials and sizing.

2.21 WIRE AND CABLE

A. Low-Voltage electrical power conductors: Refer to Electrical Section 26 05 19 for wire and cable materials.

2.22 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 and panels located in the parking structure.

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.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

A. Verify that systems are ready to receive work. Beginning of installation means installer accepts existing conditions.

B. Install system and materials in accordance with manufacturer's instructions.

C. Drawings of the TCS and FMCS network are diagrammatic only. Any apparatus not shown but required to meet the intent of the project documents shall be furnished and installed without additional cost.

D. Install all operators, sensors, and control devices where accessible for service, adjustment, calibration, and repair. Do not install devices where blocked by piping or ductwork. Devices with manual reset or limit adjustments shall be installed below 6'-0" if practical to allow inspection without using a ladder.

E. Verify locations of wall-mounted devices (such as thermostats, temperature and humidity sensors, and other exposed sensors) with drawings and room details before installation. Coordinate mounting heights to be consistent with other wall-mounted devices. Maximum height above finished floor shall not exceed 48". In accordance with the requirements of LEED EQc1: Outdoor Air Delivery Monitoring, install all wall-mounted CO2 sensors between 3 feet and 6 feet above the floor.

F. Provide valves over 3/4" size with position indicators and pilot positioners where sequenced with other controls.

G. Mount control panels adjacent to associated equipment on vibration-free walls or freestanding angle iron supports. One cabinet may accommodate more than one system in same equipment room.

H. After completion of installation, test and adjust control equipment.

I. Check calibration of instruments. Recalibrate or replace.

J. Furnish and install conduit, wire, and cable per the National Electric Code, unless noted otherwise in this section.

K. All controls associated with the proper operation of air handling units, pumps, or other mechanical equipment served by emergency power shall be connected to the emergency power system. Control components shall not be powered from the life safety branch of the emergency power system. Coordinate emergency power source connections with the Architect/Engineer.

L. All hardware, software, equipment, accessories, wiring (power and sensor), piping, relays, sensors, power supplies, transformers, and instrumentation required for a complete and operational FMCS system, but not shown on the electrical drawings, are the responsibility of the TCC.

M. Labels For Control Devices:
   1. Provide labels indicating service of all control devices in panels and other locations.
   2. Labels may be made with permanent marking pen in the control panels if clearly legible.
   3. Use engraved labels for items outside panel such as outside air thermostats.
   4. Labels are not required for room thermostats, damper actuators and other items where their function is obvious.

N. VFDs
   1. This project includes several variable frequency drives to control the flow of fans and/or pumps based on a control variable.
   2. Verify output signal required, 4-20 mA or 0-10V dc, with the EC.
   3. If VFD has a bypass feature, auxiliary contacts on the drive may not be used for motor status. A separate relay must be used to indicate motor rotation in either hand or auto positions.
   4. If a separate current transmitter or switch is indicated for status, install this device between the VFD and the motor. In this case, the drive status may be connected to the auxiliary contacts in the VFD.
   5. Some devices, such as low limits and fire alarm shutdown relays, must be hardwired to the fan motor. Make connections such that fan will shut down whether in hand or auto position if the unit has a bypass feature.

O. Airflow Stations:
   1. The transmitter shall be installed at a location that is protected from weather, water, and vibration.

2. Mount transmitter where they can easily be read (36" to 66" above floor). Do not fasten transmitters directly to ductwork or compromise duct insulation.
3. The manufacturer's authorized representative shall visit the project site during construction prior to station installations to confirm all submitted sizes, mounting requirements and locations. Size adjustments shall be made at no additional cost. The representative shall meet on site with the TCC to support and train them on proper installation procedures and calibration.
4. Install labels at each sensor and transmitter identifying its service.

3.2 GRAPHIC DISPLAY

A. Create a customized graphic for each piece of equipment indicated on the itemized points list.
B. Components shall be arranged on graphic as installed in the field.
C. Include each graphic point listed in the itemized points list using real time data.
D. Provide a graphic representation of the following:
1. Where there are multiple buildings, color code the campus map by the systems serving that building. The building graphic shall be linked to the graphic for that building's systems.
2. Where there are multiple floors, provide color codes/designations for the areas served by each AHU and TAB by floor.
3. Where multiple AHUs serve one floor, color code the areas served by each AHU. The area shall be
4. linked to the graphic for that area's AHU.
5. Provide an overall floor plan of each floor of the building color coded by zone linked to the TAB for
6. that zone. The zone shall be linked to the graphic for that zone's TAB graphic.
7. Show the location of each thermostat on the floor plan.
8. Provide separate graphics showing the chilled and heating water system flow diagram. Show temperatures and flows on the flow diagram. Each piece of equipment shown on the flow diagram shall be linked to the graphic for that piece of equipment.
9. Provide a graphic showing the steam system flow diagram. Show pressures and flows on the flow diagram. Each piece of equipment shown on the flow diagram shall be linked to the graphic for that piece of equipment.

E. The FMCS shall include full graphic operator interface to display the following graphics as a minimum:
1. Home page to include a minimum of six critical points: Outside Air Temperature, Outside Air Relative Humidity, Enthalpy, KWH, KW, etc.
2. Graphic floor plans accurately depicting rooms, walls, hallways, and showing accurate locations of space sensors and major mechanical equipment.
3. Detailed graphics for each mechanical system including AHUs, ERUs, EFs, chillers, and boilers, as a minimum.
4. Access corresponding system drawings, technical literature, and sequences of operations directly from each system graphic.

F. The FMCS shall include individual graphical buttons to access the following data stored in PDF format:
1. Project control as-built documentation including all TCS drawings, diagrams and sequences of operation.
2. TCS Bill of Material for each system, e.g. AHU, RTU, FCU, boiler, etc.
3. Technical literature specification data sheets for all components listed in the TCS Bill of Material.

3.3 CONDUIT INSTALLATION

A. Conduit Sizing and Installation: Refer to Electrical Section 26 05 33 for execution and installation.
1. Thermostats/temperature sensors shall be installed in junction boxes, flush with the wall, and shall be coordinated for orientation with Architect/Engineer.

3.4 WIRE AND CABLE INSTALLATION

A. Field Quality Control:
1. Inspect wire and cable for physical damage and proper connection.
2. Torque test conductor connections and terminations to manufacturer's recommended values.
3. Perform continuity test on all conductors.
4. Protection of cable from foreign materials:
a. It is the Contractor's responsibility to provide adequate physical protection to prevent foreign material application or contact with any cable type. Foreign material is defined as any material that would negatively impact the validity of the manufacturer's performance warranty. This includes, but is not limited, to overspray of paint (accidental or otherwise), drywall compound, or any other surface chemical, liquid or compound that could come in contact with the cable, cable jacket or cable termination components.

b. Overspray of paint on any cable, cable jacket or cable termination component will not be accepted. It shall be the Contractor's responsibility to replace any component containing overspray, in its entirety, at no additional cost to the project. Cleaning of the cables with harsh chemicals is not allowed. This requirement is regardless of the PASS/FAIL test results of the cable containing overspray. Should the manufacturer and warrantor of the structured cabling system desire to physically inspect the installed condition and certify the validity of the structured cabling system (via a signed and dated statement by an authorized representative of the structured cabling manufacturer), the Owner may, at their sole discretion, agree to accept said warranty in lieu of having the affected cables replaced. In the case of plenum cabling, in addition to the statement from the manufacturer, the Contractor shall also present to the Owner a letter from the local Authority Having Jurisdiction stating that they consider the plenum rating of the cable to be intact and acceptable.

B. Installation Schedule:

1. Conduit terminations to all devices installed in applications with rotating equipment, expansion/contraction or vibration shall be made with flexible metallic conduit, unless noted otherwise. Final terminations to exterior devices installed in damp or wet locations shall be made with liquidtight flexible metallic conduit. Terminations in hazardous areas, as defined in the National Electrical Code, shall be connected using flexible conduit rated for the environment.

3.5 FMCS INSTALLATION

A. Coordinate voltage and ampacity of all contacts, relays, and terminal connections of equipment being monitored or controlled. Voltage and ampacity shall be compatible with equipment voltage and be rated for full ampacity of wiring or overcurrent protection of circuit controlled.

B. Naming Conventions: Coordinate all point naming conventions with Owner standards. In the absence of Owner standards, naming conventions shall use equipment designations shown on plans.

3.6 COMMISSIONING

A. Upon completion of the installation, this Contractor shall load all system software and start up the system. This Contractor shall perform all necessary calibration, testing and de-bugging and perform all required operational checks to ensure that the system is functioning in full accordance with these specifications.

B. This Contractor shall perform tests to verify proper performance of components, routines, and points. Repeat tests until proper performance results. This testing shall include a point-by-point log to validate 100% of the input and output points of the FMCS system operation.

C. This Contractor shall prove that the controls network is functioning correctly and within acceptable bandwidth criteria and shall test the system with an approved protocol analysis tool. Provide a log and statistics summary showing that each channel is within acceptable parameters. Each channel shall be shown to have at least 25% spare capacity for future expansion.

D. Upon completion of the performance tests described above, repeat these tests, point by point, as described in the validation log above in the presence of Owner's Representative, as required. Properly schedule these tests so testing is complete at a time directed by the Owner's Representative. Do not delay tests so as to prevent delay of occupancy permits or building occupancy.

E. System Acceptance: Satisfactory completion is when this Contractor has performed successfully all the required testing to show performance compliance with the requirements of the Contract Documents to the satisfaction of the Owner's Representative. System acceptance shall be contingent upon completion and review of all corrected deficiencies.

3.7 PREPARATION FOR BALANCING

A. Verify that all dampers are in the position indicated by the controller (e.g., open, closed or modulating).

B. Check the calibration and setpoints of all controllers.

C. Check the locations of all thermostats and humidistats for potential erratic operation from outside influences such as sunlight, drafts, or cold walls.

D. Check that all sequences operate as specified. Verify that no simultaneous heating and cooling occurs, unless specified. Observe that heating cannot begin at TAB reheat terminals until the unit is at the minimum cfm.

E. Verify the operation of all interlock systems.

3.8 TEST AND BALANCE COORDINATION

A. The Contractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.

B. The Contractor shall provide a minimum of four (4) hours training for the Balancing Contractor in the use of these tools.

C. In addition, the Contractor shall provide a qualified technician to assist in the test and balance process until the first 20 terminal units are balanced.

D. The tools used during the test and balance process shall be returned at the completion of the testing and balancing.

3.9 DEMONSTRATION AND ACCEPTANCE

A. At completion of installation, provide two days minimum instruction for operators. Demonstrate operation of all controls and systems. Describe the normal operation of all equipment.

3.10 TRAINING

A. On-Site:

1. After completion of commissioning, the manufacturer shall provide 8 hours of training on consecutive days for 4 Owner's representatives. The training course shall enable the Owner's representatives to perform Day-to-Day Operations as defined herein. A factory-trained instructor with experience in presenting the training material and the system programmer for this project shall perform the training.

B. Day-to-Day Operations - Training Description:

1. Proficiently operate the system.
2. Understand control system architecture and configuration.
3. Understand FMCS systems components.
4. Understand system operation, including FMCS system control and optimizing routines (algorithms).
5. Operate the workstation and peripherals.
6. Log-on and off the system.
7. Access graphics, point reports, and logs.
8. Adjust and change system setpoints, time schedules, and holiday schedules.
9. Recognize malfunctions of the system by observation of the printed copy and graphic visual signals.
10. Understand system drawings and Operation and Maintenance manual.
11. Understand the job layout and location of control components.
12. Access data from FMCS controllers and ASCs.
13. Operate portable operator's terminals.

C. Advanced Operations - Training Description:

1. Make and change graphics on the workstation.
2. Create, delete, and modify alarms, including annunciation and routing of these.
3. Create, delete and modify point trend logs and graph or print these both on and ad-hoc basis and at user-definable time intervals.
4. Create, delete, and modify reports.
5. Add, remove, and modify system's physical points.
6. Create, modify and delete programming.
7. Add panels when required.
8. Add operator interface stations.
9. Create, delete, and modify system displays, both graphic and others.
10. Perform FMCS system field checkout procedures.
11. Perform FMCS controller unit operation and maintenance procedures.
12. Perform workstation and peripheral operation and maintenance procedures.
13. Perform FMCS system diagnostic procedures.
14. Configure hardware including PC boards, switches, communication, and I/O points.
15. Maintain, calibrate, troubleshoot, diagnose, and repair hardware.
16. Adjust, calibrate, and replace system components.

D. System Management - Training Description:

1. Maintain software and prepare backups.
2. Interface with job-specific, third-party operator software.
3. Add new users and understand password security procedures.

E. Provide course outline and materials in accordance with the "SUBMITTALS" article in Part 1 of this section.

F. The instructor(s) shall provide one copy of training material per student.

END OF SECTION

SECTION 23 09 02
CONTROL VALVES AND DAMPERS

PART 1 – GENERAL
1.1 RELATED WORK
1.2 GENERAL
1.3 SUBMITTALS
1.4 DAMPER SELECTION AND SIZING
PART 2 – PRODUCTS
2.1 CONTROL DAMPERS
2.2 SMOKE DAMPERS
2.3 DAMPER AND VALVE ACTUATORS
PART 3 – EXECUTION
3.1 CONTROL DAMPERS
3.2 SMOKE DAMPERS
3.3 ACTUATORS AND PILOT POSITIONERS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 0901 - Control Systems Integration
B. Section 23 0993 - Control Sequences
C. Section 23 2118 - Valves
D. Section 23 3314 - Ductwork Specialties

1.2 GENERAL

A. Devices containing mercury are not allowed.

1.3 SUBMITTALS

A. Product data sheets shall include construction materials and assembly methods, maximum design parameters (temperature, pressure, velocity, etc.), and performance data for full range of actuator stroke. Product data sheets shall include charts, graphics or similar items used in making selections, including damper to duct area ratio and free area ratio. Damper product data sheets shall indicate certified leakage rates for given pressure differentials.
B. Submit valve schedules with shop drawings, indicating unique tag numbers for each device, equipment item or system served, device model numbers, sizes, shut-off head required, actuator air pressure or force required to meet shut-off 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.
C. Valve and damper Shop Drawing submittals will not be processed unless supporting data and sizing calculations are included.
D. Submit damper schedules with Shop Drawings, indicating unique tag numbers for each device, equipment or system served, device model numbers, duct sizes, damper sizes, flow rates, pressure differentials, calculation of actual damper pressure drops, approach velocities, leakage rates, torque requirements, actuator model number, actuator torque capacities and pilot positioner locations.
E. Select dampers to meet their intended service with respect to maximum approach velocities and maximum pressure differential. Damper materials shall match duct construction materials of systems in which they are installed (galvanized steel, aluminum, 304 or 316 stainless steel, etc.).
F. Aluminum dampers may be used in galvanized steel ductwork.

1.4 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 for obtaining linear damper response.

C. Control Contractor is responsible for obtaining adequate system information necessary for sizing.

D. Two position dampers to be sized as close as possible to duct size, but in no case is damper size to be less than duct area.

E. Submit leakage and flow characteristic data for control dampers along with shop drawings. Leakage ratings shall be based on AMCA Standard 500 and dampers shall bear AMCA Air Leakage Seals.

PART 2 - PRODUCTS

2.1 CONTROL DAMPERS

A. General:

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

Class	**Static Pressure** Inches Water Column			
	1	4	8	12
	Leakage Rate cfm/ft^2			
IA	3	N/A	N/A	N/A
I	4	8	11	14
II	10	20	28	35
III	40	80	112	140

B. Standard Modulating and Two-Position Dampers:

1. Manufacturers and acceptable model numbers:
   a. Johnson Controls VD-1360 (Double Piece)
   b. Honeywell D2
   c. Ruskin CD50/CD60
   d. Air Balance AC-525/526
   e. Greenheck VCD-43/VCD-33
2. Damper frames shall be minimum of 16 ga galvanized steel or 14 ga extruded aluminum. Blades shall be minimum of 16 ga galvanized steel or 14 ga aluminum. Blades shall have maximum blade width of 8" with steel trunnions mounted in bronze sleeve, nylon or ball bearings.
3. Furnish dampers with blade seals and stainless steel side seals. Dampers and seals shall be suitable for maximum system temperature, pressure differential and approach velocity, but not less than temperature range of -40° to 200°F, pressure differential of 6” WC, and approach velocity of 4000 fpm based on 4 ft damper section width.
4. Leakage rate shall meet AMCA Leakage Class IA or I.
5. Testing and ratings shall be per AMCA Standard 500-D.

2.2 SMOKE DAMPERS

A. Refer to Section 23 3314 - Ductwork Specialties, for Smoke Damper Specification.

2.3 DAMPER AND VALVE ACTUATORS

A. Analog Electronic:

1. Manufacturers: Belimo, Honeywell, Johnson Controls, Siemens Building Technologies or TAC
2. Actuators shall be electric motor/gear drives that respond proportionally to analog voltage or current input, or digital floating control signals.
   a. Floating control actuators shall only be used for terminal hot water or chilled water control.
   b. Analog control actuators shall be used for all other modulating applications.
3. Stroke time for major equipment shall be 90 seconds or less for 90° rotation. Stroke time for terminal equipment shall be compatible with associated local controller, but no more than 6 minutes.
4. 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, flow control for major equipment items such as chillers, cooling towers, boilers, etc. Fail-last-position actuators do not have spring return feature.

5. Provide position feedback potentiometers connected to controller for closed loop control on major equipment analog control loops.
6. Actuators for terminal heating/cooling equipment do not require spring return feature.

B. Discrete Two-Position Electric:
1. Manufacturers: Belimo, Honeywell, Johnson Controls, Siemens Building Technologies or TAC
2. Actuators shall be electric motor/gear drives for two-position control. Stroke time shall be 90 seconds or less for 90° rotation.
3. Provide spring return feature for fail open or closed positions as required by control sequence. Fail-last-position actuators do not have spring return feature.

C. Speed Control Valve:
1. Manufacturers: ASCO, Parker Hannifin or approved alternate
2. Provide speed control valves for On/Off actuators to limit speed of actuation to prevent water hammers in liquid systems and reduce stresses on large dampers in air systems.
3. Speed control valves shall allow free flow of control air in one direction and metered flow in other direction. Valve stem locks shall be included to lock adjustment knob in place.
4. Mount speed control valve to exhaust port of solenoid control valve or impulse line from solenoid control valve to actuator, depending upon whether speed control is required for closing or opening of valve or damper.
5. Materials of Construction: Brass bodies with Buna-N, NBR or Nitrile Seals

PART 3 - EXECUTION

3.1 CONTROL DAMPERS

A. Furnish control dampers as shown on drawings and/or as required to perform control sequences specified, except those furnished with other equipment.

B. Control dampers furnished by Control Contractor shall be installed by Mechanical Contractor under coordinating control and supervision of Control Contractor.

C. Blank-off plates or transitions required to facilitate dampers shall be provided by Mechanical Contractor.

3.2 SMOKE DAMPERS

A. Refer to Section 23 3314 - Ductwork Specialties

3.3 ACTUATORS AND PILOT POSITIONERS

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

B. Valve and damper operating speeds shall be selected or adjusted so that actuators will remain in step with controllers without hunting, regardless of load variations. Actuators acting in sequence with other actuators shall have adjustment of control sequence as required by operating characteristics of system.

C. Provide proper linkage and brackets for mounting and attaching actuators to devices. Design mounting and/or support to provide no more than 5% hysteresis in either direction (actual movement of valve stem or damper shaft versus ideal movement) due to deflection of actuator mounting.

D. Provide single actuator on damper section not exceeding torque capacity of actuator.

E. Multiple damper sections where used shall be connected together via jackshaft or other coupling device, not by internal pinned connections at blade shafts of individual damper sections. Where multiple damper sections are connected together via jackshaft or other coupling device, damper actuator shall be mounted directly to jackshaft or other coupling device for operating damper sections. For instances where damper actuator cannot be mounted to jackshaft or other coupling device, damper actuator shall be provided for each damper section.
1. Mounting multiple actuators to common damper jackshaft or valve stem to meet torque requirements is not allowed.

F. Position feedback potentiometers shall be provided where floating control actuators are sequenced with other floating control actuators in terminal hot water control (i.e., reheat valve, fin tube radiator valve, radiant ceiling panel valve, etc.).

G. Calibrate position feedback potentiometers, where specified, with range and gain factors as required for proper operation per manufacturer's recommendations.

H. Actuators installed outdoors shall be NEMA 4X or IP66 rated or shall be provided with weatherproof NEMA 4X stainless steel enclosures (Belimo ZS-300 or equal) that have removable covers that have clasps or machine screws (no sheet metal screws) and that do not require removing fasteners from the ductwork.

END OF SECTION

SECTION 23 09 03
CONTROL INSTRUMENTATION

PART 1 – GENERAL
1.1 RELATED WORK
1.2 SUBMITTALS
1.3 FCC COMPLIANCE
PART 2 – PRODUCTS
2.1 GENERAL
2.2 GENERAL INSTRUMENTATION
2.3 DISCRETE ELECTRIC INSTRUMENTATION
2.4 PNEUMATIC INSTRUMENTATION
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PART 3 – EXECUTION
3.1 GENERAL
3.2 GENERAL INSTRUMENTATION
3.3 DISCRETE AND ANALOG INSTRUMENTATION
3.4 AIR PIPING

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 0901 - Control Systems Integration
B. Section 23 0905 - Instrument Point List
C. Section 23 0993 - Control Sequences
D. Section 23 2120 - Piping Specialties

1.2 SUBMITTALS

A. Devices shall be indexed by bill of material for each system as detailed in Section 23 0901 - Control Systems Integration.
B. Device data sheets submittal shall be submitted simultaneously with Control Systems Integration submittal. Refer to submittals section in 23 0901.
C. Thermostat/Room Temperature Sensor Schedules:
   1. Submit thermostat/room temperature sensor schedule with shop drawings. Thermostat/room temperature sensor schedule shall have detailed listing of which type is used for each room, including data concerning service and model numbers, sizes, cover types, and engineering data sheets for each control device.
D. Warranty
   1. Provide 1 year warranty on all materials and labor.
   2. Warranty requirements shall include furnishing and installing software upgrades issued by the manufacturer during the 1 year warranty period.

1.3 FCC COMPLIANCE

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

PART 2 - PRODUCTS

2.1 GENERAL

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

2.2 GENERAL INSTRUMENTATION

A. Pressure Gauges:
   1. Refer to Section 23 2120 - Piping Specialties
B. Thermometers (Dial-Type):
   1. Refer to Section 23 2120 - Piping Specialties
C. Analog Electronic Instrument Indicators:
   1. Electronic indicators, used for displaying sensor and/or output values as measured by current or voltage, shall be panel mount type and at least 2" square. Output may be either analog needle type or digital with 1/2" high LED or backlit LCD displays.
   2. Electronic indicators shall be marked in appropriate units (degrees, psi, % rh, gpm, cfm, etc.) and with appropriate range of values. Panel mounted indicators shall have minimum accuracy of 1% of scale range. Digital units shall be scaled to show 3 digits plus 1 decimal point.

2.3 DISCRETE ELECTRIC INSTRUMENTATION

A. General:
   1. Electrical devices, switches, and relays shall be UL listed and of type meeting current and voltage characteristics of project. Terminal connections shall be made at terminal blocks inside of NEMA 1 enclosures unless otherwise specified. Outdoor units (garage parking area is considered outside) shall be NEMA 4 with concealed adjustment.
   2. Ratings of normally open and normally closed contacts shall be adequate for applied load (minimum 5 amps at 240 Volts).
   3. Accuracy of devices shall be ± 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 manufacturer's standard plastic.
C. Relays:
   1. Manufacturers: IDEC, Potter Brumfield, Square D, or Allen Bradley
   2. Equal to IDEC Type RH2B-U, miniature 8 blade pilot relay with DPDT silver cadmium oxide contacts rated at 10A, 30 VDC, or 120 VAC. Coil shall match control circuit characteristics. DDC outputs shall be 24 VDC with maximum current burden of 50 milliamps. Rectangular base socket mount with blade type plug-in terminals and polycarbonate dust cover.
   3. Provide DIN rail mountable (Snap type) mounting sockets equal to IDEC SH2B-05.
D. Enclosed Relay (Relay-in-a-Box):
   1. Manufacturers: Veris Industries, Kele & Associates, Functional devices, Inc. or approved equal
   2. 1 or 2 SPDT relays in NEMA 1 or better enclosure. Coil shall be selected for control circuit characteristics.
   3. Contacts rated at 10A, 28 VDC or 120 VAC. Conduit nipple is 1/2" NPT. Maximum coil current burden 50 milliamps.
E. Pressure Differential Switches (Air Systems):
   1. Manufacturers: Cleveland Controls, Dwyer, Honeywell, Johnson Controls/Penn, Siemens Building Technologies, or TAC
   2. Adjustable set point, differential pressure type. Select switches for accuracy, ranges (20 to 80% of operating range) and dead-band to match process conditions, electrical requirements and to implement intended functions.
   3. Pressure differential switches for air systems shall have pressure rating of at least 10" WC.
   4. Switches used to protect installed system shall be manual reset type with two single pole double through contacts (SPDT)
   5. Pressure indicating differential switches for air systems shall be equal to Dwyer Series 3000 photohelic gauge.
      a. Maximum Temperature Rating: 180°F
      b. Repeatability: ± 1%
F. 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: 32 to 131°F
   d. Response Time: < 0.5 seconds

G. 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: 32 to 131°F
   d. Response Time: < 0.5 seconds

H. Mechanical Room and Local Control Panel Alarm Horns:
1. Manufacturers: Honeywell, Johnson Controls, Siemens, Panalarm, TAC, or Ronan
2. 24 V alarm horn suitable for panel mounting.

I. Plant Alarm Horns:
1. Manufacturers: Panalarm, Johnson Controls/Penn, Honeywell, Siemens Building Technologies, or Sonalert
2. Equal to Honeywell model SC806A rated at 64-100 dBa at 10 ft, 24 VAC operation. UL Listed and FM approved.

J. Indicator Lights:
1. Manufacturers: Allen Bradley, GE, Square-D, or Idec
2. 1/4" minimum size or 1-1/4" maximum size, push-to-test type. Use green for normal, yellow for warning (low/high values), and red for alarm or fail (low-low or high-high conditions). AC or DC type with voltage matched to control circuit without transformers.

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

2.4 PNEUMATIC INSTRUMENTATION

A. Space Static Pressure Sensor:
1. Manufacturers: Air Monitor Corporation, Tek-Air or Thermo Electron Corporation
2. Space static pressure probe shall be brushed aluminum with anodized finish or stainless steel with polished or painted finish selected by Architect.
3. Shielded static air probe shall be similar to Air Monitor Corporation Model 3 for flush ceiling mounting, complete with multiple sensing ports, pressure impulse suppression chamber, air flow shielding, and 3/8" FPT take-off fitting. Sensor shall be capable of sensing static pressure within 1% of actual pressure value while being subjected to maximum air flow of 100 fpm from radial source.

B. Differential Air Pressure Indicator:
1. Dwyer model 2000 Series magnehelic gauge for surface or panel mounting. 4" 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" WC for building and space pressure indication.)

C. Plastic Tubing:
1. Fire resistant virgin polyethylene, meeting stress-crack test ASTM D1693. Individual tube polyethylene or multi-tube instrument tubing bundle shall be classified as flame retardant under UL 94. Polyethylene material shall be rated as self-extinguishing when tested in accordance with ASTM D635.

2.5 ANALOG ELECTRONIC INSTRUMENTATION

A. Gas Detection Systems:
1. Manufacturers: Toxalert, Dräeger, Enmet, Honeywell Analytical, MSA or approved alternate
2. Provide gas detectors as listed below. Each detector shall be complete package with remote or local space sensors, detection instruments, local indication of current measured value for each sensor and status indicator lights for power and status of each sensor. Devices not requiring remote mounting shall be housed in metal control panel. Status indicators shall be mounted on panel faceplate.
3. Units shall have adjustable setpoints and self-test diagnostics.
a. Gas to be Detected CO and NO_2
b. Alarm Setpoint:
1) CO: low level control signal alarms 15 PPM, 25 PPM, 35 PPM and high alarm 100 PPM
2) NO_2: low alarm 1 PPM, high alarm 3 PPM
c. Range:
1) CO: 0-2 times Alarm Setpoint
2) NO_2: 0-10 ppm NO_2
d. Remote Sensor: As required.
e. Signal: 4-20 mA; Below 4 mA indicates sensor failure
f. Housing: NEMA 4X
g. Temperature: -10°F to 110°F
h. Locations: See floor plans.

B. Space Temperature Sensors:
1. Sensors shall be platinum RTD type, with the following minimum performance:
a. Temperature Coefficient of Resistivity (TCR): 0.00385 ohm/ohm/□C
b. Accuracy: ± .54°F + (0.005 X T) (Class B)
c. Accuracy: ± .27°F + (0.005 X T) (Class A)
T = Temperature of interest
d. Conformance: DIN-IEC 751
e. Operating Range: 32 to 122°F, 0 to 99% rh
2. Thermistors will be acceptable in lieu of RTD provided thermistor carries 5 year guarantee that device will maintain its accuracy within tolerance of ± 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 manufacturer's standard plastic cover.

C. Duct Mounted or Insertion Temperature Sensors:
1. Platinum RTD type, with the following minimum performance:
a. Temperature Coefficient: 0.00385 ohm/ohm/°C
b. Accuracy: ± .54°F + (0.005 X T) (Class B)
c. Accuracy: ± .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 insertions 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. Averaging type sensor to be installed in ducts larger than 24" x 24" or greater than 576in2. Mount averaging sensor across duct area in a "Z" pattern using mounting clips specific for averaging temperature sensor probes.

5. Thermistors will be acceptable in lieu of RTD provided thermistor carries 5 year guarantee that 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.

D. 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 - 20 mA DC output signal proportional to differential (total minus static or static minus ambient) pressure input signals with the following minimum performance and application criteria:
   a. Span: Not greater than twice duct static or velocity pressure at maximum flow rate, or more than 16 times velocity pressure at minimum flow rate.
   b. Accuracy: ± 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 static pressure sensing stations and with static air probes to prevent migration of moisture and particulate matter into transducers. If inputs to pressure transducers/transmitters are dead-ended, integral air filters are not required. Supply air system sensors do not require integral air filters.

E. Differential Pressure Flow Element: Pitot Tube
1. Manufacturers: Dieterich Standard, Preso, Veris Inc. or approved alternate
2. These shall be averaging differential pressure type flow elements. Flow element shall consist of:
   a. Sensing tube with two internal chambers. One shall sense upstream pressure and one shall sense downstream pressure.
   b. These chambers shall have ports of quantity and size to accurately sense flowrate in piping line-size into which these are specified to be installed.
   c. Sensing tube shall have form so shaped as to minimize measurement inaccuracies.
   d. Sensing assemblies shall be provided with suitable supports to prevent damage to these assemblies at maximum flow-rate.
      1) Accuracy: Error ± 1.0% of sensor rated range
      2) Repeatability: Error ± 0.5%
      3) Sensor Materials of Construction: Stainless Steel unless otherwise noted
   e. Insert/Retract "Hot Tap" including insertion device and isolation valve:
      1) Each sensor, which is required to be Hot-Tap shall be provided with isolating valve, packing gland and retraction tube assembly.
      2) Each sensor that is specified to be installed into line in which pressure is greater than 200 psig, or for acid or caustic service, or for hazardous chemical service shall be provided with retaining hardware to allow mechanical retraction and insertion.
   f. Refer to Section 23 2120 - Piping Specialties for Flow Sensors, provided for balancing purposes.

F. Rotary (Damper) Position Sensors:
1. Manufacturers: Kele & Associates, Fisher Controls or Westlock
2. Provide position 4-20 mA transmitter with potentiometer type (variable resistance) sensor for damper position measurement. Measurement to be linear to damper stroke.
   a. Performance:
      1) Power Supply: 24 VDC unregulated
      2) Accuracy: ± 1% of output span
      3) Repeatability: ± 0.5% of full span
      4) Maximum Temperature: 125°F

G. P-E Transducers (Pressure Transmitters):
1. Manufacturers: Ashcroft, Mamac, Setra, Kele & Associates or GE Modus
2. Units shall have the following characteristics:
   a. Input: Pressure 0-15 psig, minimum
   b. Output Signal: 4-20 mA, 0-5 VDC, 1-5 VDC, 1-10 VDC
   c. Accuracy: 1% of span
   d. Operating Temperature 32 to 125°F
   e. Power Requirements: 24 VDC (10-30 VDC)

PART 3 - EXECUTION

3.1 GENERAL

A. Install control equipment and wiring in neat and workmanlike manner and in accordance with manufacturer's recommendations. Maintain clearances, straight length distances, etc., required for proper operation of each device. Mark and detail on coordination drawings, exact locations of inline devices, wells, and taps to be installed by Mechanical Contractor.

B. Coordinate timely delivery of materials and supervise activities of other trade Contractors to install inline devices such as immersion wells, pressure tappings, any associated shut-off valves, flow switches, level switches, flow meters, air flow stations, and other such items furnished by Control Contractor which are to be installed by Mechanical Contractor.

C. Install control devices in accessible location.

D. Mount motor control devices within 5 ft of disconnect switch, or starting device furnished by Electrical Contractor unless noted otherwise. Maintain required NEC clearances.

E. Control Contractor and Mechanical Contractor shall review proposed static pressure sensor and flow meter locations with Owner and Engineer for approval prior to installation.

3.1 GENERAL INSTRUMENTATION

A. Local Control Panels:

1. Install remote mounted devices, controllers, I/O terminal blocks, power supplies, etc., inside of local control panels.
2. Locate panels as shown on drawings.
3. Locate panels adjacent to equipment served with minimum of 3 ft clearance in front of door. Provide sufficient clearances to allow full door swing and full access to internal components. Submit proposed panel locations with shop drawing submittals.
4. Mount top of panels between 5 and 6 ft above floor so that gauges and indicators are at eye level.

3.2 DISCRETE AND ANALOG INSTRUMENTATION

A. Wall Mounted Space Thermostats/Temperature Sensors:

1. Install space thermostats/sensors where indicated, as required to perform specified control sequences, and as directed to meet job site conditions.
2. Provide space temperature sensors without remote setpoint adjustment in all public spaces, hallways, and mechanical rooms unless otherwise specified.
   a. Mount space thermostats/sensors at 5 ft above floor unless otherwise indicated.
   b. Mount space thermostats/sensors with accessible setpoint adjustment or temperature reading (thermometer or digital temperature readout) at 4 ft above floor meeting ADA requirements.
3. Space thermostats/sensors located on exterior walls shall be mounted on thermally insulated sub-base.
4. Relocate space thermostats/sensors if required due to draft, interferences with cabinets, chalkboards, etc., or improper sensing.
5. Mount space thermostats/sensors in corridors, stairways and public toilets 7 ft above floor.
6. Space thermostats/sensors in corridor, stairways, vestibules and toilets shall be aspirating type.
7. Space thermostats/sensors shall be protected by heavy-duty cast and die formed guard.

B. RTD Temperature Transmitters:

1. Provide RTD temperature transmitters whenever DDCPs cannot receive RTD type inputs.

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 device creating differential between fan discharge and fan suction.

D. Outside Air Temperature Sensors:

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

E. Transmitters, Indicators, and Transducers:

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

2. Provide P-E transducers to convert analog pressure signals to analog electronic signals for input to DDC panels.

3.3 PNEUMATIC PIPING

A. Conceal all piping, except for piping in mechanical rooms and other areas where mechanical system piping is exposed.

B. Install exposed piping and conduit parallel to or at right angles to building structure and support adequately at uniform intervals.

1. Provide tubing clamps with insulated standoffs where metallic tubing may come into contact with other dissimilar metals to prevent galvanic corrosion from occurring. Use of wire ties or hose clamps to fasten tubing to structure or other piping is not allowed.
2. Use of tubing channel designed for mounting polyethylene tubing shall be allowed.

C. Polyethylene tubing not exceeding 18" exposed may be used for connection to instrument or actuator.

D. Install polyethylene tubing with no concealed splices and number code all tubing.

E. Piping type shall be as follows:

1. Inside Panels:
   a. Use polyethylene tubing.
2. Exposed:
   a. Polyethylene tubing may be used if run in fully enclosed rigid metal raceway or metal conduit where environment is within temperature limits of polyethylene tubing. Use PVC coated copper tubing or stainless steel tubing for wet environments.
3. Concealed:
   a. Use polyethylene tubing.

END OF SECTION

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SECTION 23 0905
INSTRUMENT POINT LIST

PART 1 – GENERAL
1.1 RELATED WORK
1.2 SUBMITTALS
1.3 INSTRUMENT OR DEVICES USED FOR POINT INPUT TO BAS
1.4 ANALOG ALARM POINTS
PART 2 – PRODUCTS (Not applicable to this Section)
PART 3 – EXECUTION (Not applicable to this Section)

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 0901A – Control Systems Integration.
B. Section 23 0902 – Control Valves and Dampers
C. Section 23 0903 – Control Instrumentation
D. Section 23 0993 – Control Sequences

1.2 SUBMITTALS

A. Point List:
1. Submittals shall include list of each control input and output, device it is controlling, locations of device, and symbol or label of control point in software.
2. The points listed on the attached “Instrument Point List” are not all inclusive. In addition to the points listed, include those points required to implement and monitor the features described in the control sequences.

1.3 INSTRUMENT OR DEVICES USED FOR POINT INPUT TO BAS

A. Control Contractor shall be responsible for providing necessary point input to BAS for equipment and systems provided by Mechanical Contractor or Control Contractor not covered in sequences of operation but necessary for operation of those systems or equipment.
B. Instrument or devices such as auxiliary contacts of equipment provided by other than Mechanical Contractor or Control Contractor, will be furnished with the equipment unless otherwise indicated.

1.4 ANALOG ALARM POINTS

A. Unless indicated in Section 23 0993, consult Owner for the specific values to be used for High and Low limit alarms during programming.

PART 2 - PRODUCTS

2.1 Not applicable to this Section.

PART 3 - EXECUTION

3.1 Not applicable to this Section.

END OF SECTION

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			ALARM INFORMATION												BAS SOFTWARE FUNCTIONS												
SYSTEM: SUPPLY AIR **POINT DESCRIPTION**	**SETPOINT**	**I/O TYPE (AI, AO, DI, DO, AV, BV, LOOP, MULTI)**	**LOW-LOW ALARM**	**LOW ALARM**	**HIGH ALARM**	**HIGH-HIGH ALARM**	**EQUIPMENT FAULT**	**EQUIPMENT STATUS**	**EQUIPMENT HOA**	**MAINTENANCE**	**OPEN/CLOSED**	**CRITICAL**	**LOSS OF COMM**	**ALARM TIME DELAY**	**DEMAND LIMIT**	**DAY/NIGHT SETBACK**	**ECONOMIZER**	**REHEAT COIL RESET**	**HOT WATER OA RESET**	**CHILLED WATER RESET**			**SCHEDULE**	**RUN TIME**	**TOTALIZATION**		**INTEGRATED COMM.**	**COMMENT**
SF-1																												
Supply Fan VFD Start/Stop Command	~	DO																					X					
Supply Fan VFD Speed	X	AO																										
Supply Fan HOA In Auto	~	DI							X	X																		
Supply Fan Run Status	~	BV						X		X			X											X	X		X	BACnet
Supply Fan VFD Fault	~	BV					X			X			X														X	BACnet
Supply Fan VFD Speed Feedback	~	AV											X														X	BACnet
Supply Fan VFD Power (kW)	~	AV											X														X	BACnet
Supply Fan Output Frequency	~	AV											X														X	BACnet
Supply Fan High Pressure Switch Contact 1	~	DI			X		X			X		X																
Supply Fan High Pressure Switch Contact 2	~																											Hardwired to stop VFD controlled Fan
SF-1 SUPPLY AIR DAMPER																												
Supply Air Damper Command	~	DO																										
Supply Air Damper Position Switch Close	~	DI									X																	
Supply Air Damper Position Switch Open	~	DI									X													X	X			
SF-2																												
Supply Fan VFD Start/Stop Command	~	DO																					X					
Supply Fan VFD Speed	X	AO																										
Supply Fan HOA In Auto	~	DI							X	X																		
Supply Fan Run Status	~	BV						X		X			X											X	X		X	BACnet
Supply Fan VFD Fault	~	BV					X			X			X														X	BACnet
Supply Fan VFD Speed Feedback	~	AV											X														X	BACnet
Supply Fan VFD Power (kW)	~	AV											X														X	BACnet
Supply Fan Output Frequency	~	AV											X														X	BACnet
Supply Fan High Pressure Switch Contact 1	~	DI			X		X			X		X																
Supply Fan High Pressure Switch Contact 2	~																											Hardwired to stop VFD controlled Fan
SF-2 SUPPLY AIR DAMPER																												
Supply Air Damper Command	~	DO																										
Supply Air Damper Position Switch Close	~	DI									X																	
Supply Air Damper Position Switch Open	~	DI									X													X	X			
SF-3																												

			ALARM INFORMATION												BAS SOFTWARE FUNCTIONS												
SYSTEM: SUPPLY AIR **POINT DESCRIPTION**	**SETPOINT**	**I/O TYPE (AI, AO, DI, DO, AV, BV, LOOP, MULTI)**	**LOW-LOW ALARM**	**LOW ALARM**	**HIGH ALARM**	**HIGH-HIGH ALARM**	**EQUIPMENT FAULT**	**EQUIPMENT STATUS**	**EQUIPMENT HOA**	**MAINTENANCE**	**OPEN/CLOSED**	**CRITICAL**	**LOSS OF COMM**	**ALARM TIME DELAY**	**DEMAND LIMIT**	**DAY/NIGHT SETBACK**	**ECONOMIZER**	**REHEAT COIL RESET**	**HOT WATER OA RESET**	**CHILLED WATER RESET**			**SCHEDULE**	**RUN TIME**	**TOTALIZATION**		**INTEGRATED COMM.**	**COMMENT**
Supply Fan VFD Start/Stop Command	~	DO																					X					
Supply Fan VFD Speed	X	AO																										
Supply Fan HOA In Auto	~	DI							X	X																		
Supply Fan Run Status	~	BV						X		X			X											X	X		X	BACnet
Supply Fan VFD Fault	~	BV					X			X			X														X	BACnet
Supply Fan VFD Speed Feedback	~	AV											X														X	BACnet
Supply Fan VFD Power (kW)	~	AV											X														X	BACnet
Supply Fan Output Frequency	~	AV											X														X	BACnet
Supply Fan High Pressure Switch Contact 1	~	DI			X		X			X		X																
Supply Fan High Pressure Switch Contact 2	~																											Hardwired to stop VFD controlled Fan
SF-3 SUPPLY AIR DAMPER																												
Supply Air Damper Command	~	DO																										
Supply Air Damper Position Switch Close	~	DI									X																	
Supply Air Damper Position Switch Open	~	DI									X													X	X			
SF-4																												
Supply Fan VFD Start/Stop Command	~	DO																					X					
Supply Fan VFD Speed	X	AO																										
Supply Fan HOA In Auto	~	DI							X	X																		
Supply Fan Run Status	~	BV						X		X			X											X	X		X	BACnet
Supply Fan VFD Fault	~	BV					X			X			X														X	BACnet
Supply Fan VFD Speed Feedback	~	AV											X														X	BACnet
Supply Fan VFD Power (kW)	~	AV											X														X	BACnet
Supply Fan Output Frequency	~	AV											X														X	BACnet
Supply Fan High Pressure Switch Contact 1	~	DI			X		X			X		X																
Supply Fan High Pressure Switch Contact 2	~																											Hardwired to stop VFD controlled Fan
SF-4 SUPPLY AIR DAMPER																												
Supply Air Damper Command	~	DO																										
Supply Air Damper Position Switch Close	~	DI									X																	
Supply Air Damper Position Switch Open	~	DI									X													X	X			
SUPPLY AIR FLOOR LEVEL DAMPERS (Typ. -See Floor Plans for Quantity)																												
Supply Air Damper Command	~	DO																										

			ALARM INFORMATION												BAS SOFTWARE FUNCTIONS													
SYSTEM: SUPPLY AIR **POINT DESCRIPTION**	**SETPOINT**	**I/O TYPE (AI, AO, DI, DO, AV, BV, LOOP, MULTI)**	**LOW-LOW ALARM**	**LOW ALARM**	**HIGH ALARM**	**HIGH-HIGH ALARM**	**EQUIPMENT FAULT**	**EQUIPMENT STATUS**	**EQUIPMENT HOA**	**MAINTENANCE**	**OPEN/CLOSED**	**CRITICAL**	**LOSS OF COMM**	**ALARM TIME DELAY**	**DEMAND LIMIT**	**DAY/NIGHT SETBACK**	**ECONOMIZER**	**REHEAT COIL RESET**	**HOT WATER OA RESET**	**CHILLED WATER RESET**			**SCHEDULE**	**RUN TIME**	**TOTALIZATION**		**INTEGRATED COMM.**	**COMMENT**
Supply Air Damper Position Switch Close	~	DI									X																	
Supply Air Damper Position Switch Open	~	DI									X													X	X			
Supply Air Smoke Detector (Typical of 2)	~	DI										X																
Supply Air Smoke Detector Hardwire Shutdown (Typical of 2)	~																											Hardwired to fans
Supply Air Pressure Transmitter (Typical of 2)	~	AI		X	X					X																		

			ALARM INFORMATION												BAS SOFTWARE FUNCTIONS												
SYSTEM: EXHAUST AIR **POINT DESCRIPTION**	**SETPOINT**	**I/O TYPE (AI, AO, DI, DO, AV, BV, LOOP, MULTI)**	**LOW-LOW ALARM**	**LOW ALARM**	**HIGH ALARM**	**HIGH-HIGH ALARM**	**EQUIPMENT FAULT**	**EQUIPMENT STATUS**	**EQUIPMENT HOA**	**MAINTENANCE**	**OPEN/CLOSED**	**CRITICAL**	**LOSS OF COMM**	**ALARM TIME DELAY**	**DEMAND LIMIT**	**DAY/NIGHT SETBACK**	**ECONOMIZER**	**REHEAT COIL RESET**	**HOT WATER OA RESET**	**CHILLED WATER RESET**			**SCHEDULE**	**RUN TIME**	**TOTALIZATION**		**INTEGRATED COMM.**	**COMMENT**
EF-1																											
Exhaust Fan VFD Start/Stop Command	~	DO																					X				
Exhaust Fan VFD Speed	X	AO																									
Exhaust Fan HOA In Auto	~	DI							X	X																	
Exhaust Fan Run Status	~	BV						X		X			X											X	X		X	BACnet
Exhaust Fan VFD Fault	~	BV					X			X			X														X	BACnet
Exhaust Fan VFD Speed Feedback	~	AV											X														X	BACnet
Exhaust Fan VFD Power (kW)	~	AV											X														X	BACnet
Exhaust Fan Output Frequency	~	AV											X														X	BACnet
Exhaust Fan High Pressure Switch Contact 1	~	DI			X		X			X		X																
Exhaust Fan High Pressure Switch Contact 2	~																											Hardwired to stop VFD controlled Fan
EF-1 EXHAUST AIR DAMPER																											
Exhaust Air Damper Command	~	DO																									
Exhaust Air Damper Position Switch Close	~	DI									X																
Exhaust Air Damper Position Switch Open	~	DI									X													X	X		
EF-2																											
Exhaust Fan VFD Start/Stop Command	~	DO																					X				
Exhaust Fan VFD Speed	X	AO																									
Exhaust Fan HOA In Auto	~	DI							X	X																	
Exhaust Fan Run Status	~	BV						X		X			X											X	X		X	BACnet
Exhaust Fan VFD Fault	~	BV					X			X			X														X	BACnet
Exhaust Fan VFD Speed Feedback	~	AV											X														X	BACnet
Exhaust Fan VFD Power (kW)	~	AV											X														X	BACnet
Exhaust Fan Output Frequency	~	AV											X														X	BACnet
Exhaust Fan High Pressure Switch Contact 1	~	DI			X		X			X		X																
Exhaust Fan High Pressure Switch Contact 2	~																											Hardwired to stop VFD controlled Fan
EF-2 EXHAUST AIR DAMPER																											
Exhaust Air Damper Command	~	DO																									
Exhaust Air Damper Position Switch Close	~	DI									X																
Exhaust Air Damper Position Switch Open	~	DI									X													X	X		
EF-3																											
Exhaust Fan VFD Start/Stop Command	~	DO																					X				

			ALARM INFORMATION												BAS SOFTWARE FUNCTIONS													
SYSTEM: EXHAUST AIR **POINT DESCRIPTION**	**SETPOINT**	**I/O TYPE (AI, AO, DI, DO, AV, BV, LOOP, MULTI)**	**LOW-LOW ALARM**	**LOW ALARM**	**HIGH ALARM**	**HIGH-HIGH ALARM**	**EQUIPMENT FAULT**	**EQUIPMENT STATUS**	**EQUIPMENT HOA**	**MAINTENANCE**	**OPEN/CLOSED**	**CRITICAL**	**LOSS OF COMM**	**ALARM TIME DELAY**	**DEMAND LIMIT**	**DAY/NIGHT SETBACK**	**ECONOMIZER**	**REHEAT COIL RESET**	**HOT WATER OA RESET**	**CHILLED WATER RESET**			**SCHEDULE**	**RUN TIME**	**TOTALIZATION**		**INTEGRATED COMM.**	**COMMENT**
Exhaust Fan VFD Speed	X	AO																										
Exhaust Fan HOA In Auto	~	DI							X	X																		
Exhaust Fan Run Status	~	BV						X		X			X											X	X		X	BACnet
Exhaust Fan VFD Fault	~	BV					X			X			X														X	BACnet
Exhaust Fan VFD Speed Feedback	~	AV											X														X	BACnet
Exhaust Fan VFD Power (kW)	~	AV											X														X	BACnet
Exhaust Fan Output Frequency	~	AV											X														X	BACnet
Exhaust Fan High Pressure Switch Contact 1	~	DI			X		X			X		X																
Exhaust Fan High Pressure Switch Contact 2	~																											Hardwired to stop VFD controlled Fan
EF-3 EXHAUST AIR DAMPER																												
Exhaust Air Damper Command	~	DO																										
Exhaust Air Damper Position Switch Close	~	DI									X																	
Exhaust Air Damper Position Switch Open	~	DI									X													X	X			
EF-4																												
Exhaust Fan VFD Start/Stop Command	~	DO																					X					
Exhaust Fan VFD Speed	X	AO																										
Exhaust Fan HOA In Auto	~	DI							X	X																		
Exhaust Fan Run Status	~	BV						X		X			X											X	X		X	BACnet
Exhaust Fan VFD Fault	~	BV					X			X			X														X	BACnet
Exhaust Fan VFD Speed Feedback	~	AV											X														X	BACnet
Exhaust Fan VFD Power (kW)	~	AV											X														X	BACnet
Exhaust Fan Output Frequency	~	AV											X														X	BACnet
Exhaust Fan High Pressure Switch Contact 1	~	DI			X		X			X		X																
Exhaust Fan High Pressure Switch Contact 2	~																											Hardwired to stop VFD controlled Fan
EF-4 EXHAUST AIR DAMPER																												
Exhaust Air Damper Command	~	DO																										
Exhaust Air Damper Position Switch Close	~	DI									X																	
Exhaust Air Damper Position Switch Open	~	DI									X													X	X			
EXHAUST AIR FLOOR LEVEL DAMPERS (Typ. -See Floor Plans for Quantity)																												
Exhaust Air Damper Command	~	DO																										
Exhaust Air Damper Position Switch Close	~	DI									X																	
Exhaust Air Damper Position Switch Open	~	DI									X													X	X			

			ALARM INFORMATION													BAS SOFTWARE FUNCTIONS													
SYSTEM: EXHAUST AIR **POINT DESCRIPTION**	**SETPOINT**	**I/O TYPE (AI, AO, DI, DO, AV, BV, LOOP, MULTI)**	**LOW-LOW ALARM**	**LOW ALARM**	**HIGH ALARM**	**HIGH-HIGH ALARM**	**EQUIPMENT FAULT**	**EQUIPMENT STATUS**	**EQUIPMENT HOA**	**MAINTENANCE**	**OPEN/CLOSED**	**CRITICAL**	**LOSS OF COMM**	**ALARM TIME DELAY**	**DEMAND LIMIT**	**DAY/NIGHT SETBACK**	**ECONOMIZER**	**REHEAT COIL RESET**	**HOT WATER OA RESET**	**CHILLED WATER RESET**			**SCHEDULE**	**RUN TIME**	**TOTALIZATION**		**INTEGRATED COMM.**	**COMMENT**
Exhaust Air Smoke Detector (Typical of 2)	~	DI										X																
Exhaust Air Smoke Detector Hardwire Shutdown (Typical of 2)	~																											Hardwired to fans
Exhaust Air Pressure Transmitter (Typical of 2)	~	AI		X	X					X																		

			ALARM INFORMATION												BAS SOFTWARE FUNCTIONS													
SYSTEM: IMPULSE FANS **POINT DESCRIPTION**	**SETPOINT**	**I/O TYPE (AI, AO, DI, DO, AV, BV, LOOP, MULTI)**	**LOW-LOW ALARM**	**LOW ALARM**	**HIGH ALARM**	**HIGH-HIGH ALARM**	**EQUIPMENT FAULT**	**EQUIPMENT STATUS**	**EQUIPMENT HOA**	**MAINTENANCE**	**OPEN/CLOSED**	**CRITICAL**	**LOSS OF COMM**	**ALARM TIME DELAY**	**DEMAND LIMIT**	**DAY/NIGHT SETBACK**	**ECONOMIZER**	**REHEAT COIL RESET**	**HOT WATER OA RESET**	**CHILLED WATER RESET**			**SCHEDULE**	**RUN TIME**	**TOTALIZATION**		**INTEGRATED COMM.**	**COMMENT**
IF-# - IMPULSE FANS (Typical - See Floor Plans for Quantities)	-	-																									
Fan Speed - High	~	DO																									
Fan Speed - Low	~	DO																									
Current Switch	~	DI						X		X														X	X			
GAS DETECTORS (Typical - See Floor Plans for Quantities)	-	-																									
NO2 Detector	~	AI			X	X	X																				
CO Detector	~	AI			X	X	X																				
SF-6																											
Fan Speed - High	~	DO																									
Fan Speed - Low	~	DO																									
Current Switch	~	DI						X		X														X	X			
SF-7																											
Fan Speed - High	~	DO																									
Fan Speed - Low	~	DO																									
Current Switch	~	DI						X		X														X	X			
Smoke Detector Interface (Typical of 1 per floor)	~	DI										X																
Smoke Detector Hardwire Shutdown (Typical of 1 per floor)	~																											Hardwired to fans

			ALARM INFORMATION												BAS SOFTWARE FUNCTIONS													
SYSTEM: EMERGENCY GENERATOR & DAY TANK **POINT DESCRIPTION**	**SETPOINT**	**I/O TYPE (AI, AO, DI, DO, AV, BV, LOOP, MULTI)**	**LOW-LOW ALARM**	**LOW ALARM**	**HIGH ALARM**	**HIGH-HIGH ALARM**	**EQUIPMENT FAULT**	**EQUIPMENT STATUS**	**EQUIPMENT HOA**	**MAINTENANCE**	**OPEN/CLOSED**	**CRITICAL**	**LOSS OF COMM**	**ALARM TIME DELAY**	**DEMAND LIMIT**	**DAY/NIGHT SETBACK**	**ECONOMIZER**	**REHEAT COIL RESET**	**HOT WATER OA RESET**	**CHILLED WATER RESET**			**SCHEDULE**	**RUN TIME**	**TOTALIZATION**		**INTEGRATED COMM.**	**COMMENT**
DAY TANK																												
Level Switch High	~	DI			X					X		X															
Level Switch Low	~	DI		X						X		X															
Fill Station Level Signal	~																										Hardwired Analog Level from Fill to Day Tank
Fill Station Leak Signal	~																										Hardwired Signal from Fill to Day Tank
Fuel System Leak	~	DI			X					X		X															
GENERATOR ROOM																											
Space Temperature	~	AI		X	X					X		X															
Pressure Differential Transmitter	~	AI		X	X					X		X															
Radiator Return Air Damper	X	AO																									
Generator Starting Monitor	~	DI						X		X																	
Generator Running Monitor	~	DI						X		X																	
Unit Heater Thermostat																											Hardwired to two Unit Heater Controllers
SF-5																											
Supply Fan HOA In Auto	~	DI							X	X																	
Supply Fan Status	~	DI						X		X													X	X			
Supply Fan Start/Stop	~																										Hardwired to Relay Panel
Supply Fan Pressure Control	~																										Wire PDT to VFD and use Internal PID Loop
EF-5																											
Exhaust Fan HOA In Auto	~	DI							X	X																	
Exhaust Fan Status	~	DI						X		X													X	X			
Exhaust Fan Start/Stop	~																										Hardwired to Relay Panel
SF-8																											
Fan Start	~	DO																									
Current Switch	~	DI																					X	X			
GENERATOR																											
LDI 1 - Low Lube Oil Pressure Pre-Alarm	~	DI		X	X							X	X													X	
LDI 2 - Low Water Temperature	~	DI		X	X							X	X													X	
LDI 3 - High Engine Temperature Prealarm	~	DI		X	X							X	X													X	
LDI 4 - Battery Charger AC Failure	~	DI										X	X													X	

			ALARM INFORMATION												BAS SOFTWARE FUNCTIONS												
SYSTEM: EMERGENCY GENERATOR & DAY TANK **POINT DESCRIPTION**	**SETPOINT**	**I/O TYPE (AI, AO, DI, DO, AV, BV, LOOP, MULTI)**	**LOW-LOW ALARM**	**LOW ALARM**	**HIGH ALARM**	**HIGH-HIGH ALARM**	**EQUIPMENT FAULT**	**EQUIPMENT STATUS**	**EQUIPMENT HOA**	**MAINTENANCE**	**OPEN/CLOSED**	**CRITICAL**	**LOSS OF COMM**	**ALARM TIME DELAY**	**DEMAND LIMIT**	**DAY/NIGHT SETBACK**	**ECONOMIZER**	**REHEAT COIL RESET**	**HOT WATER OA RESET**	**CHILLED WATER RESET**			**SCHEDULE**	**RUN TIME**	**TOTALIZATION**		**INTEGRATED COMM.**	**COMMENT**
LDI 6 - Control Switch Not In Automatic Position	~	DI								X		X	X													X	
LDI 7 - High Battery Voltage	~	DI			X							X	X													X	
LDI 8 - Low Coolant Level	~	DI		X								X	X													X	
LDI 9 - Low Cranking Voltage	~	DI		X								X	X													X	
LDI 10 - Low Voltage In Battery	~	DI		X								X	X													X	
LDI 11 - EPS Supplying Loads	~	DI											X													X	
LDI 12 - Generator Circuit Breaker Ground Fault	~	DI					X					X	X													X	
LDI 13 - Low Lube Oil Pressure	~	DI		X								X	X													X	
LDI 14 - High Engine Temperature	~	DI			X							X	X													X	
LDI 15 - Overcrank	~	DI					X					X	X													X	
LDI 16 - Overspeed	~	DI					X					X	X													X	
LDI 17 - Remote Emergency Manual Stop Switch	~	DI					X					X	X													X	
LDI 18 - Overcurrent (Circuit Breaker Trip And Lockout)	~	DI					X					X	X													X	
LDI 19 - Reverse Power Relay Trip	~	DI					X					X	X													X	
LDI 21 - Engine Running	~	DI											X													X	
LDI 22 - Generator Running	~	DI											X													X	
LDI 23 - Generator Circuit Breaker Open	~	DI											X													X	
LDI 24 - Generator Circuit Breaker Closed	~	DI											X													X	
LDI 25 - Generator Circuit Breaker Failed To Close	~	DI					X					X	X													X	
LDI 27 - Control Voltage Failure	~	DI					X					X	X													X	
LDI 29 - Battery Charger Failure	~	DI					X					X	X													X	
LAI 1 - Generator Phase A-B Voltage	~	AI											X													X	Volts
LAI 2 - Generator Phase B-C Voltage	~	AI											X													X	Volts
LAI 3 - Generator Phase C-A Voltage	~	AI											X													X	Volts
LAI 4 - Generator Phase A Current	~	AI											X													X	Amperes
LAI 5 - Generator Phase B Current	~	AI											X													X	Amperes
LAI 6 - Generator Phase C Current	~	AI											X													X	Amperes
LAI 7 - Total Real Power	~	AI											X													X	KW
LAI 8 - Total Apparent Power	~	AI											X													X	KVA
LAI 9 - Total Reactive Power	~	AI											X													X	KVAR
LAI 10 - Generator Power Factor	~	AI											X													X	
LAI 11 - Generator Phase A Frequency	~	AI											X													X	Hertz
LAI 12 - Generator Phase B Frequency	~	AI											X													X	Hertz
LAI 13 - Generator Phase C Frequency	~	AI											X													X	Hertz
LAI 14 - Battery Voltage	~	AI											X													X	Volts

			ALARM INFORMATION												BAS SOFTWARE FUNCTIONS													
SYSTEM: EMERGENCY GENERATOR & DAY TANK **POINT DESCRIPTION**	**SETPOINT**	**I/O TYPE (AI, AO, DI, DO, AV, BV, LOOP, MULTI)**	**LOW-LOW ALARM**	**LOW ALARM**	**HIGH ALARM**	**HIGH-HIGH ALARM**	**EQUIPMENT FAULT**	**EQUIPMENT STATUS**	**EQUIPMENT HOA**	**MAINTENANCE**	**OPEN/CLOSED**	**CRITICAL**	**LOSS OF COMM**	**ALARM TIME DELAY**	**DEMAND LIMIT**	**DAY/NIGHT SETBACK**	**ECONOMIZER**	**REHEAT COIL RESET**	**HOT WATER OA RESET**	**CHILLED WATER RESET**			**SCHEDULE**	**RUN TIME**	**TOTALIZATION**		**INTEGRATED COMM.**	**COMMENT**
LAI 15 - Engine Oil Pressure	~	AI											X														X	KPA
LAI 16 - Engine Speed	~	AI											X														X	RPM
LAI 17 - Engine Water Temperature	~	AI											X														X	Degrees Centigrade
LAI 18 - Engine Running Time	~	AI											X											X			X	Hours

			ALARM INFORMATION												BAS SOFTWARE FUNCTIONS												
SYSTEM: TYPICALS **POINT DESCRIPTION**	**SETPOINT**	**I/O TYPE (AI, AO, DI, DO, AV, BV, LOOP, MULTI)**	**LOW-LOW ALARM**	**LOW ALARM**	**HIGH ALARM**	**HIGH-HIGH ALARM**	**EQUIPMENT FAULT**	**EQUIPMENT STATUS**	**EQUIPMENT HOA**	**MAINTENANCE**	**OPEN/CLOSED**	**CRITICAL**	**LOSS OF COMM**	**ALARM TIME DELAY**	**DEMAND LIMIT**	**DAY/NIGHT SETBACK**	**ECONOMIZER**	**REHEAT COIL RESET**	**HOT WATER OA RESET**	**CHILLED WATER RESET**			**SCHEDULE**	**RUN TIME**	**TOTALIZATION**		**INTEGRATED COMM.**	**COMMENT**
TYPICAL UNIT HEATER - ELECTRIC (See Floor Plans for Quantity)																											
Room Temperature Sensor	~																										Hardwired to Heater
Room Temperature	~	AV		X	X								X													X	BACnet
Room Temperature Setpoint	X	AV											X													X	BACnet
Room Temperature Deadband	X	AV																								X	BACnet
Run Status	~	BV						X		X			X										X	X		X	BACnet
Miscellaneous (5 Points Determined in Field)																											BACnet
TYPICAL UNIT HEATER - GAS (See Floor Plans for Quantity)																											
Room Temperature Sensor	~																										Hardwired to Heater
Room Temperature	~	AV		X	X								X													X	BACnet
Room Temperature Setpoint	X	AV											X													X	BACnet
Room Temperature Deadband	X	AV																								X	BACnet
Run Status	~	BV						X		X			X										X	X		X	BACnet
Miscellaneous (5 Points Determined in Field)																											BACnet
TYPICAL ELECTRIC HEATER (See Floor Plans for Quantity)																											
Room Temperature Sensor	~																										Hardwired to Heater
Room Temperature	~	AV		X	X								X													X	BACnet
Room Temperature Setpoint	X	AV											X													X	BACnet
Room Temperature Deadband	X	AV																								X	BACnet
Run Status	~	BV						X		X			X										X	X		X	BACnet
Miscellaneous (5 Points Determined in Field)																											BACnet
TYP. GAS RADIANT HEATER (See Floor Plans for Quantity)																											
Snow Melt Sensor System (Refer to Floor Plans and Specs for Qty of Sensors.)	~																										Hardwired to Controller
Snow Melt Controller (Refer to Floor Plans and Specs for Qty of Controllers.)	~																										Hardwired to Heater
TYPICAL EXHAUST FAN (Toilet and General - See Floor Plans for Qty.)																											
Exhaust Fan Start/Stop Command	~	DO																					X				
Current Switch	~	DI						X																X	X		
AUX. Start/Stop Switch	~	DI						X																			Required for Workshop Only
Smoke Detector Hardwire Shutdown	~																										Hardwired to fan

			ALARM INFORMATION												BAS SOFTWARE FUNCTIONS													
SYSTEM: TYPICAL FAN COIL UNIT WITH AIR COOLED CONDENSER **POINT DESCRIPTION**	**SETPOINT**	**I/O TYPE (AI, AO, DI, DO, AV, BV, LOOP, MULTI)**	**LOW-LOW ALARM**	**LOW ALARM**	**HIGH ALARM**	**HIGH-HIGH ALARM**	**EQUIPMENT FAULT**	**EQUIPMENT STATUS**	**EQUIPMENT HOA**	**MAINTENANCE**	**OPEN/CLOSED**	**CRITICAL**	**LOSS OF COMM**	**ALARM TIME DELAY**	**DEMAND LIMIT**	**DAY/NIGHT SETBACK**	**ECONOMIZER**	**REHEAT COIL RESET**	**HOT WATER OA RESET**	**CHILLED WATER RESET**			**SCHEDULE**	**RUN TIME**	**TOTALIZATION**		**INTEGRATED COMM.**	**COMMENT**
FAN COIL UNIT (Typical - See Floor Plans for Quantity)																												
Room Temperature Sensor	~	AV																										Hardwired to Fan Coil
Room Temperature	~	AV		X	X								X														X	BACnet
Cooling Mode	~	BV						X					X														X	BACnet
Heating Mode	~	BV						X					X														X	BACnet
Room Temperature Setpoint	X	AV											X														X	BACnet
Room Temperature Deadband	X	AV																									X	BACnet
Fan Run Status	~	BV						X		X			X											X	X		X	BACnet
Compressor Run Status (Each Stage)	~	BV						X		X			X											X	X		X	BACnet
Miscellaneous (5 Points Determined in Field)																												BACnet
Drain Pain Condensate Sensor	~	DI			X			X		X		X	X															
AIR COOLED CONDENSER (Typical - See Floor Plans for Quantity)																												
Compressor Start/Stop	~																											Hardwire all Staging Required

			ALARM INFORMATION													BAS SOFTWARE FUNCTIONS													
SYSTEM: UTILITY METERS **POINT DESCRIPTION**	**SETPOINT**	**I/O TYPE (AI, AO, DI, DO, AV, BV, LOOP, MULTI)**	**LOW-LOW ALARM**	**LOW ALARM**	**HIGH ALARM**	**HIGH-HIGH ALARM**	**EQUIPMENT FAULT**	**EQUIPMENT STATUS**	**EQUIPMENT HOA**	**MAINTENANCE**	**OPEN/CLOSED**	**CRITICAL**	**LOSS OF COMM**	**ALARM TIME DELAY**	**DEMAND LIMIT**	**DAY/NIGHT SETBACK**	**ECONOMIZER**	**REHEAT COIL RESET**	**HOT WATER OA RESET**	**CHILLED WATER RESET**			**SCHEDULE**	**RUN TIME**	**TOTALIZATION**		**INTEGRATED COMM.**	**COMMENT**
ELECTRICAL METER																												
kW/Pulse Frequency Input	~	FI																										Demand and Consumtion (kW and kWh)
																												Display on Dashboard
GAS METER																												
BTU/Pulse Frequency Input	~	FI																										Demand and Consumtion
																												Display on Dashboard

			ALARM INFORMATION												BAS SOFTWARE FUNCTIONS													
SYSTEM: TRANSFER SWITCH AND FIRE PUMP **POINT DESCRIPTION**	**SETPOINT**	**I/O TYPE (AI, AO, DI, DO, AV, BV, LOOP, MULTI)**	**LOW-LOW ALARM**	**LOW ALARM**	**HIGH ALARM**	**HIGH-HIGH ALARM**	**EQUIPMENT FAULT**	**EQUIPMENT STATUS**	**EQUIPMENT HOA**	**MAINTENANCE**	**OPEN/CLOSED**	**CRITICAL**	**LOSS OF COMM**	**ALARM TIME DELAY**	**DEMAND LIMIT**	**DAY/NIGHT SETBACK**	**ECONOMIZER**	**REHEAT COIL RESET**	**HOT WATER OA RESET**	**CHILLED WATER RESET**			**SCHEDULE**	**RUN TIME**	**TOTALIZATION**		**INTEGRATED COMM.**	**COMMENT**
TRANSFER SWITCH L1SAHB1																												
ON GENERATOR POWER	~	DI								X		X												X	X			
TRANSFER SWITCH L1EAHB1																												
ON GENERATOR POWER	~	DI								X		X												X	X			
TRANSFER SWITCH L1LAHB1																												
ON GENERATOR POWER	~	DI								X		X												X	X			
FIRE PUMP RUNNINF AUX. CONTACT																												
FIRE PUMP RUNNING	~	DI								X		X												X	X			

SECTION 23 09 93
CONTROL SEQUENCES

PART 1 – GENERAL
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3.1 CONTROL SEQUENCE
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3.11 RESTROOM AND JANITOR EXHAUST FAN – CONTROL SEQUENCE
3.12 WORKSHOP EXHAUST FAN – CONTROL SEQUENCE
3.13 STANDBY POWER OPERATION
3.14 SMOKE CONTROL SYSTEMS – CONTROL SEQUENCE

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 0901A - Control System Integration, applies to the work of this Section.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Refer to sections stated under related work.

PART 3 - EXECUTION

3.1 CONTROL SEQUENCE

A. Systems shall perform in accordance with the following. Controls contactor responsible to coordinate and work with packaged equipment providers to provide communication interfaces and interconnecting wiring.

B. All setpoints shall be field adjustable (FA) from the operator workstation.

3.2 EMERGENCY GENERATOR ROOM VENTILATION SYSTEM - CONTROL SEQUENCE

A. System consists of a generator supply fan with backdraft damper, generator exhaust fan with backdraft damper, exhaust air radiator recirculation damper, minimum outside air fan with backdraft damper, combustion air backdraft damper, two gas fired unit heaters, instrumentation, and hardwired controls using a relay panel.

B. Controls contractor to create a set of wiring schematics indicating interconnecting wiring configuration of system. Control contractor to coordinate with generator manufacturer for relay signals.

C. Controls contractor responsible for relay panel and signal wiring to fans, dampers, generator, and sensors.

D. Electronic controllers are not allowed for sequencing the generator supply fan and generator exhaust fan (see instrument flow diagrams). Generator supply fan VFD internal PID loop shall control room supply fan speed to maintain room pressure. Room temperature control can be by the BAS system.

E. All control dampers shall be fail open type except the exhaust air radiator recirculation damper which shall be fail closed.

F. Normal operation:

1. Minimum outside air fan operates continuously. Confirm operation via current switch
2. Combustion air backdraft damper is closed.

3. Two gas fired unit heaters maintain a minimum space temperature using a single thermostat to cycle system on and off using packaged controls. Temperature shall not be allowed to go below 40°F per NFPA 110.

G. Emergency Generator Operation
1. Generator starts from transfer switch signal when power is lost or from a test signal. Combustion air is supplied by the combustion air backdraft damper.
2. Once the generator is starting or running the hardwired relay panel tells the supply fan and exhaust fan VFDs to start based on generator hardwired signals. Once the transfer switch provides power to the VFDs, they start and go to a preset speed.
3. A temperature sensor in the space modulates the exhaust air radiator recirculation damper (recirculates air off the radiator) to maintain a space temperature above 40F.
4. The supply fan VFD shall use an internal PID loop to modulate its speed to maintain a slightly negative pressure in the generator room allowing the combustion air backdraft damper to close.

H. Alarms
1. Generator Running
2. Generator Starting
3. High space temperature
4. Low space temperature
5. Space pressure too negative or too positive
6. Generator supply fan not in Auto
7. Generator exhaust fan not in Auto
8. Minimum outside air fan failure (via current switch)

3.3 EMERGENCY GENERATOR DAY TANK - CONTROL SEQUENCE

A. System consists of a day tank, day tank level transmitter, fuel line solenoid valves, fill station, and hard wired interconnecting wiring.

B. Level controller, shall be provided by mechanical contractor and coordinated with the controls contractor for signals.

C. Controls contractor to create a set of wiring schematics indicating interconnecting wiring configuration of system. Control contractor to coordinate with generator manufacture, day tank manufacture, and fill station manufacture for signals required for a functioning system. Controls contractor to provide and install interface wiring.

D. Day tank level transmitter shall signal package fill station the tank level. This is used when filling the day tank. Fill station has a control valve that closes on a high level to stop filling.

E. Day tank integral fuel management system to monitor tank level and leak detection devices. Controls contractor to provide signal wiring and conduit.

F. Alarms
1. On drop of day tank oil level below preset minimum, BAS shall be alarmed using a low-level signal form the day tank level transmitter.
2. On rise of day tank oil level above preset maximum, BAS shall be alarmed using a high-level signal from the day tank level transmitter.
3. On detection of leaks in the system. BAS shall be alarmed using a signal from the integral fuel management controller.

3.4 FAN COIL HEAT PUMP AND AIR COOLED CONDENSING UNITS - CONTROL SEQUENCE

A. Each fan coil unit heat pump has packaged operating and safety automatic control furnished by unit manufacturer.

B. Unit shall operate in a heating or cooling mode using deadband control for transfer from heating to cooling or cooling to heating. Unit shall be controlled using a BACnet thermostat connected to the BAS system

C. Interlock condensing unit to associated evaporator unit and fan coil so that condensing unit is operative only when associated evaporator and fan coil unit is operating.

D. Refrigerant compressor shall be cycled by heating/cooling/deadband thermostat.

E. Map BACnet communication points. See points list for minimum points required.

F. Provide drain pain condensate sensor to alarm on condensate backup.

G. Controls contractor to provide and install interface wiring.

3.5 UNIT HEATERS - CONTROL SEQUENCE

A. Space thermostat shall control each unit to maintain space set point temperature.

B. Space thermostat shall cycle unit gas valve (or electric heater) and fan motor to maintain space set point temperature.

C. Controls contractor to provide/install interconnect wiring and provide/install BACnet thermostat.
D. Map BACnet communication points. See points list for minimum points required.

3.6 ELECTRIC HEATERS - CONTROL SEQUENCE

A. Space thermostat shall control each unit to maintain space temperature setpoint.
B. Space thermostat shall cycle unit electric heater contactor to maintain space set point temperature.
C. Controls contractor to provide/install BACnet IP thermostat and provide/install interconnect wiring.
D. Map BACnet communication points. See points list for minimum points required.

3.7 GAS FIRED RADIANT HEATERS - CONTROL SEQUENCE

A. Snow/ice detector provided with heater and controller shall operate heater when snow/ice is detected. Each unit to maintain slab temperature above the melting point of ice.

3.8 SMOKE/FIRE ALARM MODE - CONTROL SEQUENCE

A. Smoke detectors in ductwork:
    1. Smoke detectors furnished, installed, and wired to fire alarm control panel by electrical contractor.
    2. Wire contact on fire alarm system provided by EC to fan starters to shut down fans when Fire Alarm System is in alarm condition.
    3. Smoke detectors or smoke detector contacts to be provided for the following units.
        a. EF-1/2 & EF-3/4
            1) Exhaust air ductwork
        b. SF-1/2 & FF-3/4
            1) Supply air ductwork
        c. All impulse fans
        d. General exhaust fans
    4. Provide BAS alarm when smoke detector is in alarm.

3.9 GARAGE VENTILATION SUPPLY AND EXHAUST FANS - CONTROL SEQUENCE

A. System consists of 4 supply fans, 4 exhaust fans, dampers, sensors, and ductwork.
B. System is designed for variable supply and exhaust of the parking garage based on operating mode and gas detection system.
C. Provide verification of fire pump(s) status. If fire pump is operating and facility is operating on generator power, inhibit supply and exhaust fans from operating.
D. Provide scheduled occupied and unoccupied mode controlled by the building automation system. Supply and exhaust fans shall be off during unoccupied hours.
E. Gas detection system shall override schedule mode and operate fans in occupied mode if an impulse fan is required to operate to remove pollutants, regardless of BAS occupied/unoccupied mode.
F. During occupied mode:
    1. System volume control will be accomplished by variable frequency drive(s) and shall incorporate lead/lag control for paired fans (SF-1 & 2 with EF-1 & 2; SF-3 & 4 with EF-3 & 4).
        a. The lead fan is the fan which will start first and stop last in the sequence. The lag fan is the fan which will follow the lead fan in the start sequence and precede the lead fan in the stop sequence.
        b. Initial designation of lead and lag fan shall be manually definable through BAS.
        c. When all fans are stopped, the fan with the lowest run time shall be the lead fan, followed by the fan with succeeding lowest run time.
        d. Lead and lag fans shall automatically start and stop as required when system is enabled.
        e. Equalize run time on fans based on accumulated run time. When lead fan total operating hours exceeds total operating hours of lag fan by 720 hours, lag fan shall become lead fan, the lead fan shall become lag fan. Switch-over of lead and lag fan shall occur between 8 AM and 10 AM, Tuesday through Thursday unless defined otherwise. See Supply static pressure control for damper sequencing when starting a fan and stopping a fan.
        f. On failure of fan as determined by VFD feedback, the failed fan shall be removed from the sequence, associated damper shall close, and an alarm shall be generated at the BAS. The succeeding lag fan shall become the lead.
    2. Interlock supply fans with exhaust fans so that the same number of exhaust fans run as supply fans.
    3. Supply static pressure control:
        a. A static pressure controller with its pressure sensor located in the supply duct shall modulate VFD(s) on supply fans to maintain a set static pressure (FA). Setpoint shall be determined by TAB contractor.

b. If supply fan is above 95% (FA) for 10 minutes (FA), open lag supply fan damper and ramp lag supply fan up in speed as lead fan ramps down in speed. Once speeds match, modulate fans in unison. Lag exhaust fan and associated damper shall be activated at the same time.
c. If lead and lag supply fans are below 45% (FA) for 10 minutes (FA), stop lag supply fan and close associated damper. Lag exhaust fan and associated damper shall deactivate at the same time.

4. Exhaust static pressure control:
   a. A static pressure controller with its pressure sensor located in exhaust duct shall modulate VFD(s) on exhaust fans to maintain set static pressure (FA). Setpoint shall be determined by TAB contractor.
5. Unless otherwise shown on drawings, locate static pressure sensors in main duct two-thirds down the duct length.
6. Each supply fan and exhaust fan has a two-positon control damper and high pressure switch associated with them to protect ductwork. Hardwire high pressure switch to stop fan when high pressure is sensed. Switch shall be manual reset type.
7. Each level of the parking garage shall operate as a separate control zone with control dampers in main duct risers. Dampers will position between minimum and maximum air flow based on gas detection system (CO and NO_2).
   a. At CO levels greater than 25 PPM detected in the control zone, the floor supply and exhaust dampers shall position to full open. Once CO levels return below the 25 PPM for 10 minutes (FA), return dampers to minimum position.
   b. At NO_2 levels greater than 1 PPM detected in the control zone, the floor supply and exhaust dampers shall modulate to full open. Once NO_2 levels return below the 1 PPM for 10 minutes (FA), return dampers to minimum position.

G. Alarms
1. Fan failures
2. Damper Failures to open or close on command.
3. Supply fan and exhaust fan high pressure switches

3.10 GARAGE VENTILATION IMPULSE FANS, SF-5 AND SF-6 – CONTROL SEQUENCE

A. System consists of two speed impulse fans and gas detectors. See mechanical floor plans for locations and quantities
B. Monitor run status of fan with current switch
C. The 2-stage impulse fans shall be controlled by a signal from the BAS based on gas detection system alarms for CO and NO_2 sensors. Upon activation of the fire alarm system, the BAS shall signal the fan to shut down.
D. Each level of the parking garage shall operate as a separate control zone. Any sensor in a floor zone shall activate the logic detailed below.
   a. At CO levels greater than 15 PPM detected in the control zone, the impulse fans within the control zone shall operate at half speed. Once CO levels return below 15 PPM for 10 minutes (FA), impulse fans shall shut off.
   b. At CO levels greater than 35 PPM detected in the control zone, the impulse fans within the control zone shall operate at full speed. Once CO levels return below 35 PPM for 10 minutes (FA), impulse fans shall return to half speed.
   c. At NO_2 levels greater than 1 PPM detected in the control zone, the impulse fans within the control zone shall operate at half speed. Once NO_2 levels return below 1 PPM for 10 minutes (FA), impulse fans shall shut off.
   d. At NO_2 levels greater than 3 PPM detected in the control zone, the impulse fans within the control zone shall operate at full speed. Once NO_2 levels return below 3 PPM for 10 minutes (FA), impulse fans shall return to half speed.
2. Alarms
   a. CO and NO_2 alarm levels identified above.
   b. Any CO or NO_2 sensor failure (reads below 4mA)
   c. Impulse fan failure as read by current switch.

3.11 RESTROOM AND JANITOR EXHAUST FAN – CONTROL SEQUENCE

A. The fan shall provide a continuous level of ventilation to the spaces. Upon activation of the fire alarm system, the BAS shall signal the fan to shut down.
B. Monitor run status of fan with current switch and alarm on fan failure.

3.12 WORKSHOP EXHAUST FAN – CONTROL SEQUENCE

A. A wall mounted switch shall activate the fan. The fan shall run at a single speed. Upon activation of the fire alarm system, the BAS shall signal the fan to shut down. Controls contractor to provide and install interface wiring including wall switch.

3.13 STANDBY POWER OPERATION:

A. Upon loss of offsite power, hardwired loss of power signals from automatic transfer switch will be used to automatically start standby generator. Loss of power signal is also input to BAS. Entire BAS shall be on UPS power.

B. BAS, upon loss of off-site power, will inhibit all major loads which are backed up by standby diesel generator from restarting upon availability of standby power.

C. Mechanical systems shall restart automatically in the following order. Time interval between starts shall be 10 seconds (FA):

First:	SF-5 and EF-5
Second:	SF-1, EF-1
Third:	SF-2, EF-2
Fourth:	SF-3, EF-3
Fifth:	SF-4, EF-4
Sixth:	ACC-2, ACC-3, ACC-4, ACC-7, ACC-8
Seventh:	FCU-2, FCU-3, FCU-4, FCU-7, FCU-8
Eighth:	FCU-1, FCU-5, FCU-6
Ninth:	FH-1
Tenth:	UH-1, UH-0, UH-8, UH-9, UH-10, UH-11, UH-12, UH-13, UH-14, UH-15, UH-16
Eleventh:	EF-7
Twelfth:	EF-8
Thirteenth:	GRH-1, GRH-2, GRH-3, GRH-4
Fourteenth:	

D. Return to Normal Power Operation:

1. Once normal power is restored, switch over will be accomplished with duration of power interruption not less than Phase 1.
2. All equipment operating on standby power will continue to operate without interruption.

3.14 UTILITY METERS

A. See point list for metering requirements.

3.15 SMOKE CONTROL SYSTEMS – CONTROL SEQUENCE

A. No sequence required for this phase of the build out.

END OF SECTION

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SECTION 23 12 14
LIQUID FUEL SYSTEMS

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3.6 STARTUP

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes equipment, piping, tanks, pumps, and installation requirements for the installation of fuel oil systems to serve engine generators.

1.2 RELATED WORK

A. Section 20 0513 - Motors
B. Section 20 0529 - Mechanical Supporting Devices
C. Section 23 0993 - Control Sequences
D. Section 23 2116 - Pipe and Pipe Fittings
E. Section 26 2913 - Enclosed Controllers
F. Section 26 3213 - Engine Generators

1.3 QUALITY ASSURANCE

A. Order piping with each length marked with manufacturer's name or trademark and type of pipe; with each shipping unit marked with purchase order number, metal or alloy designation, temper, size, and supplier's name.
B. Equipment and accessories shall be UL Listed and labeled.
C. Installed material not meeting specification requirements must be replaced with material that meets these specifications without additional cost to Owner.
D. Contractor qualifications: Contractor must hold special licenses and certifications to perform fuel oil systems work. Contractor shall submit copies of certifications and licenses as part of submittal process. Contractor must have successfully completed at least 20 fuel oil projects of similar size and facility. Statement of qualifications shall include name of job, dollar value, brief description of scope, name and phone number of end user customer. Statement of qualifications shall list qualified projects going back at least 5 yrs.

1.4 REFERENCE STANDARDS

A. Installation shall conform to:
1. NFPA 30, Flammable and Combustible Liquids Code
2. NFPA 31, Standard for Installation of Oil-Burning Equipment
3. ASME B31.9 Building Services Piping

4. International Fire Code (Chapters 6 and 34)
5. National Electric Code
6. United States Environmental Protection Agency Regulations
7. Federal Register, CFR 40, Part 280.
8. Local Code Requirements

B. Day tanks shall conform to:
1. NFPA 37, Standard for Installation and Use of Stationary Combustion Engines and Gas Turbines
2. Day tanks UL Listed and Labeled "Inside Storage Tanks for Oil Burner Fuel" will be considered as meeting this provision.
3. UL 142 Standard for Steel Aboveground Tanks for Flammable and Combustible Liquids

1.5 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.

1.6 PERMITS

A. Once Engineer approves submittal, Contractor shall promptly apply and pay for all necessary installation permits. No work shall proceed without valid local permit to install.

B. Contractor shall assist Owner in obtaining permits to operate fuel oil storage tank. Owner will pay for permit to operate. Contractor shall pay for permit to install and inspections and compliance documents.

1.7 SUBMITTALS

A. Shop Drawings for each item including, but not limited to, the following:
1. Pipe, fittings, and joints
2. Valves
3. Day tanks
4. Gauge assembly
5. Fuel oil accessories
6. Leak detection system
7. All other appropriate data
8. Engine generator submittal from Electrical contractor.

B. Fuel Oil System: Provide shop drawings for fuel oil system schematic, fuel oil system layout, pipe sizes, location of supports, elevations, and equipment mounting details. Schematic shall indicate entire fuel oil system from end to end with all devices, line sizes, tank sizes, leak detectors, control valves, bill of materials and sequence of operation.

C. Permit Applications: Provide copies of all permit applications.

PART 2 - PRODUCTS

2.1 PIPING

A. Fuel Oil (Above Ground and Inside Building)
1. 2" and Smaller:
   a. Pipe: ASTM A53, Grade A or B, Type E or ASTM A106, Grade B, standard weight, carbon steel
   b. Fittings: ASME B16.3, Class 300 (300 psi), malleable iron, threaded or ASTM A105 Grade II/ASME B16.11, 3000 lb psi forged steel, socket weld
   c. Unions: Malleable iron, ASME B16.39 with ground joint, bronze or brass to iron. Use unions of pressure class and joint type equal to that specified for fittings of respective piping service. Minimum pressure class of unions shall be Class 250 (250 psi).
2. 2-1/2" and Larger:
   a. Pipe: ASTM A53, Grade A or B, Type E or ASTM A106, Grade B, standard weight, carbon steel
   b. Fittings: ASTM A234 Grade WPB/ASME B16.9, standard weight, seamless, carbon steel weld

c. Flanges:
1) Class 150 (150 psi), 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.

d. Flange Gaskets: Gasket material to be asbestos free and suitable for pressure temperatures and fluid of piping system. Non-metallic gaskets shall be in accordance with ASME B16.21 and ASTM F104. Unless otherwise indicated or recommended by manufacturer, gaskets shall be similar to Garlock IFG 5500 with 1/16" thick gasket.

e. Bolting:
1) Bolts, bolt studs, nuts and washers shall have zinc plated finish.
2) Thread shall be in accordance with ANSI/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 1-1/8" and larger in diameter shall be 8 pitch thread series.
3) Threaded rods are not allowed as fastening elements.
4) Use carbon steel bolts or stud bolts conforming to ASTM A307, Grade B with nuts conforming to ASTM A307.

B. Fuel Oil (Fill, Vent and Gauge)
1. 2" and Smaller:
a. Pipe: ASTM A53, Type F, standard weight, carbon steel
b. Fittings: ASME B16.3, Class 150 (150 psi), black malleable iron, threaded or ASTM A234 Grade WPB/ASME B16.9, standard weight, seamless, carbon steel welds
c. Unions: Malleable iron, Class 250 (250 psi). Refer to Unions for Fuel Oil (Above Ground) in this Section
2. 2-1/2" and Larger:
a. Pipe: ASTM A53, Type F or Grade B, Type E or S, standard weight, carbon steel
b. Fittings: ASTM A234 Grade WPB/ASME B16.9, standard weight, seamless, carbon steel weld
c. Flanges: Class 150 (150 psi). Refer to Flanges for fuel Oil (Above Ground) in this Section

2.2 FUEL OIL SYSTEM VALVES

A. Manufacturers: Morrison Bros., Apollo, Milwaukee, Nibco, or Watts, equal to model listed
B. Ball Valves:
1. 3" and Smaller: ASTM B584 bronze body, threaded, chrome plated bronze or chrome plated brass ball, or stainless steel ball, full port, PTFE, or Teflon seat rings, blowout-proof stem, two-piece construction, UL 842 Listed and FM approved, 600 psi WOG, 150 psi SWP, Morrison Fig. 691B.
C. Globe Valves:
1. 2" and Smaller: ASTM B62 bronze body, threaded, renewable TFE seat disc, union or screw-over bonnet, malleable iron hand wheel, Class 150 (300 psi WOG), conforming to MSS SP-80, Nibco Figure T-235
2. 2-1/2" and Larger: iron body, bronze mounted, flanged, bolted bonnet, renewable bronze seat and disc, Class 125 (200 psi WOG), conforming to MSS SP-85, Nibco Figure F-718
D. Swing Check Valves:
1. 2" and Smaller: ASTM B62 bronze body, threaded, regrinding, Y pattern, renewable TFE seat disc, Class 150 (300 psi WOG), conforming to MSS SP-80, Nibco Figure T-433
2. 2-1/2" and Larger: iron body, brass or bronze mounted, renewable seat and disc, Class 125 (200 psi WOG), conforming to MSS SP-71, Nibco Figure F-918
E. Spring Loaded Check Valves:
1. 2" and Smaller: bronze or iron body, threaded, Class 125 (250 psi WOG), Nibco Figure T-480
2. 2-1/2" and Larger: iron body, wafer style, bronze trim, stainless steel spring, bronze or Buna-N seat, 200 psi WOG, Nibco Figure W-960
F. Solenoid Valves:
1. 3" and Smaller: Brass or bronze body, viton seat and disc, stainless steel spring, threaded, pilot operated, similar to ASCO RedHat.
2. Actuator shall be line voltage, Class H (high temperature), listed by UL or CSA.
G. Anti-Syphon Valves:
1. 3" and Smaller: bronze body, threaded, UL Listed, spring loaded poppet, composition seat and dashpot, similar to Preferred Utilities Mfg. Corp. Model A.

H. Fire Valves (External Emergency Valves):
1. Ductile iron body, stainless steel trim, PTFE gasket, threaded for 2" and smaller and flanged for 2-1/2" and larger, Class 150, 200 psi WOG, similar to Morrison Bros. Co. Fig. 346 Series.
2. Fusible link shall be UL listed for 165°F.

2.3 THREADED JOINT SEALANTS

A. Use sealant, suitable for oil or petroleum products, similar to Loctite Model 54531.

2.4 FUEL OIL DAY TANK

A. Manufacturers: Simplex, Preferred or Tramont
B. Provide packaged, free standing day tank system with secondary containment type and capacity for a minimum runtime of 8 hours. Capacity to be coordinated with Electrical Contractor selection of Engine Generator per Section 26 3213 Engine Generators. Tank shall be sized to include 133% tank size per NFPA 110.
C. Day tank shall include integral controls required for a complete, self-contained design.
D. Day tank shall include:
1. Solenoid valve for isolation of fuel supply from main storage tank
2. Duplex fuel strainers to protect solenoid valve and pumps
3. Manual shutoff valve
4. Exterior enamel coating
5. Automatic closing, ductile iron valve with 165°F fusible link, on engine supply connections.
6. Anti-siphon valve or 24 vdc solenoid valve for anti-siphon on generator suction lines. Check valve on generator return lines for anti-siphon.
7. Outdoor vent cap for all vents.
E. Connections for day tank shall include:
1. One 1” fuel oil fill line with internal fill pipe to 6" of bottom of tank and braced at tank bottom
2. One 1” fuel oil supply line with internal pipe to 6" of bottom of tank
3. One 1” fuel oil return line
4. One 4” vent
5. One 4” emergency vent
6. One 2” outlet equipped with cap for manual gauging of tank level
7. One gauge opening with coupling bushed to required size
8. One 1” drain
9. One 6” inspection port with gasketed plate
F.
G. Day tank accessories:
1. Solenoid Valves: each day tank shall be furnished with solenoid valve (with manual bypass), NPT, 100 psi, normally closed, viton soft goods, under control of level controller described below.
2. Sight Glasses: Carbon steel or brass body, 150 psi rated glass, delrin or nylon wheel, as manufactured by Ernst or McMaster Carr. Furnish on day tank(s) supply and return to main tank and generator supply and return lines to day tank.
3. Temperature Sensor: Provide and program temperature sensor in each generator day tank. Integrate into fuel system PLC. Alarm in Fuel Control System and to BAS at 140°F.
4. Ultrasonic level probe: Provide and program ultrasonic level probe to display actual gallons remaining in day tank. Display shall be local, at BAS and at Fuel Management and control panel.
5. Drop Tubes: Provide full height drop tubes for supply, return and fill lines.
6. Mechanical level gauge: Provide Sculley or equal mechanical level gauge.
7. Provide manual hand pump for emptying of fuel basins or sumps.
8. Anti-siphon: Provide Preferred Utilities UL Listed anti-siphon valves on generator suction lines and where shown on drawings. Line size Magnatrol solenoid valves may be used. All solenoid valves shall be furnished with manual override or manual valve bypass.
9. Solenoid valves: Install line size Magnatrol solenoid valves with manual bypass between generator day tanks and generator for anti-siphon function. Valves to open on “generator run” signal and close after generator warmdown. Magnetrol solenoid valves shall be normally closed when de-energized.
10. Leak Detector: Provide Preferred Utilities model PS-LDS-7101 leak detector in rupture basin and in vent line receiver.
11. Fusible Link Valve: In line sizes 1” or smaller, apply fusible link Fusomatic Gate Valve, as manufactured by Preferred Utilities or equal. In larger sizes, apply model 110 oil lever gate valve with fusible link, as manufactured by Preferred Utilities or equal.
12. Day tank controller shall include:
a. Fuel level indicator

b. Low level alarm
c. High level alarm
d. Tank leak alarm
e. Leak sensor
f. Contacts for all alarms and level indicator to be interfaced to Building Automation System (BAS)

2.5 FUEL OIL SYSTEM ACCESSORIES

A. Duplex strainers: Kraissl, Hayward or Tate Andale. 200 psi WOG, cast iron, threaded ends with Buna-N O-rings and stainless steel screens with 1/32" diameter perforation.
B. Remote fill containment port and station:
C. Wall recessed mount, stainless steel, 7 gallon spill capacity, hinged and gasketed access door with locking handle, ¾" drain fitting. Manufacturer to match day tank. Simplex, Preferred or Tramont
   1. Provide fuel fill line valve and cap for day tank connection. Control wire in a conduit shall be provided for communication with tank level transmitter. Provide display gauge indicating tank level in gallons.
   2. Provide manual hand pump for emptying of fuel sump.
D. Flexible Connectors:
   1. Flexible connectors shall be listed and labeled in accordance with UL 536.
   2. 304 stainless steel inner hose and wire braided exterior sleeve, suitable for minimum 150 psig WOG and 1500°F with minimum burst pressure of 750 psig.
   3. Flexible connectors shall be vacuum rated.

2.6 EMERGENCY PRESSURE RELIEF VENTS

A. Morrison Bros. Co. 244 Series, OPW 201 or equal
B. Vents shall be aluminum or cast iron construction with Buna-N seats. Vents shall be self-closing after over pressure has been dissipated. Restraining cable shall connect head and flange and also serve as grounding cable. Vents shall be sized to meet codes.

2.7 HEAT TRACE

A. Outdoor piping shall be heat traced. Heat trace system shall be Raychem/Tyco thermal self-regulating heating cable system or equal. System shall include power connection kit, end seal kit, cables and thermostat. Contractor shall submit detailed system layout as per manufacturer's instruction, including total length of heating cable, circuit breaker sizing and selection and quantity and type of components and accessories.

2.8 INTEGRATED FUEL MANAGEMENT SYSTEM

A. Manufacturers: Day tank fuel fill station and fuel management control shall be provided from a single manufacturer. Preferred Utilities, Simplex, or Tramont
B. Integrated fuel management system shall perform tank gauging and leak detection functions for fuel system. Control unit shall be microprocessor based Fuel Management and Control System. Fuel control system shall include BACNET interface or interface required by BAS system. Coordinate with BAS contractor.
C. General: Control system shall include these functions: day tank level control, main tank overfill prevention, tank inventory, leak monitoring, and automatic data transfer to BAS system. There shall be single master control panel. Panel shall be capable of manual control and override of any fuel system component.
D. Design Criteria:
   1. System design shall include all electrical and control schematics, ladder logic and written sequences of operations.
   2. Control modules shall be mounted indoors wherever shown on drawings. Furnish NEMA 4 enclosures where located in areas that are not temperature controlled. Outdoor mounted control modules shall include heaters for cold weather operation and to control condensation.
   3. Control modules shall be UL Listed, UL Canada listed, or CE stamped as appropriate for location.
   4. Tank level transmitter: System shall include Tank Level Transmitter: System shall include probe capable of detecting fuel level in tank to the nearest 0.125".
   5. Monitoring Panel: Monitoring panel shall display tank volume in gallons. Panel shall have touch screen display to graphically indicate real-time operating and alarm conditions. Device status and alarms shall be color-coded.
   6. Leak detectors: leak detectors shall be provided for installation in secondary containment to detect leak in fuel system. Sensor shall set off audible and visual alarm on control panel and shall alarm to BAS via BACNET.

7. Overfill Alarm and Acknowledgement Switch: Provide audible and visible overfill alarm and manual acknowledgement/reset switch for mounting in tank filling area as shown on plans. This device is to be used in conjunction with mechanical opv to prevent overfilling of tank.

PART 3 - EXECUTION

3.1 PIPING

A. General
1. Remove foreign materials before erection. Ream ends of piping to remove burrs.
2. Install piping parallel to building walls and ceilings and at such heights 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.
3. Provide anchors, expansion joints, swing joints and expansion loops so that piping may expand and contract without damage to itself, equipment or building.
4. Mitered ells, 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.
5. Do not install piping over electrical panelboards, switchgear, switchboards or motor control centers.
6. Install valves, control valves and piping specialties, including items furnished by others, as specified and/or detailed. Make connections to all equipment installed by others where that equipment requires piping services indicated in this Section.

B. Threaded Pipe Joints
1. Threads of pipe and fittings shall conform to ASME B1.20.1.
2. Cut threads so that no more than 3 threads remain exposed after joint is made. 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.

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

D. Fuel Oil (Fill, Vent, Gauge and Above Ground Supply and Return)
1. Install supply, return, fill, vent and gauge lines where indicated, including flexible connections and other piping specialties included with equipment furnished by others. Solder-joints and unions with gaskets or packing are not allowed. Pitch horizontal piping at minimum 1/8" per foot down to tank.
2. Install flexible piping connections in supply and return lines at each diesel engine. Return line from each engine to day tank to contain no manual or automatic valves to restrict flow; pressure relief valves are acceptable.
3. Install vent pipe to drain toward tank without sags or traps in which liquid may collect.
4. Terminate vent pipes outside of building, not less than 2 ft measured vertically or horizontally from any building opening, not less than 25 ft from any outside air intake, and with weather-proof and flame-proof vent cap or hood.

E. Piping System Pressure Tests
1. Coordinate pressure tests with Engineer and Owner at least 3 days in advance of its occurrence and conduct tests in presence of Engineer.
2. Submit pipe pressure testing plan in accordance with NFPA 30.
3. Conduct pressure test prior to flushing and cleaning of piping systems.
4. Conduct pressure test in accordance with ASME B31.9 and NFPA 30 with test pressure at 120psig.
5. If leaks are found, repair with new materials and repeat test; caulking will not be acceptable.
6. 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.
7. No pressure drop shall occur during test period. Any pressure drop in during test period indicates leakage.

8. 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.

F. Initial System Fill and Vent.

1. Fill and vent systems with proper fuel oil.

3.2 DAY TANKS

A. Install day tanks as shown on drawings. Provide with bracing and framing of ample strength and rigidity to support tank when full.

B. Install tanks at height recommended by emergency generator manufacturer.

C. Route emergency and operating vents separately to outside of building.

3.3 FUEL OIL SYSTEM ACCESSORIES

A. Install foot valve with extractor assembly on fuel oil suction line in each storage tank.

B. Install vent caps on oil tank vents to atmosphere.

C. Install fill boxes on oil tank fill lines.

D. Install remote fill containment port and station.

3.4 EMERGENCY PRESSURE RELIEF VALVES

A. Install relief valves in accordance with manufacturer's installation directions.

3.5 INTEGRATED FUEL MANAGEMENT SYSTEM

A. Install integrated fuel management system in strict accordance with manufacturer's instructions, National Electrical Code NFPA 70, and NFPA30A.

3.6 STARTUP

A. Verify that piping system has been flushed, cleaned and filled.

B. Execute and document results for approved, written commissioning plan. Following commissioning, train Owner in accordance with approved, written training plan. Record, produce and turnover training materials.

END OF SECTION

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SECTION 23 21 16

PIPE AND PIPE FITTINGS

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1.1 RELATED WORK
1.2 DESCRIPTION
1.3 SUBMITTALS
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PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 0529 - Mechanical Supporting Devices
B. Section 23 0902 - Control Valves and Damper (Valves)
C. Section 23 0903 - Control Instrumentation (Wells, Taps or In-line Devices)
D. Section 23 2116 Pipe and Pipe Fittings
E. Section 23 2118 - Valves
F. Section 23 2120 - Piping Specialties
G. Section 26 3213 - Engine Generators

1.2 DESCRIPTION

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

1.3 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. Valves
    6. Regulators
    7. Flanges; ASTM number, grade, class, type, material
    8. Bolts and nuts; material
    9. Thread joint sealants; material
    10. Flange gaskets; material, rating
    11. Unions; ASTM number, type, material, rating
    12. Type of welding
    13. Welding Quality Control Program
    14. Test pressure and media
    15. Pipe flushing/cleaning plan
    16. Pipe cleaning method
    17. 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.
D. Provide Flushing and Cleaning Plan:
    1. Submit pipe flushing/cleaning plan for water, fluid, natural gas systems for approval. Plan shall detail methods for compliance with requirements of this section, including:
        a. Flushing and cleaning procedure narratives.
        b. Size, power source, and connection points of contractor provided pumps that will be used for flushing and cleaning.
        c. Method of sectionalizing piping to obtain required velocity.
        d. Minimum velocities at each section of pipe, clearly indicating any sections where 6 fps cannot be achieved.
        e. Location and means of temporary bypasses for coils, control valves and other equipment.
        f. Flushing schedule and drawings or diagrams that will be used for inspection and sign off prior to and after procedure, at Owner's option.
    2. Submit documents showing verification of flushing/cleaning following specified requirements and results.

1.4 QUALITY ASSURANCE

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

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

1.5 PRODUCT 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.

1.6 NATURAL GAS SERVICE

A. Contact local gas company for cost of gas service to building, including pressure reducing valves, if required, and gas meter. Include this cost in Bid.

B. All charges for gas service as shown on drawings including connection from main in street or other location to gas meter shall be paid by this Contractor. This includes setting of gas meter and work performed by Gas Company.

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

D. Cost of gas service, meters and regulating equipment to inlet side of meters will be paid by Gas Company.

1.7 PIPE WELDING

A. Procedure and Welding Qualification Records:

1. Submit Welding Procedure Specifications (WPSs) and their supporting Procedure Qualification Records (PQRs) to be used on the work to Engineer for review and approval prior to performing any welding. These documents shall meet requirements of ASME B31.1 and B31.9, as applicable.
2. Unless otherwise indicated, welding shall be done using only the following processes:
   a. Shielded Metal Arc Welding (SMAW), also known as "stick" welding
   b. Gas Tungsten Arc Welding (GTAW), also known as TIG and Heliarc welding
   c. Gas Metal Arc Welding (GMAW), also known as MIG welding
   d. Flux-Cored Arc Welding (FCAW), a variation of GMAW
   e. Submerged Arc Welding (SAW)
3. Unless otherwise stated, fabrication, installation, inspection, examination and testing shall be in accordance with ASME B31.1 or B31.9, as applicable.
4. Backing rings (chill rings) or consumable inserts are not allowed, unless specifically requested by Owner or Engineer.

B. Weld Inspection and Examination:

1. Provide examination services for all welding for this Project. Examination shall be in accordance with requirements of ASME B31.1, Table 136.4 or B31.9, as applicable.
2. Periodically, as welding progresses, submit report, signed by weld examiner, indicating status of project welding quality.
3. Arrange with Owner's Inspector for observation of 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.

C. 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 B31.1 or B31.9, as applicable. In addition, there shall be an independent witness of welder tests. That witness shall be representative of independent testing laboratory, Authorized (Code) Inspector, Owner's or Engineer's Inspector or consultant approved by National Certified Pipe Welding Bureau.
6. Welder qualifications must cover all pipe sizes 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."

D. Weld Record:
1. For welding within the scope of ASME B31.1 Power Piping, submit to Engineer for approval an administrative procedure for recording, locating, monitoring and maintaining quality of welds to be performed on the project. This quality control document record shall include but not be limited to:
   a. Drawings and schedules identifying location of each weld by individual number, identification of welder who performed each weld by individual welder's name, stamp number, date, and WPS used.

1.8 PIPE CERTIFICATION

A. Certification is required for all pipe within scope of ASME B31.1. Submit certification papers, as outlined below, within 30 days of delivery of pipe to project site.
B. Type E or S Pipe:
1. Furnish manufacturer's mill certificates (material test report) including dimensions, heat numbers, chemical analysis and tensile test results for pipe shipped to project site.

PART 2 - PRODUCTS

2.1 NATURAL GAS PIPE, FITTINGS AND JOINTS UNDER (5 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 A197/ANSI B16.3 Class 150, black malleable iron, threaded
3. Joints: Threaded

B. 2-1/2” and Larger:
1. Pipe: ASTM A53, Grade B, Type E or S, standard weight, (Schedule 40), carbon steel
2. Fittings: ASTM A234 Grade WPB/ANSI B16.9, standard weight, (Schedule 40), seamless, carbon steel, welded
3. Joints: Welded

2.2 VENTS AND RELIEF VALVES

A. Unless otherwise indicated, use pipe and pipe fittings as indicated for the system to which relief valve or vent is connected.
B. ASTM A53, Type F, carbon steel pipe with standard weight, carbon steel fittings may be used for steam vents smaller than 4”.
C. Use ASTM A53, Type E carbon steel pipe with ASTM A234 Grade WPB/ASME B16.9, standard weight, seamless carbon steel weld fittings for refrigerant vent piping.

2.3 METERS

A. Meters shall be provided by the local utility.

2.4 COOLING COIL CONDENSATE DRAIN

A. Piping shall be one of the following, unless otherwise indicated on drawings:
1. Pipe: ASTM A53, Type F, standard weight, galvanized steel
2. Fittings: ASTM A126/ASME B16.4, cast iron, threaded, ASTM A123 galvanize coated
3. Pipe: ASTM B88, Type M, hard temper copper tubing

4. Fittings: ASTM B16.22 wrought copper fittings
5. Joint: ASTM B32, 95-5 tin-antimony solder, Bridgit or Silvabrite

2.5 ENGINE EXHAUST

A. All Sizes:
1. Pipe: ASTM A312, 304, Schedule 10S, seamless stainless steel
2. Fittings: ASTM A403, Gr. WP, Class S or Class W, ASME 16.9, stainless steel welded

B. All Sizes:
1. Factory-built double wall piping system by Metalbestos, AMPCO, Metal Fab

2.6 STAINLESS STEEL PIPING (304)

A. 2" and Smaller:
1. Pipe: ASTM A312, 304, Schedule 10S, seamless stainless steel
2. Fittings: ASTM 182, Gr. F304, ASME B16.11, 3000 lb socket-weld
3. Unions: 3000 lb socket-weld, stainless steel ground joint

B. 2-1/2” and Larger:
1. Pipe: ASTM A312, 304, Schedule 10S, seamless stainless steel
2. Fittings: ASTM A403, Gr. WP, Class S or Class W, ASME 16.9
3. Flanges: ASTM A182, Gr. F304, ASME B16.5, 150 lb std. with 1/16" raised face, serrated face finish and welding neck
4. Bolts: Stud bolts, ASTM A193, Gr. B7
5. Nuts: ASTM A194, Gr. 2H

2.7 DIELECTRIC UNIONS, FLANGES AND FITTINGS (STEEL PIPE TO COPPER PIPE)

A. 2" and Smaller:
1. Use bronze ball valves specified in Section 23 2118 for dielectric purpose.
2. Dielectric fittings similar to Victaulic Style 647 or Clearflow Dielectric Waterway fittings may be used in lieu of dielectric unions for pipe sizes 2" and smaller.
   a. Clearflow fittings shall be ASTM A53 electro zinc-plated steel pipe with high temperature polyolefin polymer liner, suitable for continuous use at temperatures up to 230°F and pressures up to 300 psig.
3. ASTM A197/ASME B16, equal to Stockham Figure 693-1/2, Watts Series 3000 or Wilkins (Zurn) Model DU series dielectric unions with EPDM dielectric gasket, 250 psi at 180°F.

B. 2-1/2” through 4”:
1. Watts dielectric flange fittings Series LF 3100/LF 3110 with dielectric gasket, 175 psi at 180°F.
2. Dielectric fittings similar to Victaulic Style 647 or Clearflow Dielectric Waterway fittings may be used in lieu of dielectric unions for pipe sizes 2-1/2” and larger.
   a. Clearflow fittings shall be ASTM A53 electro zinc-plated steel pipe with high temperature polyolefin polymer liner, suitable for continuous use at temperatures up to 230°F and pressures up to 300 psig.

2.8 DIELECTRIC UNIONS, FLANGES AND FITTINGS (STEEL TO STEEL PIPE)

A. 1" and Smaller: Similar to Epco model HA-B with dielectric gasket, 250 psi at 210°F

B. 1-1/2" and Larger: Similar to Epco model W with bolt insulators, dielectric gasket, bolts and nuts, 175 psi at 210°F). Pikotek model VSC dielectric gasket with viton sealing element, G-10 sleeve and double washers, suitable to 350°F, may be used with specified flanges.

2.9 UNIONS AND FLANGES

A. Unions:
1. 2" 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.
2. 2" and Smaller: Forged steel, ASTM A105 Grade 2, ASME B16.11, 3000 lb WOG with steel to steel seats. Joint type shall match that specified for fittings of respective piping service.

B. Flanges:
1. 2-1/2” and Larger: ASTM A105, ASME B16.5, hot forged steel, welding neck pattern. Slip-on pattern are 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. General - 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 LS, flexible graphite filler, 304 SS winding, carbon steel centering ring, 0.175" thickness.
4. Service Temperature (801°F thru 1500°F) - Flexitallic, Garlock, Lamos equal to Flexitallic Style CG, flexible graphite filler, 316 SS winding, carbon steel centering ring, 0.175" thickness.
5. Service Temperature (1501°F thru 1700°F) - Flexitallic, Garlock, Lamos equal to Flexitallic Style CG, flexible graphite filler, Inconel 600 winding, 316 SS 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, use carbon steel bolts or stud bolts conforming to ASTM A307, Grade B for service temperature up to 400°Fand ASTM A193, Grade B7 for service temperature up to 800°F with nuts conforming to ASTM A194.
   a. Bolts conforming to ASTM A307, Grade A may be used for piping governed by ASME B31.9.
5. For Class 400 and 600 flanges at 800°F or lower temperature, use alloy steel bolts or stud bolts conforming to ASTM A193, Grade B7 or B16, with nuts conforming to ASTM A194, Grade 2H.

2.10 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 to 400°F and up to 10,000 psi (liquids) and 2000 psi (gases), certified by UL, CSA, and NSF.
B. Use sealant similar to Loctite Model 54531 for piping handling oil or petroleum products.

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

A. Weld branch outlet fittings shall conform to MSS-SP-97, ASME B16.9 for weldolets, ASME B1.20.1 for threadolets and ASME B16.11 for sockolets.
B. Materials shall match material of header piping and wall thickness of outlet or branch end shall match wall thickness of branch pipe.

2.12 REFRIGERANT PIPING

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

PART 3 - EXECUTION

3.1 GENERAL

A. 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. Grounding to gas piping is prohibited.
D. Gas piping shall be installed with dirt legs adjacent to equipment and with drain tees and plugs at low points.
E. Gas piping in plenum ceilings shall have welded joints.
F. Install gas piping above ground in buildings.
G. 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.

H. 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.

I. 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.

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

K. 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.

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

M. 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.

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

O. "Weldolets" with outlet size 2-1/2” and larger and "Threadolets" or "Sockolets" with outlet size 2" and smaller may be used for branch connections up to one pipe size smaller than main. Use "Threadolets" where threaded fittings are specified and use "Sockolets" where socket weld fittings are specified. Install in accordance with PFI (Pipe Fabrication Institute) Standard ES49.

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

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

R. Install valves, control valves and piping specialties, including items furnished by others, as specified and/or detailed.

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

T. For piping within the scope of ASME B31.1 Power Piping, transfer piping material specification and "Heat Number" to each segment of pipe prior to cutting.

3.2 PRESSURE REGULATORS

A. Pressure regulator at gas meter provided by gas company.

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

C. Regulator shall be accessible for maintenance and protected from fire and mechanical damage. Regulator shall be supported from structure by brackets and supports.

D. Vent from relief valve shall be routed 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.

E. Provide unions on both sides of regulators for removal and maintenance.

F. Provide gas cock for pressure verification.

3.3 METERS

A. Verify transmission of signal to the Building Automation System.

3.4 CONNECTIONS

A. Shutoff valves shall be accessible in case of emergency; installed minimum of 5 ft from equipment. Provide shutoff valves at each piece of equipment.

3.5 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.

3.6 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.

3.7 WELDED PIPE JOINTS

A. Inspect pipe and pipe fittings for roundness before they are fit-up or set in place.
B. Properly clean and prepare pipe base material before fit-up. Verify joint land and bevel.
C. Preheat pipe base material as required by welding procedure specification. Temperature of pipe material must be minimum of 50°F before welding.
D. Properly align and adjust joint as required by welding procedure and thickness of material. Verify tolerances after tacking sequence.
E. Use weld material diameter as procedurally required for type and thickness of work being done.
F. Use sufficient argon pre-purge and argon post-purge for GTAW processes. Post purge should be until weld is no longer glowing plus 5 seconds. Maintain purge for at least 2 layers of weld material.
G. Properly store welding materials.
H. Clean tacks before welding out. Remove slag after each pass by grinding to avoid slag inclusion.
I. Weld reinforcement shall not exceed limits established in Chapter V of ASME B31.1.
J. Brush each weld free of rust and paint with rust resistant product that matches piping surface color.
K. For piping within scope of ASME B31.1, each weld shall be permanently marked by welder performing weld. Each welder shall sign and date field welding log record for all welds performed by welder as indicated in Part 1.
L. Conduct radiographic test for sections or joints that cannot be tested by hydrostatic test methods (such as joints cut into existing piping systems) by qualified radiographic testing firm.

3.8 COPPER PIPE JOINTS

A. Cutting of tubing shall not make tubing out of round. Ream cut tube ends to full inside diameter.
B. Remove slivers and burrs remaining from tube cut by reaming and filing both pipe surfaces. Clean fitting and tube with emery or sand cloth. Remove residue from cleaning operation, apply flux and assemble joint. Use solder or brazing to secure joint as specified for specific piping service.
C. Press Joint Option:
    1. Cut pipe square and ream before assembly
    2. Insert pipe fully into fitting and mark on pipe at shoulder of fitting
    3. Check fitting alignment against mark on pipe to ensure pipe is fully engaged
    4. Press joint with press tool approved by fitting manufacturer

3.9 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" per one foot for proper drainage.
C. Where copper piping is allowed, joints and fittings may be secured with 95-5 tin-antimony solder or brazing alloys.

3.10 ENGINE EXHAUST

A. Install engine exhaust lines where indicated on drawings, including mufflers, flexible connections and other required exhaust line components furnished with engine. Isolate piping as indicated in Vibration Isolation section of these Specifications. Pitch horizontal piping down and away from muffler to drain point where pipe rises. Install drain valve at this point on muffler body if it has provision for drain connection, and at all low points in exhaust line where condensate may collect. Drain valves to be accessible without use of ladder.
B. Exhaust pipes passing directly through combustible roofs to be guarded at point of passage by ventilated metal thimbles which extended not less than 9" above and not less than 9" below roof construction and which are at least 6" in diameter larger than vent pipe.
C. Terminate exhaust piping with vent cap.

3.11 DIELECTRIC UNIONS AND FITTINGS

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

C. Install steel to steel pipe dielectric unions or flanges in [hot water] [chilled water] [steam and steam condensate] piping at each point where interior steel piping is connected to exterior underground steel piping.

3.12 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.

3.13 REFRIGERANT PIPING

A. Install refrigerant piping system to meet requirements of Wisconsin Department of Industry, Labor and Human Relations Refrigeration Code.

B. Solder joints shall be ASTM Grade 4 or 5 and have melting point of approximately 1250°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.

C. Leak test by charging system to pressure of 10 psig with the same type of refrigerant that will be used in the system.

D. 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.

E. After completion of leak test, evacuate system with vacuum pump to 2.5 mm Hg absolute as measured on accurate gauge.

F. 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.

G. 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.

H. Refrigeration piping must be installed by firms who are experienced in installation of such piping.

3.14 HYDRONIC 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 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 a minimum 100 psig test pressure.

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. If piping system is drained after testing and left empty or untreated for more than 3 days, add Nalco 2572 at recommended dosages for dry system lay-up.

3.15 HYDRONIC FLUSHING AND CLEANING PIPING SYSTEMS

A. Notify Owner and/or Owner’s representative at least 7 days in advance.

B. Flush fluid systems thoroughly for 15 minutes or longer, as required to ensure removal of dirt and foreign matter from piping system.
C. Flush gas piping with clean, dry compressed air for one (1) h minimum. Open and clean drip legs. Repeat flushing until no debris is found in drip legs.

3.16 GAS AND FUEL OIL SYSTEM TESTING

A. Conduct Pneumatic test with test medium of dry, oil free air, carbon dioxide, or nitrogen for natural gas, and fuel oil piping and in accordance with ASME B31.1 137.4.
B. 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.
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.

3.17 GAS AND FUEL OIL SYSTEM FLUSHING AND CLEANING

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

3.18 PIPE PAINTING

A. Exposed exterior carbon steel, black iron or other ferrous pipe and fittings shall be prepared and painted by qualified painters using corrosion inhibitive paints. Pipe shall be prepared in accordance with paint manufacturer's instructions and primed (2 coats) and finish painted (2 coats). Paint type shall be approved by Architect/Engineer.
B. Protect piping from weather and paint promptly to prevent corrosion.

END OF SECTION

SECTION 23 21 18
VALVES

PART 1 – GENERAL
1.1 RELATED WORK
1.2 SUBMITTALS
PART 2 – PRODUCTS
2.1 FUEL SYSTEM VALVES
PART 3 – EXECUTION
3.1 GENERAL
3.2 SHUT-OFF VALVES
3.3 DRAIN VALVES
3.4 SWING CHECK VALVES

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 0700 - Mechanical Systems Insulation
B. Section 23 0902 - Control Valves and Dampers
C. Section 23 1214 - Liquid Fuel Systems
D. Section 23 2116 Pipe and Pipe Fittings
E. Section 23 2120 - Piping Specialties (Flow Sensors and Meters)

1.2 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

2.1 FUEL SYSTEM VALVES

A. Globe valves, ball, plug, check valves, and drain valves: Crane, Nibco, Stockham, Powell, Milwaukee, Hammond, or Grinnell equal to manufacturer's Figure number listed. Provide valves of same make for these services.
B. Other valves: acceptable manufacturers and Figure Number listed under each item.
C. Globe Valves:
   1. 2" and Smaller: ASTM B62, bronze body, bronze trim, threaded, renewable TFE seat disc, union bonnet, malleable iron handwheel, Class 150 150 psi WP, conforming to MSS SP-80, Nibco Fig. T-235
D. 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
E. Drain Valves:
   1. Ball valve as specified above with threaded hose adapter and cap. If 3-piece ball valves are specified, use 2-piece ball valves with same construction.
F. Ball Valves:
   1. Acceptable Manufacturers: Neles-Jamesbury, Apollo, Kerotest, Nibco and Watts equal to manufacturer's Figure number listed
   2. 2” and Smaller:
      a. Bronze body, threaded, quarter turn, chrome plated brass ball, large port, reinforced TFE seat and stem packing, blowout-proof stem, Apollo GB-50 ball valve, UL Listed, AGA approved.

b. Carbon steel body, threaded, quarter turn, 2 piece design, 316 stainless steel ball and stem, full port, spiral wound 316 stainless steel and teflon seats and seals, blowout proof stem, 800 psi CWP rated, level handle. Jamesbury Fire-Tite, Series 2000
c. Carbon steel body, quarter turn, 3 piece design, chrome plated steel ball, full port, TFE seats and seals, blowout proof stem,1000 psi CWP, lever handle. Jamesbury Fire-Tite, Series 4000.

3. 2-1/2" through 8":
a. Carbon steel body, ASTM A53 Grade A, Class 150, quarter turn, carbon steel weld ends, ASTM A572 Grade 50 and ANSI B16.25, Type 304 stainless steel ball, stainless steel stem, Buna-N double O-ring seals, PTFE seats, ductile iron hand wheel, API-6D test requirement. Jamesbury 7150 Series with E-Pak.

G. 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.

H. Vented Gas Pressure Regulators:
1. Acceptable Manufacturers: Fisher, Rockwell, Sensus, or American
2. 2" and Smaller Venting: Cast iron body, aluminum spring case, plated steel spring, Nitrile diaphragm and disc, threaded, vent to exterior of building, 150 psi CWP, -20°F to 160°F, listed in compliance with ANSI Z21.80 Valve shall be capable of 500 cfh with an inlet pressure of 2 psig and an outlet pressure of 0.5 in psig.

I. Ventless 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. Valve shall be capable of 500 cfh with an inlet pressure of 2 psig and an outlet pressure of 0.5 in psig.

PART 3 - EXECUTION

3.1 GENERAL

A. Install valves as shown on plans, details and according to manufacturer's installation recommendations.
B. After piping systems have been pressure tested and put into service, but before final adjusting and balancing, inspect valves for leaks. Adjust, replace packing or replace valves to stop leaks.
C. Install control valves furnished under Control Systems. Provide reducing fittings as required.
D. Refer to Section 23 2116, Part 3 for reducing fittings requirement for valves smaller than pipe size.
E. .

3.2 SHUT-OFF VALVES

A. Provide shut-off valves at all equipment, at riser take-offs at each floor, and at each automatic valve for servicing.
B. Install steam system shut-off valves in horizontal piping. Shut-off valves are not allowed in vertical piping.

3.3 DRAIN VALVES

A. Provide drain valves at all low points of piping systems for complete drainage of systems.
B. Unless otherwise indicated, provide 1/2" drain valve for 1/2" piping and minimum 3/4" drain valve for 3/4" and larger piping.

3.4 SWING CHECK VALVES

A. Provide swing check valves at each condensate pump discharge line.

END OF SECTION

SECTION 23 21 20
PIPING SPECIALTIES

PART 1 – GENERAL
1.1 RELATED WORK
1.2 REFERENCE STANDARDS
1.3 SUBMITTALS
PART 2 – PRODUCTS
2.1 MATERIALS
2.2 PIPE EXPANSION DEVICES
PART 3 – EXECUTION
3.1 GENERAL
3.2 PIPE EXPANSION DEVICES

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 0903 - Control Instrumentation (Temperature and Pressure Sensing Requirements)
B. Section 23 2118 - Valves

1.2 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.

1.3 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. Expansion joint schedule indicating joint tag no., system, proximity to rotating or reciprocating equipment, required movement in all planes, service pressure, test pressure, service temperature, fluid velocity and cycles to failure (both thermally and seismically, if applicable).
9. All other appropriate data.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Unless otherwise specified, select devices for highest pressures and temperatures existing in respective systems in accordance with ANSI Specifications.
B. Piping specialties in copper piping shall have bronze or brass body with solder ends.

2.2 PIPE EXPANSION DEVICES

A. Expansion Joints (Bellows-type):
1. Manufacturers: Flexonics, Metraflex, Expansion Joint Systems, Microflex, American BOA, or Hyspan
2. Expansion joints shall be flanged, packless, constructed of Incoloy 600 bellows and stainless steel fittings.
3. Expansion joints shall be rated for working temperature and pressure of the system, but not less than 50 psig WP.
4. Furnish joints with limit stops or tie rods to prevent over traversing.
5. Furnish external sheet metal shrouds on all expansion joints required to be insulated. Shrouds shall be removable for field inspection of joints. Refer to Section 20 0700 - Mechanical Systems Insulation for insulation requirement.

6. Furnish joints with internal sleeves (liners) constructed of Incoloy 600 with sufficient clearance between bellows and sleeve to permit full rated rotational and lateral movement. Provide drain holes for sleeves as required.

PART 3 - EXECUTION

3.1 GENERAL

A. Install piping specialties as indicated on plans, details and according to manufacturer's recommendations.

3.2 PIPE EXPANSION DEVICES

A. Expansion Joints (Bellows Type):

3.3 Stretching of expansion joint to correct for piping misalignment or to accommodate available end-to-end spacing shall not be allowed.

3.4 Remove all shipping rods and spacers and clean inside of expansion joints thoroughly before putting joints into service.

3.5 Install anchors and guides as specified herein and as shown on drawings prior to putting joints into service.

END OF SECTION

SECTION 23 21 23
PUMPS

PART 1 – GENERAL
1.1 RELATED WORK
1.2 SUBMITTALS
1.3 DESIGN CRITERIA
PART 2 – PRODUCTS
2.1 CONDENSATE PUMP UNITS
PART 3 – EXECUTION
3.1 INSTALLATION

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 0513 - Motors
B. Section 23 2120 - Piping Specialties

1.2 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. Motor data (refer to Section 20 0513 - Motors)
   5. Seals
   6. Materials of construction
   7. Dimensions and weights
   8. Manufacturer's installation instructions
   9. All other appropriate data

1.3 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 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.
D. Pumps shall operate without objectionable noise or vibration.

PART 2 - PRODUCTS

2.1 CONDENSATE PUMP UNITS

A. Manufacturers: Bell & Gossett, or equal to the manufacturer's model scheduled.
B. Pumps shall be complete with acid resistant constriction, high efficiency ECM motor and factory installed and wired operating and controls.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install pumps in strict accordance with manufacturer's instructions to avoid any stress and misalignment.
B. 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.

END OF SECTION

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SECTION 23 31 14
DUCTWORK

PART 1 – GENERAL
1.1 RELATED WORK
1.2 SUBMITTALS
1.3 DELIVERY, STORAGE AND HANDLING
1.4 DESCRIPTION
1.5 DESIGN CRITERIA
PART 2 – PRODUCTS
2.1 GALVANIZED STEEL SHEET
2.2 STAINLESS STEEL SHEET
2.3 FLEXIBLE DUCT
2.4 MANUFACTURED DUCTWORK (POSITIVE PRESSURE)
2.5 MANUFACTURED ROUND DUCTWORK (NEGATIVE PRESSURE)
2.6 DUCT SEALANTS AND GASKETS
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2.8 ACOUSTIC DUCT COVERING
PART 3 – EXECUTION
3.1 GENERAL
3.2 ELBOWS
3.3 LONGITUDINAL SEAM
3.4 TRANSVERSE JOINT
3.5 DUCT SUPPORTS
3.6 PROTECTION OF DUCTWORK
3.7 DUCT LEAKAGE TEST
3.8 LOW PRESSURE DUCT CONSTRUCTION (PRESSURE CLASS 2" WG AND UNDER)
3.9 HIGH PRESSURE DUCT CONSTRUCTION (PRESSURE CLASS 3" WG AND OVER)
3.10 FLEXIBLE DUCT
3.11 ACOUSTICAL DUCT COVERING

PART 1 - GENERAL

1.1 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 0902 - Control Valves and Dampers
F. Section 23 3314 - Ductwork Specialties

1.2 SUBMITTALS

A. For each duct system, submit schedule utilizing reinforcement tables from SMACNA HVAC Duct Construction Standards Metal and Flexible where applicable. Each duct system schedule shall include, but not be limited to, the following:
   1. Name of Contractor/manufacturer fabricating each duct system
   2. Material and gauge
   3. Pressure class
   4. Transverse joint type and length and reinforcement rigidity class with designated joint T number or proprietary duct connection if utilized for each system
   5. Certified test results of proprietary joint products, if used, tested in accordance with SMACNA procedures
   6. Intermediate reinforcement spacing and rigidity class with metal angle dimensions and gauge
   7. Type of longitudinal seam
   8. Fitting construction details
   9. Support methods including spacing, upper attachments, and lower attachments
   10. Sealant and gasket
   11. Sealing class
B. Duct leakage testing methods, apparatus and apparatus certification signifying meter is in conformance with ASME Requirements for testing meters.

C. Duct liner including data on thermal conductivity, air friction correction factor, and temperature and velocity limitation.
D. Submit the following information for welded sheet metal ductwork:
   1. Welding Procedure Specification (WPS) for welded joints. Form to be similar to ANSI/AWS D9.1-2006 Code, Appendix "D".
   2. Procedure Qualification Record (PQR) for each WPS. Form to be similar to ANSI/AWS D9.1-2006 Code, Appendix "E".
   3. Welder and Welding Operator Qualification Test Record (satisfactory performance) for each field or shop welder. Form to be similar to ANSI/AWS D9.1-2006 Code, Appendix "F".

1.3 DELIVERY, STORAGE AND HANDLING

A. Protect duct and fittings from damage due to normal handling during shipment and storage. Protection shall be applied to ends of duct to prevent dirt and moisture from entering ducts and fittings.

1.4 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.

1.5 DESIGN CRITERIA

A. All products shall conform to NFPA 90A, and shall possess flame spread rating of not over 25 and smoke developed rating no higher than 50.
B. Unless otherwise indicated, construct all ductwork of galvanized sheet metal for pressure class not less than 2” WG for positive pressure ductwork and not less than -2” WG for negative pressure ductwork.
C. Ductwork shall comply with Local, State and Federal requirements.
D. Duct transverse joints and reinforcement material, including angle ring flanges and stiffeners, shall be of same material as duct.
E. Except as modified in this Section of specifications or on drawings, use material, weight, thickness, gauge, construction and installation methods as outlined in the following SMACNA publications:
   1. HVAC Duct Construction Standards Metal and Flexible, 3rd Edition, 2005, for rectangular and round ductwork up to positive 10” WG and negative 10” WG and flat oval ductwork up to positive 10” WG.
      a. Tie rods shall be 1/2” or 3/4”, galvanized steel EMT/conduits with bolt assembly consisting of rubber washer and friction anchored threaded insert similar to Ductmate Easyrod or PPI Condu-Lock.
   2. Round Industrial Duct Construction Standards, 2nd Printing 1999
   3. Round Industrial Duct Construction Standards, 2nd Edition, September, 1999
   4. Rectangular Industrial Duct Construction Standards, 2nd Edition, 2004
   5. Accepted Industry Practice for Industrial Duct Construction, 2nd Edition, 2008, for round ductwork -4” to 20” WG (Table 1-A) and for rectangular ductwork -4” to 20” WG (Table 2-A).
   6. Adhesives and sealants used on installation of ducts shall comply with South Coast Air Quality Management District (SCAQMD) Rule #1168; Indoor Environmental Quality Section, Credit IEQ-4.1.

PART 2 - PRODUCTS

2.1 GALVANIZED STEEL SHEET

A. Lock Former Quality (LFQ), cold rolled, open hearth soft steel sheet capable of double seaming without fracture, ASTM A924/A924M or ASTM A653/A653M. Galvanized coating shall be G90.
B. Use G90 Galvaneal or Zincgrip where painting is specified.

2.2 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.

2.3 FLEXIBLE DUCT

A. Manufacturers: Thermaflex, or Flexmaster

B. Factory fabricated, UL listed under UL-181 as Class 1 duct, meeting requirements of NFPA 90A with flame spread of 25 or less and smoke developed rating of 50 or under.

C. Flexible duct shall have minimum ratings as follows:
   1. Operating Temperature: -20ºF to 250ºF
   2. Internal Working Pressure: Positive: 6" WG
      Negative: 1" WG
   3. Burst Pressure: 2-1/2 times working pressure
   4. Velocity: 5000 fpm

D. Unless otherwise indicated, duct shall be nonmetallic insulated type composed of polyester film, polyethylene film, nylon film, CPE film, or coated woven fiberglass liner bonded permanently to corrosion resistant coated steel wire helix without adhesive.

E. Insulation shall be flexible fiberglass insulation with minimum R-value of 6 at mean temperature of 75ºF. Vapor barrier jacket shall be aluminum foil reinforced, polyethylene, or metalized polyester film with maximum perm rating of 0.05 perm per ASTM.

F. Insulation material shall not be exposed to air stream.

G. Lined flexible duct shall have the following minimum acoustical performance in accordance with ARI Standard 885. Dynamic Insertion Loss in each octave band of 5 ft or 10 ft straight duct shall not be less than the following:

Duct Diameter (in)	Dynamic Insertion Loss (dB) Octave Band Center Frequency (Hz) (Based on 5 ft length)					
	125	250	500	1000	2000	4000
6"	6	9	18	22	24	15
8"	6	10	18	20	21	12
10"	5	11	18	18	18	9

Duct Diameter (in)	(Based on 10 ft length)					
	125	250	500	1000	2000	4000
6"	10	15	28	33	35	22
8"	10	18	29	32	32	20
10"	9	19	28	31	29	18

2.4 MANUFACTURED ROUND DUCTWORK (POSITIVE PRESSURE)

A. Single Wall:
   1. Manufacturers: Lindab, Semco or McGill AirFlow, equal to McGill AirFlow Uni-Seal duct and fittings suitable to positive 4" WG.
   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" diameter with minimum 16 ga. Use fittings as indicated on drawings, as specified, and as required in accordance with manufacturer's published data.
   3. Unless otherwise indicated, connection shall be slip type with minimum 2" insertion length or flanged joint in accordance with manufacturer's recommendations. When flange joints are required, use Van Stone angle rings welded to duct.
   4. Internal bracing is not allowed.
   5. Pre-sealed snaplock pipe system "Greenseam +" as manufactured by Ductmate Industries may be used for low pressure supply air duct.

2.5 MANUFACTURED ROUND DUCTWORK (NEGATIVE PRESSURE)

A. Manufacturers: McGill AirFlow 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.

2.6 DUCT SEALANTS AND GASKETS

A. Sealant:
   1. Flexible, water based, adhesive sealant compounded specifically for sealing joints and seams in ductwork. Hardcast, McGill AirSeal, Ductmate PROseal, Mon-Eco Industries, Childers, DP1010 or H.B. Fuller/Foster.
   2. Sealants shall be UL 723 (ASTM E84) classified, and meet NFPA 90A and 90B.
   3. Select sealants as recommended by manufacturer for specific application.
   4. Duct tapes are not allowed.

B. Gaskets:
   1. Butyl, copolymer or neoprene based tape similar to Ductmate 440 Gasket Tape or Neoprene Gasket Tape for flanged joints.

2.7 ACOUSTIC DUCT ENCLOSURE

A. Enclosure shall consist of inner layer (2" thick, minimum 3 psf glass or mineral fiber similar to Type R insulation specified in Section 20 0700 - Mechanical Systems Insulation) and outer layer of 2 layers of 5/8" sheet rock with staggered seams, attached to sheet metal studs. Sheet rock shall be attached to structure not ductwork.

2.8 ACOUSTIC DUCT COVERING

A. Sound barrier material shall be similar to Kinetics Model KNM-100B or EAR Lag-10. Barrier material to have acoustic ratings of STC-27, 1.0 lb/ft2 weight, and minimum continuous operating range from -10°F to 180°F.

B. Minimum sound transmission loss at each octave band shall be as follows:

Sound Transmission Loss (dB) Octave Band Center Frequency (Hz)					
125	250	500	1000	2000	4000
15	18	21	27	32	37

PART 3 - EXECUTION

3.1 GENERAL

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

B. Make allowances for beams, pipes or other obstructions in building construction and for work of other contractors. Check plans showing work of other trades and consult with Engineer in event of interference. Transform, divide, or offset ducts as required, in such a manner as to maintain same cross sectional area of duct as indicated on drawings. Where it is necessary to install pipes or similar obstructions through ducts, consult with Engineer and obtain written approval from Engineer and Owner. If approved, provide streamlined encasement or collar designed in accordance with SMACNA Standards and seal to prevent air leakage.

C. Ductwork shall be free of kinks and dents.

D. Fabricate and install duct, fittings, joints, seams, reinforcement, supports, sealing, liner, etc., in sizes indicated on drawings and in accordance with manufacturer's published data and SMACNA Standards except as modified in this section of specifications or on drawings.

E. Provide transitions where different size or different shape ductwork segments are connected. Use concentric transitions unless otherwise shown. Unless otherwise indicated, make diverging transitions with maximum angle of 15° per side (30° total diverging) and converging transitions with maximum angle of 25° per side (50° total converging).

F. Provide transitions at ductwork system components and connections to equipment. Refer to Specification Section 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, sound attenuator devices or other devices installed in duct systems with angles or channels, and make all connections to such equipment including equipment furnished by others. Secure frames with gaskets, nuts, bolts and washers.
K. Blank off unused portion of outside air intake or exhaust louvers.
L. 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.
M. 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.
N. Do not install ductwork over electrical panelboards, switchgear, switchboards or motor control centers.
O. When original galvanized finish is altered or damaged, apply field galvanizing paint as follows:
    1. Prepare surface with use of power sanders or wire brushes to remove rust, paint, etc.
    2. Apply cold galvanizing material equal to ZRC Products, Inc.

3.2 ELBOWS

A. Rectangular Duct (SA/RA/EA):
    1. Use radius elbows with centerline radius to width ratio of 1.5 (SMACNA Type RE 1).
    2. Where 1.5 centerline radius elbows do not fit, use radius elbows with centerline radius to width ratio of 1.0 (SMACNA Type RE 3).
    3. Where 1.0 centerline radius elbows do not fit, use radius elbows with centerline radius to width ratio of 0.75 (SMACNA Type RE 3) or 45° throat with radius heel elbows (SMACNA Type RE 8).
    4. Use splitter vanes for 1.0 radius elbows, 0.75 radius elbows and 45° throat with radius heel elbows as follows;
        a. No vanes for duct with width less than 24”
        b. Single vane for duct with width 24” to 36”
        c. Two vanes for duct with width over 36”
    5. Fabricate splitter vanes in accordance with SMACNA HVAC Duct Construction Standards, Chart 4-1, (p. 4.11) and Figure 4-9 (p. 4.13).
    6. Square throat elbows with or without turning vanes are not allowed unless specifically indicated. Square throat elbows without turning vanes may be used for transfer air ducts.
B. Round Duct:
    1. Unless specific type is indicated, use radius elbows with centerline radius to diameter ratio of 1.5 regardless of duct velocity. Where 1.5 radius elbows do not fit, use 1.0 radius elbows.

3.3 LONGITUDINAL SEAM

A. Rectangular Duct:
    1. Unless otherwise indicated, use Pittsburgh lock seam.
    2. Seal longitudinal seams with approved sealant or pre-sealed with encapsulated mastic.
    3. Button punch snap lock construction (SMACNA L-2) may be used for ductwork that is both 2” WG (+ or -) and lower, and 36” and smaller in width or height. For ductwork over 24” in width or height, add screw 4” from each end.
    4. Button punch snap lock construction is not allowed for ductwork in chases and areas above inaccessible ceiling.
    5. Button punch snap lock construction is not allowed on aluminum ductwork.
B. Round Duct:
    1. Unless otherwise indicated, longitudinal seams shall be in accordance with SMACNA HVAC Duct Construction Standards with the following exceptions.
        a. SMACNA seam types RL-3, 6A, 6B, 7 and 8 shown in Figure 3-2 are not allowed.

3.4 TRANSVERSE JOINT

A. Rectangular Duct:
    1. Transverse joints shall be in accordance with SMACNA HVAC Duct Construction Standards.
    2. Ductmate 25/35 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, 2005, provided that corner pieces with bolts are used. If TDF/TDC flanges are damaged, replace the damaged joint(s) by straightening and reinforcing with minimum 1-1/2” x 1-1/2” x 1/4" angle at each side of transverse joint.
    4. Refer to Detail for non-externally insulated outdoor ductwork.

B. Round Duct:
1. Unless otherwise indicated, use beaded sleeve joints (SMACNA RT-1) with minimum 2” insertion length or flange joints (SMACNA RT-2 or RT-2A).
2. Connection systems manufactured by Ductmate Industries (Spiralmate and Ovalmate) or McGill AirFlow (Uni-flange) may be used for supply air ductwork.
3. AccuFlange connected systems may be used with gaskets specified in Part 2 of this Section.
4. Lindab SPIROsafe or McGill AirFlow (Uni-Gasket) self-sealing duct system will be acceptable for supply and return air ductwork.

3.5 DUCT SUPPORTS

A. Unless otherwise indicated, use straps or Z bar hangers with 3/8” rods to support rectangular ducts 60” wide and smaller and trapeze hangers with rods or angles to support rectangular ducts over 60” wide.
B. For round ducts 24” diameter or smaller, use single hanger.
1. Round Duct Strap Bracket by Ductmate Industries may be used up to 24” diameter.
C. For round ducts 25” diameter or larger, use 2 minimum 3/8” rods, with trapeze in accordance with the following schedule:

Duct Size	Trapeze (Half Round)
25” to 36”	1-1/2” x 1-1/2” x 1/8"
37” to 48”	1-1/2” x 1-1/2” x 1/4" or 2” x 2” x 1/8"
49” to 60”	2” x 2” x 1/4"
61” to 84”	2-1/2” x 2-1/2” x 1/4"

D. Refer to Section 20 0700 - Mechanical Systems Insulation for ductwork insulation, weight bearing inserts and insulation protection shield requirements.
E. Support vertical ducts at every floor, but not exceeding 12 ft.
F. The following upper attachments, upper attachment devices, lower hanger attachments, hanger devices, and/or hanger attachments are not allowed except where specifically indicated:
1. Hook or loop
2. Nailed pin fasteners
3. Expansion nails without washers
4. Powder actuated fasteners (forced entry anchors). Forced entry anchors may be used for upper attachments of flexible ductwork supports.
5. Beam or "C" clamps without retaining clips or friction clamps (provide retaining clips for "C" clamps)
6. Non-factory manufactured upper attachments for metal pan deck including wire coil and double circle (Items 16 and 17 of Fig 5-4 of SMACNA HVAC Duct Construction Standards 2005)
7. Wire hanger
8. Trapeze hangers supported by wires or straps
9. Rods, straps or welded studs directly attached to metal deck
10. Drilled hole with attachment to structural steel
11. Lag screw expansion anchor
12. Rivets
13. Non-metallic hangers or straps
G. Supporting devices shall be standard products of manufacturers having published load ratings.
H. Refer to Section 20 0529 - Piping and Equipment Supporting Devices for additional support requirements including attachments to structures.
I. Unless Architectural Documents indicate the required framing, provide angle iron framing around roof opening where duct penetrates through roof decking, to maintain roof decking structural integrity in accordance with roof decking manufacturer's recommendations. This is not required for concrete decking. For concrete decking, consult with the project structural engineer for location and size of opening prior to execution of Work.

3.6 PROTECTION OF DUCTWORK

A. Protect ductwork during construction against entry of foreign matter and construction dirt.
B. Keep ductwork capped when work is complete for the day or when duct is not being worked on or added to. Use of polyvinyl (VISQUEEN) with duct tape wrap is an adequate measure as long as it is secure with no openings or tears in product.
C. If ductwork is not protected, remove dirt and foreign matter from the duct system and obtain inspection and approval from Engineer upon completion of cleaning before operating fans.
D. Exhaust fans are not allowed to operate during construction to avoid intake of construction dirt/dust into exhaust air ductwork.

3.7 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. Test each supply, return, and exhaust ductwork as follows, unless otherwise indicated in this section or in schedules.
   1. Test 10% of total installed duct area.
   2. Engineer will select sections of ductwork to be tested.
   3. If test results are acceptable to Engineer, remainder of ductwork is permitted to proceed without further testing. If ductwork fails test, repair all ductwork including ductwork not tested. Then repeat leakage tests for new sections of ductwork as described above.

D. Leakage test procedures shall be in accordance with test method described in Section 3 of SMACNA HVAC Air Duct Leakage Test Manual, except as modified in this Section. Test apparatus shall be in accordance with Section 5 of SMACNA HVAC Air Duct Leakage Test Manual.

E. Test pressure shall be equal to duct pressure class. Negative pressure ductwork shall be tested with negative test pressure.

F. Air leakage shall not exceed limits specified. If leakage exceeds allowable limits, identify leaked areas, repair, seal and retest.

G. Do not insulate ductwork until it has been successfully tested.

H. Maximum permitted leakage (L) in cfm/100 sf duct surface area of each ductwork shall be calculated by:
   $L = C_L \times P^{0.65}$
   1. P = test pressure (duct pressure class).
   2. CL = duct leakage class, 2 for round/oval ducts and 4 for rectangular ducts and flexible ducts.
   3. Total allowable leakage in a duct section:
      = L x (total duct surface area of the section)

3.8 LOW PRESSURE DUCT CONSTRUCTION (PRESSURE CLASS 2" WG AND UNDER)

A. Use welds, rivets or nuts, and bolts for fabricating ductwork. Fully threaded sheet metal screws may be used on duct hangers, transverse joints and other SMACNA approved locations if screw does not extend more than 1/2" into duct. Sheet metal "TEK" screws 3/4" in length may be used as fasteners in conjunction with factory made transverse joints.

B. Unless otherwise indicated, construct branch take-off fittings as follows:
   1. For branch take-offs including branch ducts serving more than one diffuser or grille, use 45° entry fittings. For supply air ducts, conical taps may be used.
   2. For take-offs serving single diffuser, register or grille, use straight spin-in collars with manual balancing dampers.

C. Splitter dampers and/or extractors are not allowed.

3.9 HIGH PRESSURE DUCT CONSTRUCTION (PRESSURE CLASS 750 PA (3" WG) AND OVER)

A. Use manufactured ductwork or contractor fabricated ductwork meeting specified Construction Standards and fitting performance.

B. High pressure duct construction to be used in all locations where duct width is greater than or equal to 72", unless otherwise noted on plans. Use high pressure ductwork for all duct between control damper and SF-1, SF-2, SF-3, SF-4, SF-5, EF-1, EF-2, EF-3, EF-4, and EF-5.

C. Submit construction details including materials, type of service, reinforcing methods, and sealing procedures.

D. Use elbows, tees, laterals, crosses and accessory fittings as shown on drawings and as required to fabricate duct system.

E. Use conical tees for round ductwork and 45 degree entry fittings for branch take-offs from mains unless otherwise indicated.

F. Provide manufactured bellmouth fittings at each fan supply air plenum to provide smooth entrance of air into duct system.

G. Construct high pressure ductwork for 4" WG pressure class.

3.10 FLEXIBLE DUCT

A. Install flexible ducts in accordance with manufacturer's installation instructions and SMACNA Standards, except as modified in this Section of Specifications.

B. In supply air systems without air terminal devices, flexible ducts may be used for final connections to diffusers, grilles, and registers. Flexible ducts shall be of minimum length required to make connections, but shall not be greater than 6 ft in length, unless noted otherwise.

C. In return and general exhaust air systems without air terminal devices, flexible ducts may be used for final connections to return grilles and registers and general exhaust grille and registers. Flexible ducts shall be of minimum length required to make connections, but no greater than 6 ft in length, unless noted otherwise.

D. In return and general exhaust air systems with air terminal devices, flexible ducts shall be used for duct connections to grilles and registers for sound attenuation purposed, except above non-accessible ceilings. Flexible ducts shall be minimum 6 ft long and maximum 8 ft long.

E. Centerline radius of bends shall not be less than one duct diameters. FlexFlow Elbow supports by Thermaflex or similar products shall be used at diffuser/grille connection to assure full radius elbow.

F. Support flexible ductwork with min 1-1/2" wide saddle at a maximum of 5 ft on center and at elbow, with no portion lying on ceiling supporting system.

G. Individual sections of flexible ductwork shall be of one-piece construction. Splicing of short sections is not allowed.

H. Connect flexible duct liner to collars and rigid duct with stainless steel draw bands. If collars have beads, position draw bands behind beads.

I. 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.

J. Flexible ducts are not allowed above non-accessible ceilings.

K. Flexible ducts are not allowed in high pressure ductwork.

L. Flexible ducts are not allowed to pass through any partition, wall, floor or ceiling.

3.11 ACOUSTIC DUCT COVERING

A. Wrap outside of duct with inner layer material. Apply outer layer material over inner layer material. Do not rigidly tie outer layer material to ductwork.

B. If manufactured barrier materials are used, install in accordance with manufacturer's installation instruction.

C. Apply covering to the following ductwork:

1. Ductwork as indicated to be covered

END OF SECTION

SECTION 23 33 14
DUCTWORK SPECIALTIES

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3.12 INSTRUMENT TEST HOLES

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 0595 - Air Systems Test Adjust Balance
B. Section 23 0902 - Control Valves and Dampers (Control Dampers)

1.2 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

1.3 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 or unit at where the specialties are mounted, unless otherwise noted.
C. Unless otherwise noted, ductwork specialties shall be designed and constructed for pressure class of ductwork in which they are installed.

PART 2 - PRODUCTS

2.1 MANUAL BALANCING DAMPERS

A. Manufacturers: Ruskin, Greenheck, Vent Products, Pottorff or Air Balance, constructed in accordance with SMACNA HVAC Duct Construction Standards, except as modified below.

B. Rectangular Dampers:

1. For low pressure ductwork, for damper blade height up to 12", use single blade type with minimum 22 ga galvanized steel blade with minimum 3/8" rod for blade width up to 18", and with minimum 18 ga galvanized steel blade with minimum 1/2" continuous rod for blade width from 19" to 48". For damper blade height more than 12", use multiple blade type with minimum 16 ga galvanized steel channel frames, opposed blade linkage operation, with blades minimum 16 ga and 6" to 8" maximum blade width, minimum 1/2" continuous rod and 1/2" x 1/2" galvanized steel angle blade stops. Bearings shall be nylon or molded synthetic. Construct dampers over 48" in width or height in multiple sections with mullions.
2. For high pressure ductwork, dampers shall be constructed to withstand maximum pressure of 5" WG at closed position and maximum velocity of 3500 fpm at open position. Frame and blades shall be constructed of minimum 16 ga with minimum 1/2" diameter or square rod.

C. Single Blade Round Dampers:

1. For low pressure ductwork, damper shall have blade 24 ga, but no less than two gauges more than duct gauge. Rod shall be minimum 3/8" diameter or square continuous. Bearings shall be nylon or molded synthetic.
2. For high pressure ductwork, damper blade shall be minimum 16 ga. Rod shall be minimum 1/2" square continuous and tack welded to blade. Provide sealed end bearing similar to Ventlok #609 and acorn nut type dial regulator similar to Ventlok #635 or 641.

D. Provide damper operators with locking devices and damper position indicators. Sheet metal screws are not allowed in construction or installation of dampers. Use rivets or tack welds.

E. Dampers shall be properly stiffened and fabricated to prevent vibration, flutter or other noise.

F. Extend damper shafts through duct insulation or use elevated regulators for externally insulated ducts to accommodate specified insulation thickness.

2.2 SPLITTER VANES AND TURNING VANES

A. Radius Elbow Splitter Vanes (SMACNA Type RE-3):

1. Splitter vanes for radius elbows shall be constructed in accordance with SMACNA HVAC Duct Construction Standards Chart 4-1, (p. 4.11) and Figure 4-9 (p. 4.13).

B. Turning Vanes (SMACNA Type RE-2):

1. Turning vanes are not allowed unless specifically indicated.

2.3 BACKDRAFT DAMPERS

A. Manufacturers: Ruskin or 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, maximum temperature of 250°F and maximum system pressure of 5" WG for damper width of 60" and 14" WG for damper width of 12".

D. Maximum damper leakage shall be 13.5 cfm/sf based on pressure differential of 1" WG.

2.4 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 555 with 165°F fusible link and shall meet construction standards as set forth in NFPA 90A.

C. Fire resistance rating of fire dampers shall be as shown on drawings.

D. Dampers shall be dynamic type dampers rated to minimum 2000 fpm and 4" WG.

E. 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.

F. For round ducts, dampers similar to Ruskin Model FDR25 may be used where products are suitable for duct size, velocity and static pressure.

G. Damper fire rating shall be compatible with rating of building surface in which damper is used.

H. Submit UL installation details showing mounting method and duct connection method.

2.5 ACCESS DOORS

A. Access doors shall be rectangular, minimum 22 ga frame and minimum 24 ga door, fit air tight with neoprene gasket and shall be suitable for duct pressure class. When access doors are installed in insulated ductwork or equipment provide insulated doors with insulation equivalent to what is provided for adjacent ductwork or equipment. Access doors constructed with sheet metal screw fasteners are not acceptable.

B. Low Pressure Ducts (Pressure Class 2" and Under):

1. Doors shall be hinged type with sash lock for exposed application and non-hinged type with cam latches for concealed application.
2. Access doors constructed in accordance with SMACNA HVAC Duct Construction Standard (Figure 7-2) or similar to Ruskin Model ADC or ADH will be acceptable.
3. Sandwich style access doors made by Ductmate, Ward Industries, Greenheck, or Flexmaster are acceptable, provided that they meet insulation requirements.

2.6 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 NFPA 90A and 701 (formally UL 214).

B. General Supply, Return and Exhaust Ductwork:

1. Material for fully interior use to be 30 oz per square yard, double coated with neoprene, tensile strength of 500 lbs x 500 lbs, tear strength of 13 lbs x 13 lbs, suitable for -40°F to 200°F continuous operation similar to Duro Dyne Neoprene.
2. Material for located within general parking areas exposed to ambient, shall be combination of inner layer of Duro Dyne Neoprene and outer layer of 24 oz per square yard, coated with Hypalon, UV resistant, suitable for -40°F to 250°F, similar to Duro Dyne Durolon.

2.7 EXHAUST HOODS

A. Manufacturers: Carnes, Greenheck, Ammerman, Acme, Cook, Louvers and Dampers, Vent Products, Jenn-Air, or Penn

B. Hoods shall be low silhouette type.

C. Hoods shall be aluminum, all welded construction with mitered corner.

D. Hoods shall be removable, cross broken, undercoated with insulating mastic and fabricated of aluminum alloy 3003-H14. Louver blades and extruded members shall be aluminum alloy 6063-T5.

E. Finish shall be baked enamel; color selected by Architect. Submit color selection charts with shop drawings.

F. Exhaust hoods shall be furnished with 1/2", 19 ga galvanized steel bird screen.

G. Hoods shall be furnished with factory fabricated curbs and extended bases, as required for mounting with inlet/outlet minimum of 24" above roof.

H. Curbs shall be galvanized steel or extruded aluminum with continuous welded corner seams, treated wood nailer, minimum 1-1/2" thick 3 lb/ft3 density rigid mineral fiberboard insulation with metal liner.

2.8 LOUVERS

A. Manufacturers: Air Balance, Inc., Airolite, Industrial Louvers, Airstream Products Co. Inc., American Warming, Carnes, Ruskin and Ventilating, Vent Products, Construction Specialties, DOWCO, Pottorff, or Louvers and Dampers, Inc.

B. Similar to Airolite Type K638, 12 ga aluminum frame and blades, 45° blades with water baffle, 4" deep, all-welded assembly with light bronze anodized finish.

C. Similar to Airolite Type K6776, extruded aluminum alloy not less than 12 ga (0.081" thick, 6063-T52 frame and blades, all-welded assembly, 35° blades with water baffle, 6" deep. Louvers shall bear AMCA certified ratings seal for air performance and water penetration, shall have free area not less than 50% based on 48" x 48" section, and shall have water penetration less than 0.02 oz per square foot under AMCA test at 1300 fpm.

D. Finish shall be similar protection as anodized coating minimum thickness 0.0007".

E. Blank-off panels on unused portion of louver shall be 2" thick insulated panels fabricated of minimum 22 ga galvanized steel on both surfaces. Insulation to be rigid type with minimum R value of 10[(h·ft2·°F)/(Btu)]. Panels shall be reinforced with minimum 20 ga steel stiffeners.

2.9 BIRD SCREENS

A. Bird screens shall be 1/2" square mesh formed with 0.063" diameter aluminum wire.

B. Frame shall be removable type of minimum 12 ga, extruded aluminum.

2.10 INSTRUMENT TEST HOLES

A. Manufacturers: Ventlok 699 (up to 1" insulation thickness) or Ventlok 699-2 (over 1" insulation thickness).

B. Use concave gaskets for round ductwork.

2.11 CONTROL DAMPERS

A. Furnished by Control Contractor.

PART 3 - EXECUTION

3.1 MANUAL BALANCING DAMPERS

A. Install manual balancing dampers in supply and exhaust branch ducts, as shown on drawings and as required to regulate airflow to meet air balance requirements.

B. Install manual balancing damper in branch duct to each diffuser and grille. Install dampers as close as possible to take-offs.

C. Install balancing dampers so as not to flutter or vibrate and as far as possible upstream from the air outlet.

D. Balancing damper is not required where terminal air device serves a single diffuser or grille.

3.2 SPLITTER VANES AND TURNING VANES

A. Install splitter vanes (SMACNA Type RE-3) as shown on drawings and as specified in Section 23 3114 – Ductwork, for rectangular radius elbows. Install splitter vanes in accordance with SMACNA Standards and/or manufacturer's recommendations.

B. Turning vanes (SMACNA Type RE-2) are not allowed unless specifically indicated.

3.3 BACKDRAFT DAMPERS

A. Install backdraft dampers where indicated on drawings.

B. Where motorized dampers are shown in exhaust fan discharge duct, or in duct connecting to relief or exhaust louver, backdraft dampers are not required unless specifically indicated. Where motorized dampers are not shown, provide backdraft dampers in these locations.

3.4 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 h 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.

3.5 ACCESS DOORS

A. Install access doors where specified, indicated on drawings, and in locations where maintenance, service, cleaning or inspection is required, including automatic dampers, fire dampers, smoke dampers, smoke detectors, fan bearings, filters, bird screens, valves and control devices within duct or casing, at outside air intake duct and at inlet side of turning vanes in return ductwork.

B. Locate access doors for greatest ease of access.

C. Size and quantity of duct access doors shall be sufficient to perform intended service, but not less than the following:

Rectangular Duct Size	Minimum Access Door Quantity and Size
10"and smaller	(1) 8" x 8"
12" to 15" and smaller	(1) 10" x 10"
16" to 21"	(1) 14" x 14"
22" to 27"	(1) 18" x 18"
28" to 47"	(1) 24" x 24"
48" to 96"	(2) 24" x 24"

Round Duct Size	Minimum Access Door Size

Round Duct Size	Minimum Access Door Size
10” and smaller	8” x 4”
15” and smaller	12” x 8”
29” and smaller	16” x 12”
30” and over	24” x 18”

D. Increase duct size to accommodate access door size indicated above where required.

3.6 FLASHINGS

A. Install counterflashings where shown on drawings. Install in accordance with SMACNA recommendations. Refer to architectural specification for material requirements.

3.7 DUCT FLEXIBLE CONNECTIONS

A. Connect ductwork to fans or casings containing rotating equipment or mounted on vibration isolators with duct flexible connections. Installed width shall be suitable for specific application but shall not be less than 4”. Install flexible connections in accordance with SMACNA Standards with double lock or "Grip Loc" connection.

3.8 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.

3.9 EXHAUST HOODS

A. Install hoods as shown on the drawings and/or as scheduled.

B. General Contractor will install curbs furnished with hoods unless otherwise indicated.

3.10 LOUVERS

A. Provide insulated metal panel on unused portion of louver.

B. Louvers will be provided by General Contractor.

C. Install louvers as shown on the drawings and/or as scheduled.

3.11 BIRD SCREENS

A. Provide bird screens or insect screens as indicated on drawings at louvers and at intake/exhaust openings.

B. Unless otherwise indicated, provide bird screens where filters are specified and insect screens where filters are not specified.

3.12 CONTROL DAMPERS

A. Install dampers in locations indicated on drawings, as detailed and according to manufacturer's instructions.

B. Install blank-off plates or transitions as specified in Control Sections.

C. Provide adequate operating clearance and access to operators.

D. For dampers located in general parking areas exposed to ambient, provide weather protection enclosure for parts of damper such as linkage and actuator located outside of duct. Enclosure shall be removable and made of galvanized steel sheet.

3.13 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

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SECTION 23 34 00
FANS

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PART 3 – EXECUTION
3.1 INSTALLATION

PART 1 - GENERAL

1.1 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

1.2 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 hp 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 hp curves, and selection range (surge curves, maximum rpm, etc).

C. Indicate performance data, based on both design air quantity and 110% of design air quantity.

D. For variable air volume application, indicate operating points at 100, 80, 60 and 40% of design capacity on fan curves including data to indicate effect of variable frequency drives on flow, pressure and hp.

E. Complete equipment data sheet attached at end of this Section for each piece of equipment and submit with shop drawings. Shop Drawings will be returned without review if data sheets are not provided for each piece of equipment and if data sheet is not filled out completely.

1.3 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.

C. Each fan wheel shall be statically and dynamically balanced to Balance Quality Grade G6.3 per ANSI S2.19 and AMCA 204-05. Complete fan assembly shall be factory balanced statically and dynamically in accordance with Standard AMCA 204-05 for Balance Quality and Vibration Levels for Fans and meet or exceed guidelines in Application Category BV-3.

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's scheduled rpm shall not exceed the following values when fan is rigidly mounted.
   1. Direct Drive 0.08 in/sec peak velocity
   2. Written records of run test and vibration test shall be available upon request.

E. Unless otherwise indicated, vibration level of installed fan assembly flexibly mounted shall not exceed 0.35 in/sec

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. Sound power levels shall be based on tests performed in accordance with AMCA Standards 300 and 301.

H. 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.

I. Consider drive efficiency in motor selection according to manufacturer's published recommendation, or according to AMCA Publication 203, Appendix L.

J. 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.

K. Unless otherwise scheduled, AMCA Type C spark resistant construction shall be used for fans handling flammable or grease laden vapors. Fans having spark resistant construction shall be electrically grounded so as to prevent static electricity from building up.

PART 2 - PRODUCTS

2.1 MIXED FLOW FANS

A. Manufacturers: Twin City, Greenheck, Chicago Blower, or PennBarry

B. Housings: Heavy gauge steel with welded fabrication, adequate reinforcing to prevent housing distortion, fully streamlined inlet cones, multiple straightening vanes following fan wheel to redirect air flow to minimize noise and reduce turbulence and flanged inlet and outlet. Fan housings shall be designed to promote straight line, air flow from entrance to discharge.

C. Wheels: Wheels shall be mixed flow type with single-thickness cambered blades. Blades shall be continuously welded to back plate and wheel cone. Wheels shall be statically and dynamically balanced and complete fan assembly including motor and drive shall be test balanced at or near operating speed at factory prior to shipment.

D. Shaft: Fan shaft shall be turned and polished steel and sized so first critical speed is at least 25% over maximum operating speed for each pressure class.

E. Bearings: Air handling quality, heavy duty, grease packed, cast iron, pillow block type with grease seal, furnished with external grease fittings, selected for minimum life (ABMA L-10) of not less than 80,000 h (equivalent to L-50 average life of 400,000 h) at maximum cataloged operating speed. Drives and bearings shall be contained within belt tube, isolating drives completely away from airstream.

F. Painting: Fan parts shall be painted with prime coat after metal cleaning and surface preparation. In addition, apply second coat of paint to exterior surfaces.

G. Inlet Bells and Screens: Furnish inlet bells and 1" mesh screens for fans shown without inlet ductwork.

2.2 IN LINE DUCT FANS

A. Manufacturers: Twin City, Greenheck, PennBarry, Cook, ACME, Jenn-Air or Carnes

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.

2.3 CEILING EXHAUST FANS

A. Manufacturers: Greenheck, PennBarry, Jenn-Air, Cook, Broan, Carnes, or ACME

B. Fans shall be complete with centrifugal blower wheel, steel housing with acoustical lining, integral exhaust grille, adjustable mounting brackets to allow for any ceiling thickness, permanently lubricated motor, integral junction box with motor factory wired and motor overload protection.

C. Provide unit discharge outlet as indicated on plans.

D. Provide units with appropriate wall, eave or roof discharge assembly, as indicated, complete with birdscreen and gravity backdraft damper.

2.4 JET THRUST FANS

A. Manufacturers: Greenheck, FlaktWoods, SystemAir or Fantech

B. Fans shall be complete with aluminum airfoil propeller wheel, galvanized steel housing with welded construction, adjustable mounting brackets to allow for any ceiling thickness, inlet mesh guard, 2 diameter inlet silencer, permanently lubricated motor, integral junction box with motor factory wired and motor overload protection, 2 diameter outlet silencer, outlet mesh guard, and directional vanes as indicated on plans.

C. Bearings: Shall be prelubricated and sealed and designed for minimum life of 40,000 h operation (ABMA L-10).

D. Painting: Fan parts shall be painted with prime coat after metal cleaning and surface preparation. In addition, apply second coat of paint to exterior surfaces.

E. Motors: Shall be 2 speed, split capacitor, totally enclosed, impedance protected.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units as shown on drawings, and according to manufacturer's installation instructions. On units provided with drain connection, install drain valve and cap discharge of drain.

B. Verify lubrication of motor and fan bearings and lubricate properly in accordance with manufacturer’s recommendation and Section 20 0000, Part 3 under LUBRICATION.

C. General Contractor will install curbs furnished with fans unless otherwise indicated.

D. Perform field mechanical balancing, if necessary, to meet vibration tolerance specified in Part 1 of this Section.

END OF SECTION

Fan Data Sheet

General

Project	_____
Identification	_____
Service	_____
Location	_____
Type	_____
Manufacturer	_____
Model Number	_____

Performance

Capacity	_____
Efficiency (%)	_____
Brake Horsepower at design flow rate (cfm)	_____
Brake Horsepower at 110% of design flow rate (cfm)	_____

Physical Characteristics

Size	_____
Class	_____
Drive Arrangement	_____
Discharge Rotation	_____
Drive	_____
Bearing	_____

Motor

Manufacturer	_____
Horsepower	_____
Voltage	_____
Phase	_____
Hertz	_____
RPM	_____
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

Vibration Isolators	_____
Special Coating (Yes or No)	_____
Special Coating Type	_____

SECTION 23 37 13
DIFFUSERS, REGISTERS AND GRILLES

PART 1 – GENERAL
1.1 SUBMITTALS
1.2 DESIGN CRITERIA
PART 2 – PRODUCTS
2.1 MANUFACTURERS
2.2 CEILING DIFFUSERS
2.3 ARCHITECTURAL SQUARE PANEL CEILING DIFFUSERS
2.4 REGISTERS AND GRILLES
2.5 SECURITY GRILLES
2.6 WIRE MESH GRILLES OR SCREENS
PART 3 – EXECUTION
3.1 INSTALLATION

PART 1 - GENERAL

1.1 SUBMITTALS

A. Shop Drawings including, but not limited to, the following:
1. Manufacturer's name and model number
2. Identification as referenced in the Documents
3. Capacities/ratings
4. Materials of construction
5. Sound ratings
6. Dimensions
7. Finish
8. Color selection charts where applicable
9. Manufacturer's installation instructions
10. All other appropriate data

1.2 DESIGN CRITERIA

A. Performance data shall be based on tests conducted in accordance with ASHRAE Standard 70-2006.
B. Screw holes on surface shall be counter sunk to accept recessed type screws.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Titus, Price, Carnes, Nailor, Anemostat, Metalaire, or Krueger
B. Acceptable manufacturers for specialty products are listed under each item.

2.2 CEILING DIFFUSERS

A. Diffusers shall be aluminum or steel as scheduled, unless otherwise indicated, and furnished with frame type appropriate to installation. Furnish diffusers with equalizing grids where it is not possible to maintain minimum 2 times duct diameter straight duct into diffuser. Equalizing grids shall consist of individually adjustable vanes designed for equalizing airflow into diffuser neck and providing directional control of airflow.
B. Diffuser models, sizes and finishes shall be as shown on drawings and/or as scheduled. Unless noted otherwise, diffusers shall have baked enamel or powder coat finish with color selected by Architect.
C. Perforated face ceiling diffusers shall have minimum 51% free face area and pattern controllers accessible through removable or hinged faceplate. Unless otherwise indicated, pattern controllers shall be curved vane type mounted in neck of diffuser. Unless otherwise indicated, furnish diffusers with round neck inlets with minimum 1” depth.

2.3 ARCHITECTURAL SQUARE PANEL CEILING DIFFUSERS

A. Architectural square panel ceiling diffusers shall be similar to Titus Model OMNI diffuser.

B. Diffusers shall have one piece 18 ga face panels. Face panel shall be removable by means of four positive locking posts. Exposed surface of face panel shall be smooth, flat, and free of visible fasteners and have rounded off corners. Face panel shall project no more than 3/8" below outside border of diffuser back pan. Back of face panel shall have an aerodynamically shaped, roller edge to ensure tight horizontal discharge pattern.

C. Ceiling diffusers with 24" x 24" full face shall have no less than 18" x 18" face panel size.

D. Back pan shall be one piece die-stamped and shall include integrally drawn round inlet. Diffuser back pan shall be constructed of 22 ga steel. Diffuser neck shall have minimum of 1-1/4" depth available of duct connection. Back pan shape with face panel shall deliver 360° radial horizontal air pattern.

E. Unless otherwise indicated, diffusers shall have baked enamel or powder coat finish with color selected by Architect.

2.4 REGISTERS AND GRILLES

A. Registers and grilles shall be aluminum or steel as scheduled unless otherwise indicated, and furnished with frame type appropriate to installation.

B. Supply registers and grilles shall be double deflection type blades to provide for air deflection adjustment in all directions.

C. Return and exhaust registers and grilles shall have fixed blade core.

D. Registers shall be furnished complete with opposed blade volume control dampers, operable from face.

E. Register and grille models, sizes and finishes shall be as shown on drawings and/or as scheduled. Unless noted otherwise, registers and grilles shall have baked enamel finish with color selected by Architect.

2.5 SECURITY GRILLES

A. Security grilles shall be steel with 14 ga blades supported at 6" OC. Provide No. 10 1/4" mesh behind blades to prevent insertion of objects through face of grille. Provide metered, welded corner joints and opposed blade balancing damper. Grilles shall be similar to Titus S-3300.

2.6 WIRE MESH GRILLES OR SCREENS

A. Grilles shall be 2 X 2 mesh (1/2") galvanized steel or aluminum hardware cloth in spot welded galvanized steel frame with 1-1/2" width.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install grilles, registers and diffusers as shown on drawings and according to manufacturer's instructions.

B. Unless otherwise indicated, size ductwork drops to diffusers or grilles to match unit collar sizes.

C. Seal connections between ductwork drops and diffusers/registers/grilles air tight.

D. Support independently diffusers and grilles designed for T-bar mounting that exceed weight limit of ceiling suspension system in which they are to be installed.

E. Unless otherwise shown, provide wire mesh screen at end of each open ended duct (OED) that is exposed in occupied spaces.

F. Blank off unused portion of linear diffusers and grilles.

G. Where diffusers, registers and grilles cannot be installed to avoid seeing inside duct, paint inside of duct with flat black paint to reduce visibility.

H. Protect diffusers, registers and grilles from construction dirt. Clean or replace those soiled or stained prior to turnover to Client.

END OF SECTION

SECTION 23 51 00
SMOKESTACK, BREECHING AND VENT PIPING

PART 1 – GENERAL
1.1 RELATED WORK
1.2 SUBMITTALS
1.3 DESIGN CRITERIA
PART 2 – PRODUCTS
2.1 GAS HEATER VENTING SYSTEM
2.2 ENGINE EXHAUST EXPANSION JOINTS
PART 3 – EXECUTION
3.1 INSTALLATION

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 0700 - Mechanical Systems Insulation

1.2 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

B. Submit the following information for welded sheetmetal 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".

1.3 DESIGN CRITERIA

A. All products, fabrication and installation shall comply with requirements of NFPA 211 together with State and Local Codes.

PART 2 - PRODUCTS

2.1 GAS HEATER VENTING SYSTEM

A. Vent piping shall have outer jacket of 0.025” thick aluminized coated steel and inner of 0.015” thick Type 430 stainless steel with ½” insulating air space.

B. Provide vents complete with all necessary accessories including flashing, counter flashing, storm collar, insulated thimble, guides, rain cap, clean out, fittings, and all necessary supports.

2.2 ENGINE EXHAUST EXPANSION JOINTS

A. Expansion joints shall be factory fabricated and made of Type 321 stainless steel bellows with carbon steel flanges.

B. Minimum design pressure and temperature shall be 15 psig and 1000°F.

C. Joints shall be Hyspan Series 2500 or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install stack, vents and expansion devices as shown on drawings, details and in accordance with manufacturer's recommendations. Coordinate carefully with General Contractor.

B. Support breechings adequately from building structure with provisions for breeching expansion and contraction.

END OF SECTION

SECTION 23 55 14
GAS-FIRED HEATING EQUIPMENT

PART 1 – GENERAL
1.1 RELATED WORK
1.2 REFERENCE
1.3 SUBMITTALS
PART 2 – PRODUCTS
2.1 GAS FIRED UNIT HEATERS
2.2 INFRA-RED HEATING DEVICES
PART 3 – EXECUTION
3.1 INSTALLATION

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 0513 - Motors
B. Section 23 5100 - Smokestack, Breeching and Vent Piping
C. Section 23 0901 - Control Systems Integration
D. Section 23 0993 - Control Sequences

1.2 REFERENCE

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

1.3 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. Dimensions and weights
   6. Wiring diagrams
   7. All other appropriate data

PART 2 - PRODUCTS

2.1 GAS FIRED UNIT HEATERS

A. Manufacturers: Lennox, Hastings, Reznor, Sterling or Applied Air with capacity and operating characteristics as scheduled.
   1. Units shall be AGA or CSA Certified for use with natural gas, 1000 Btu/ft3.
B. Casings:
   1. Heavy gauge cold rolled steel with metal side panel liners, foil covered fiberglass insulation in bottom of cabinet and with baked enamel finish.
C. Blowers:
   1. Direct drive fans statically and dynamically balanced.
D. Louvers:
   1. Adjustable vertical and horizontal louvers for control of air diffusion.
E. Burners:
   1. Aluminized steel construction, 4 rows of practically continuous ports for quiet and clean combustion.
F. Heat Exchanger:
   1. Heavy gauge aluminized steel, with smooth lines for minimum restriction to airflow.
G. Gas Controls:
   1. All controls shall meet the latest AGA, CSA and FMG requirements, including manual main shut-off valve, 24V redundant combination gas control valve with 100 % safety shut-off and pilot valve, main gas pressure regulator suitable for 0.5 psig inlet pressure.

H. Electric Controls:
   1. Provide complete with the following electric control devices: Solid-state electronic direct spark ignitor, fan and limit controls, 24 V transformer.

2.2 INFRA-RED HEATING DEVICES

A. Provide "Co-Ray-Vac Model HED", natural gas fired infrared vacuum gas heating system as manufactured by Roberts-Gordon Appliance Corp., or approved equal. System shall employ and locate proper number of firing units shown on drawings.

B. Overall system shall contain required number of independent sub-systems, each comprised of combination of firing units and aluminized steel radiant and flue pipe, together with centrifugal vacuum pumps, vacuum proving switches, condensate traps, thermostats, gas piping, and electrical wirings; installed according to instructions, diagrams, and prints furnished by manufacturer. System shall be rated for hazardous environments, with moisture-resistant construction.

C. Each firing unit shall consist of integral burner control device and shall have input rating as specified on plans. No part of system heat emitting surface shall exceed a temperature of 900°F. Each system shall vent all products of combustion outdoors by means of vacuum pump. Install vents where shown and as indicated in equipment instructions and in accordance with local requirements.

D. Installation of all equipment and material shall conform to manufacturer's recommendation. Combustion chambers, pipework, gas lines, and electric conduit shall be attached to or suspended from building structure in manner suitable to meet standards of durability and safety.

E. Burner units shall have 100% gas safety shutoff in case of ignition or vacuum failure and be UL Listed and AGA approved.

F. Gas controls shall meet the latest AGA, CSA and FMG requirements, including manual main shut-off valve, 24V redundant combination gas control valve with 100 % safety shut-off and pilot valve, main gas pressure regulator suitable for 0.5 psig inlet pressure.

G. Provide Tekmar 090 or equal in slab snow melt sensor with packaged snow melting control to match sensor.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units as indicated on drawings and details and according to manufacturer's instructions. Provide all supporting steel for units hung from roof structure.

B. Install vent piping to outdoors from all gas pressure regulators located within building.

C. Install snow melt sensors and control. Coordinate with control contractor for control system integration to BAS.

END OF SECTION

SECTION 23 81 44
HEAT PUMPS

PART 1 – GENERAL
1.1 RELATED WORK
1.2 REFERENCE
1.3 SUBMITTALS
1.4 DESIGN CRITERIA
1.5 TEST REPORTS
1.6 OPERATION AND MAINTENANCE DATA
1.7 GUARANTEE
PART 2 – PRODUCTS
2.1 HEAT PUMPS
PART 3 – EXECUTION
3.1 INSTALLATION

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 0513 - Motors
B. Section 23 0550 - Vibration Isolation
C. Section 23 0901 - Control Systems Integration
D. Section 23 0993 - Control Systems and Sequence

1.2 REFERENCE

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

1.3 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. Motor data (refer to Section 20 0513 - Motors)
   8. Power and control wiring diagrams
   9. Vibration isolation furnished with units
   10. Dimensions and weights
   11. Manufacturer's installation instructions
   12. 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 hp curves. Indicate design-operating point clearly on fan curves.

1.4 DESIGN CRITERIA

A. Design unit specifically for outdoor, horizontal airflow application.
B. Unit shall be completely factory assembled and run tested, piped, internally wired, fully charged with refrigerant and compressor oil when specified, and shipped in one piece.
C. Unit shall be factory run tested to check heating and cooling operation, fan and blower rotation and control sequence.
D. Furnish unit 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. Insulation and liners shall meet NFPA-90A Requirements.
F. Unit shall be UL Listed and carry UL Label.
G. Coils shall be rated in accordance with AHRI Standards.
H. 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.

I. Fan motor shall not operate into motor service factor in any of 3 cases. Drive efficiency shall be considered in motor selection according to manufacturer's published recommendation, or according to AMCA Publication 203, Appendix L.

J. 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.

1.5 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 Architect and Owner 10 days written notice of the time. Instructions shall be deemed completed when affidavit of instruction has been signed by representative of manufacturer and Owner.

1.6 OPERATION AND MAINTENANCE DATA

A. Manuals shall indicate unit model numbers, serial numbers, sizes, type, and indicate name and address of service company.

B. Description of maintenance required weekly, monthly, quarterly, semi-annually and annually shall be included along with recommended lubrication type.

1.7 GUARANTEE

A. Manufacturer and Contractor shall provide warranty on heat pump for a period of 1 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, replacement of belts and lubrication of bearings.

C. Manufacturer shall provide additional 4 yr warranty for refrigeration compressors.

PART 2 - PRODUCTS

2.1 HEAT PUMPS

A. Manufacturer:
1. Trane, York, Lennox, FHP or Carrier
2. Equal to manufacturer's model with capacity and operating characteristics as scheduled.

B. Casings:
1. Completely weatherproof and constructed of heavy gauge galvanized steel phosphatized with baked enamel finish. Insulate interior surfaces of cabinet with minimum of 1/2" glass fiber insulation.
2. Access doors to be heavy gauge galvanized or phosphatized zinc-coated steel complete with hinges or fasteners to secure door. Access doors and removable panels to have neoprene gaskets.
3. 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.

C. Supply Air Fans:
1. Statically and dynamically balanced and tested in factory.
2. Entire fan and drive assemblies shall be mounted on common base and be completely isolated from unit by factory mounted vibration isolators.

D. Filters:
1. Filters shall be integral to unit and to accessible.
2. Filters shall be 2" fiberglass throwaway type.
3. In addition, furnish one set of 1" glass fiber throwaway filters to be used during construction and initial start-up periods.

E. Refrigerant Circuits:
   1. System shall 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. Provide all other components required to modulate between heating and cooling modes.

F. Evaporator and Condenser Coils:
   1. Direct expansion type, factory charged with R-410A refrigerant and fully tested.
   2. Evaporator coils to be of non-ferrous construction with 3/8" OD seamless copper tubes mechanically bonded to configurated aluminum fins.
   3. Provide fully insulated drain pan fabricated from zinc-coated steel with additional coat of insulating sealer.
   4. Condenser coils shall be 3/8" OD seamless copper tubing mechanically bonded to heavy-duty configurated aluminum fins. Condenser fans to be direct drive type with exposed fan and shaft surfaces suitably weatherproofed. Fan motors to be furnished with normal and current overload protection and permanently lubricated motor bearings.
   5. Coils shall be leak tested at factory to ensure pressure integrity.

G. Compressor:
   1. Compressor shall be hermetic type with spring isolators.
   2. Provide compressor with internal thermal overloads, crankcase sight glass and crankcase heater.
   3. Provide capacitor start kit for single-phase units.
   4. Compressor shall be capable of starting and operating at ambient temperatures to -15°F.

H. Electrical:
   1. Furnish each unit with short circuit and over current protection motor starter, and contactors.
   2. Each unit shall include low voltage control transformer.
   3. Motor hp and voltages shall be as scheduled.

I. Unit Controls:
   1. Unit shall be completely factory wired for 24V controls.
   2. Microprocessor based unit controls shall contain all required algorithms to meet requirements of Mechanical Drawing Controls Sequences.
   3. Provide heating/cooling/deadband thermostat.
   4. Refrigeration safety controls to include high and low pressure cutout, oil pressure cutout, compressor overload protections, magnetic contractors and low voltage control transformer.
   5. Provide system with necessary controls to maintain head pressure at ambient to 0ºF.
   6. Provide defrost controls for use during heating cycle.
   7. Provide BACnet IP communication card for BAS system integration.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all units as indicated on plans and according to unit manufacturer's instructions.
B. Contractor shall install units on equipment support stands.
C. Provide all necessary connections to unit as shown on drawings and as required to complete installation.
D. Manufacturer and/or manufacturer's representative shall calibrate all of the unit's control devices and adjust unit automatic dampers to insure proper operation of system. Manufacturer shall coordinate with Controls Contractor to insure proper operation of system.
E. Provide joint commissioning of system with BAS provider to map points and verify system operation.

END OF SECTION

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SECTION 23 82 14
HEATING AND COOLING TERMINAL DEVICES

PART 1 – GENERAL
1.1 RELATED WORK
1.2 SUBMITTALS
1.3 REFERENCE STANDARDS AND DESIGN CRITERIA
PART 2 – PRODUCTS
2.1 ELECTRIC HEATERS
2.2 ELECTRIC HEAT TRACING
2.3 SPLIT SYSTEM
PART 3 – EXECUTION
3.1 INSTALLATION
3.2 ELECTRIC HEATERS
3.3 ELECTRIC HEAT TRACING

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 0513 – Motors
B. Section 23 5514 – Gas fired heating Equipment

1.2 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. Motor data (refer to Section 20 0513 - Motors)
9. For chilled beams, submit performance data from independent testing agency. Performance data to include cooling capacity at supply water temperatures scheduled, air pressure drop, sound data, and water pressure drop for each beam length.
10. All other appropriate data

1.3 REFERENCE STANDARDS AND DESIGN CRITERIA

A. Units including electrical work shall be UL Listed.
B. 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

2.1 ELECTRIC HEATERS

A. Manufacturers: Berko, Trane, Electromode, 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. Provide adjustable thermostatic control for operation of fan and heater.
D. For units with integral fans, furnish units with fans switches to maintain fan operation until all residual heat in elements has been dissipated.
E. Fans shall be statically and dynamically balanced. Fans and motors shall be mounted for vibration free operation.
F. Cabinets shall be 20 ga steel. Exposed cabinets shall have baked enamel finish in one of manufacturer's standard colors, selected by Architect.

2.2 ELECTRIC HEAT TRACING

A. Manufacturers: Raychem, Dekoron, Pentair Thermal Management, Bylin Engineered Systems, or Thermon

B. Heaters:

1. Self-regulating type, 2 tinned-copper bus wires, self-regulating polymer core maintaining temperature of pipe above freezing. Cover heater with polyolefin dielectric jacket, tinned-copper braid jacket and outer polyolefin jacket.

C. Electrical Service: 208 V, 1 Ph, 60 Hz Confirm voltage with Electrical Engineer; 208, 220, 240, or 277.

D. Accessories:

1. Include power connection kits, tee kits, end seal kits, splice kits, and control transformers as required. Include fiberglass tape or cable ties to fasten heater to pipe.

E. Automatic control by means of ambient sensing thermostat with the following features:

1. Stainless steel air temperature sensor
2. Set point of 1.6ºC(35ºF) with adjustable range of -4ºC to 162ºC (25ºF to 325ºF)
3. Electrical rating of 22 amps
4. NEMA - 4X metal enclosure

F. Refer to Section 22 0533.

2.3 SPLIT SYSTEM

A. Manufacturers: Mitsubishi, Toshiba, Carrier, Lennox or approved equal. Manufacturer shall be responsible for entire system consisting of DX cooling fan coil unit and condensing unit.

B. Provide factory assembled and tested, outdoor mounted, air-cooled condensing unit suitable for installation on grade or on a suspended platform as required per location on plans. Include compressor, air cooled condenser, refrigerant, lubrication system, interconnecting wiring, safety, required valves and operating controls, motor starting components and additional features as specified herein or required for safe, automatic operation. Capacity and operating characteristics as indicated in the equipment schedule. Coil performance data shall be in accordance with AHRI Standard 410. Refrigerant shall be R-410A.

C. Condensing unit cabinet is to be constructed of heavy gauge, galvanized steel coated with weather resistant paint. Provide removable access panels to facilitate full access to the compressor, fan and control components.

D. Furnish head pressure control to start and operate compressor satisfactorily at ambient temperature to-15ºF at minimum compressor load.

E. Provide factory assembled indoor fan coil unit. Cabinet shall be impact resistant and fully insulated. Supply fan shall be direct drive tangential blower. Motor shall be multi-speed, ODP with permanently lubricated bearings. Cooling coil shall be copper tube with aluminum fin and galvanized steel tube sheets. Drip pan under coil shall have drain connection with internal trap. Unit shall have filter rack with factory supplied cleanable filters. Unit shall be furnished with integral wall mounting bracket and mounting hardware.

F. Indoor fan coil unit shall be powered by outdoor condensing unit.

G. Provide with complete electronic microprocessor control system with shall control space temperature, determine optimum fan speed, and run self-diagnostics. The temperature shall be controlled by a programmable wired remote thermostat with integral temperature sensor and wall mounting bracket. Provide BACnet IP communication card for BAS system integration.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units as indicated on drawings, and according to manufacturer's installation instructions.

B. Protect units during construction against entry of foreign matter and construction dirt.

C. Unless otherwise shown on drawings, mount vertical type wall mounted heating units 12" above finished floor.

D. Provide joint commission with BAS provider to map points and verify system operations.

3.2 ELECTRIC HEATERS

A. Units shall be provided by Mechanical Contractor and wired by Electrical Contractor.

3.3 ELECTRIC HEAT TRACING

A. Attach heater linearly to clean, dry pipe with tape or ties in accordance with manufacturer's installation instructions.

B. Heater shall cover valves and piping specialties installed in piping where heater is specified or shown on drawings.

C. Effectively distribute heat along pipe and develop proper temperature. Consult manufacturer's data and installation instructions for sizing, spacing of heater, and heater location on pipe.
D. For installation on non-metallic piping, apply heater using aluminum tape.
E. Manufacturer's representative shall instruct workmen in proper installation techniques.
F. After installation and before and after installing thermal insulation, subject heat to testing using 1000 VDC megger. Minimum insulation resistance shall be 20 to 1000 megohms regardless of length.

END OF SECTION

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SECTION 26 00 00
GENERAL ELECTRICAL REQUIREMENTS

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PART 1 - GENERAL

1.1 DESCRIPTION

A. Intent of drawings and Specifications is to obtain complete systems tested, adjusted, and ready for operation.

B. Except as otherwise defined in greater detail, the terms "provide", "furnish" and "install" as used in Division 26 Contract Documents shall have the following meanings:
   1. "Provide" or "provided" shall mean "furnish and install".
   2. "Furnish" or "furnished" does not include installation.
   3. "Install" or "installed" does not include furnishing.

C. Include incidental details not usually shown or specified, but necessary for proper installation and operation.

D. Check, verify and coordinate work with drawings and specifications prepared for other trades. Include modifications, relocations or adjustments necessary to complete work or to avoid interference with other trades.

E. Included in this Contract are electrical connections to equipment provided by others. Refer to Architectural, Mechanical, Plumbing, and final shop drawings for equipment being furnished under other sections for exact locations of electrical outlets and various connections required.

F. Information given herein and on drawings is as exact as could be secured but is not guaranteed. Do not scale drawings for dimensions.

G. Where architectural features govern location of work, refer to Architectural Drawings.

H. Perform work in "neat and workmanlike" manner as defined in ANSI/NECA 1, Standard Practices for Good Workmanship in Electrical Contracting.

1.2 RELATED WORK

A. Utility Services:
   1. Determine utility connection requirements and include in Base Bid all costs to Owner for utility service.
   2. Include costs for temporary service, temporary routing of service or other requirements of a temporary nature associated with utility service.

B. Demolition:
   1. Division 02 - Building Demolition.

2. Perform required demolition to accomplish new work.
    a. Remove abandoned wiring to source of supply.
    b. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut conduit flush with walls and floors, and patch surfaces.
    c. Disconnect abandoned outlets and remove devices.
    d. Remove abandoned outlets if conduit servicing them is abandoned and removed.
    e. Provide blank cover for abandoned outlets that are not removed.
    f. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.
    g. Disconnect and remove abandoned luminaries. Remove brackets, stems, hangers, and other accessories.
    h. Disconnect electrical systems in walls, floors, and ceilings scheduled for removal.
3. Accomplish work in neat workmanlike manner to minimize interference; annoyance or inconvenience such work might impose on Owner or other Contractors.
4. Unless otherwise noted, remove from premises materials and equipment removed in demolition work.
5. Equipment noted to be removed and turned over to Owner, shall be delivered to Owner at place and time Owner designates.
6. Where materials are to be turned over to Owner or reused and installed by Contractor, it shall be Contractor's responsibility to maintain condition of materials and equipment equal to that existing before work began. Repair or replace damaged materials or equipment at no additional cost to Owner.
7. Where demolition work interferes with Owner's use of premises, schedule work through Architect, Owner and with other Contractors to minimize inconvenience to Owner. Architect must approve schedule before Contractor begins such work.

C. Cleaning and Repair
1. Luminaires:
    a. Remove existing luminaries for cleaning.
    b. Use mild detergent to clean exterior and interior surfaces; rinse with clean water and wipe dry.
    c. Replace lamps and broken electrical parts.

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

E. Painting:
1. Furnish equipment with factory-applied finish coats or paint equipment per Division 09 – Finishes unless specified otherwise.
2. Furnish equipment with factory applied prime finish unless otherwise specified.
3. If factory finish on equipment furnished by Contractor is damaged in shipment or during construction, refinish equipment to satisfaction of Architect.
4. Furnish one can of touch up paint for each final factory-applied finish coat of product.

1.3 REQUIREMENTS OF REGULATORY AGENCIES

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

1.4 REFERENCE STANDARDS

A. Agencies or publications referenced herein refer to the following:
1. 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.

1.5 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.

1.6 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. Windblown 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 see page.
21. NEMA 13 - Same as NEMA 12 plus oil or coolant spraying or splashing.

1.7 SUBMITTALS

A. Shop Drawings (Product Data):

1. Refer to Division 01 - Submittal Procedures.
2. Note that for satisfying submittal requirements for Division 26, "Product Data" is usually more appropriate than true "Shop Drawings" as defined in Division 01. However, the expression "Shop Drawings" is generally used throughout 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. Where submittals cover products containing non-metallic materials, include "Material Safety Data Sheet" (MSDS) from manufacturer stating physical and chemical properties of components and precautionary considerations required.
10. Submit shop drawings or product data as soon as practicable after signing contracts. Submittals must be approved before installation of materials and equipment.
11. Submittals that are not complete, not permanent, or not properly checked by Contractor, will be returned without review.
12. "Coordination Drawings", which are normally prepared by Contractor to coordinate work among various trades and to facilitate installation, shall not be submitted for Division 26 work unless specifically requested in technical sections. These types of drawings typically include dimensioned piping, ductwork or electrical raceway layouts.
13. Unless specifically requested in Division 26 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. 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 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.

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

1.8 JOB CONDITIONS

A. Building Access:
1. Arrange for necessary openings in building to allow for admittance of all apparatus.

B. Coordination:
1. Equipment provided under other Divisions of these specifications.
   a. Motors
   b. Electrically powered equipment
   c. Electrically controlled equipment
   d. Starters, where specified
   e. Variable frequency drives, where specified
   f. Control devices, where specified
   g. Temperature Control wiring

2. Provide the following devices required for control of motors or electrical equipment, unless 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 0901.
3. Connect and wire equipment complete and ready to operate according to wiring diagrams furnished by various trades.
4. Wire starters or other similar control devices furnished by others.
5. This contractor's drawings and/or specifications show number and hp rating of motors furnished by others, together with their actuating devices. Should any change in size, hp rating, voltage, or means of control be made to any motor or other electrical equipment after Contracts are awarded, Contractor responsible for change shall immediately notify this Contractor. Additional costs due to these changes shall be responsibility of Contractor initiating change.
6. Equipment and wiring shall be selected and installed for conditions in which it will be required to perform. (i.e., general purpose, weatherproof, rain tight, explosion proof, dust tight, or any other special type as required.)
7. Comply with local utility motor starting requirements and provide starters for motors furnished by others as specified herein or under various trade sections of those specifications.

C. Cutting and Patching:
1. Refer to General Conditions of the Contract and Division 01 - Cutting and Patching.
2. Perform cutting and patching required for complete installation of systems, unless otherwise noted. Patch and restore work cut or damaged to original condition. This includes openings remaining from removal or relocation of existing system components.
3. Provide materials required for patching unless otherwise noted.
4. Do not pierce beams or columns without permission of Architect and then only as directed. If openings are required through walls or floors where no sleeve has been provided, hole shall be core drilled to avoid unnecessary damage and structural weakening.
5. Where alterations disturb lawns, paving, walks, etc., replace, repair or refinish surfaces to condition existing prior to commencement of work. This may include areas beyond construction limits.

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

1.9 WARRANTY

A. Refer to Division 01 for general warranty requirements.
B. Refer to technical sections for warranty requirement for each system.
1. Where no warranty requirements are called out, warrant or 1 year after acceptance by Owner equipment, materials, and workmanship to be free from defect.

C. Repair, replace, or alter systems or parts of systems found defective at no extra cost to Owner.
D. In any case, wherein fulfilling requirements of any guarantee, if this contractor disturbs any work guaranteed under another contract, this contractor shall restore such disturbed work to condition satisfactory to Architect and guarantee such restored work to same extent as it was guaranteed under such other contract.
E. Warranty shall include labor, material, and travel time.

PART 2 - PRODUCTS

2.1 PRODUCT SUBSTITUTIONS

A. Refer to Division 01 - Product Requirements.

PART 3 - EXECUTION

3.1 GENERAL

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

3.2 DELIVERY, STORAGE, AND HANDLING

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

3.3 FLOOR, WALL, ROOF AND CEILING OPENINGS

A. Coordinate location of openings, chases, furred spaces, etc. with appropriate Contractors. Provide sleeves and inserts that are to be built into structure during progress of construction.
B. Remove temporary sleeves, if used to form openings, prior to installation of permanent materials. Utilize minimum 24 ga galvanized sheet metal for permanent sleeves unless otherwise noted.
C. Provide Schedule 40 carbon steel pipe with integral water stop for steel sleeves required below grade or to exterior.
D. Submit to Structural Engineer for review and approval size and location of core-drilled holes prior to execution.
E. Submit product data and installation details for penetrations of building structure. Include schedule indicating penetrating materials, (steel conduit, PVC conduit, cables, cable tray, etc.), sizes of each, opening sizes and sealant products intended for use.
F. Where penetrations of fire-rated assemblies are involved, seal penetrations with appropriate firestopping systems as specified in Section 26 0593 - Electrical Systems Firestopping.
G. Submit complete penetration layout drawings showing openings in building structural members including floor slabs, bearing walls, shear walls, etc. Indicate and locate, by dimension, required openings including those sleeved, formed or core drilled. Submit drawings for approval prior to preparing openings in structural member.
H. 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.
I. Seal non fire-rated floor penetrations with non-shrink grout equal to Embeco by Master Builders, or urethane caulk, as appropriate.
J. Seal non-rated wall openings with urethane caulk.
K. Where penetrations occur through exterior walls into building spaces, use steel sleeves with integral water stop, similar to type "WS" wall sleeves by Thunderline Corporation. Seal annular space between sleeves and pipe with "Link-Seal" modular wall and casing seals by Thunderline Corporation, or sealing system by another manufacturer approved as equal by Engineer. Sealing system shall utilize Type 316 stainless steel bolts, washers and nuts.
L. Finish and trim penetrations as shown on details and as specified.
M. Provide chrome or nickel plated escutcheons where raceways pass through walls, floors or ceilings and are exposed in finished areas. Size escutcheons to fit raceways for finished appearance. Finished areas shall not include mechanical/electrical rooms, janitor's closets, storage rooms, etc., unless suspended ceilings are specified.
    1. Penetrations other than conduits (junction boxes, light fixtures, etc.) including wiring devices shall be sealed as follows:
        a. Seal non-rated opening with silicone sealant.
        b. See drawings for details.
        c. Confirm selected sealant is compatible with paint provided by others prior to application.
        d. Product: One-Part Mildew-Resistant Silicone Sealant: Type S; Grade NS; Class 25; Uses NT, G, A, and as applicable to nonporous joint substances indicated, O; formulated with fungicide; intended for sealing interior joints with nonporous substrates and subject to in-service exposure to conditions of high humidity and temperature extremes; subject to compliance with requirements. Provide one of the following:
            1) 786 Mildew Resistant Silicone Sealant; Dow Corning Corp.
            2) Sanitary 1700 Silicone Sealant; General Electric Co.

3) 898 Silicone Sanitary Sealant; Pecora Corp.
4) Tremsil 600; Tremco Corp.
5) OmniPlus; Sonneborn Building Products Div., Rexnord Chemical Products, Inc.

3.4 EQUIPMENT ACCESS

A. Install raceways, junction and pull boxes, and accessories to permit access to equipment for maintenance. Relocate raceways or accessories to provide maintenance access at no additional cost to Owner.

B. Install equipment with sufficient maintenance space for removal, repair or changes to equipment. Provide ready accessibility to equipment and wiring without moving other future or installed equipment.

C. Access doors in walls, chases, or inaccessible ceilings will be provided under Division 08 - Access Doors and Frames, unless otherwise indicated. Access doors for equipment shall provide access for servicing, repairs and/or maintenance.

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

E. Provide access doors in walls, chases or inaccessible ceilings for equipment requiring access for servicing, repairs and maintenance, unless otherwise noted. Access frames and doors shall be as manufactured by Milcor, Incorporated, or similar, of style applicable to surface. Provide access doors used in fire-rated construction with UL label. Provide steel, prime-coated access doors in dry locations. Provide stainless steel access doors for use in ceramic tile walls, toilet rooms, locker rooms, and in areas subject to excessive moisture. Provide access doors of sufficient size to allow complete maintenance. Coordinate location of access doors with General Contractor and rough-in equipment accordingly.

F. Locate electrical outlets and equipment to fit details, panels, decorating or finish at space. Architect reserves right to make minor position changes of outlet locations before work has been installed.

G. Verify door swings before installing room light switch boxes. Install boxes on latch side of door unless otherwise noted.

3.5 EQUIPMENT SUPPORTS

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

B. Provide steel shell with plug type concrete anchors for attaching equipment to concrete. Plastic, rawhide or anchors using lead are not allowed.

C. Do not support equipment or luminaires from metal roof decking.

3.6 SUPPORT PROTECTION

A. In occupied areas, mechanical and electrical rooms and areas requiring normal maintenance access, guard certain equipment to protect personnel from injury.

B. Provide minimum 1/2” thick Armstrong Armaflex insulation or similar product applied with Armstrong 520 adhesive on lower edges of equipment, including bus duct, cable tray, pull boxes and electrical supporting devices suspended less than 7 ft above floors, platforms or catwalks in these areas.

C. Protect threaded rods or bolts at supporting elements as described above. Trim threaded rods or bolts such that they do not extend beyond supporting element.

3.7 LEAD SHIELDING

A. Wherever installation of this contractor's equipment destroys radiological integrity of wall, floor, or ceiling, this contractor shall be responsible to provide suitable lead shielding to restore that integrity. Coordinate these requirements with General Contractor.

3.8 ELECTRICAL SYSTEMS IDENTIFICATION

A. Refer to Section 26 0553 – Electrical Systems Identification.

3.9 ACCEPTANCE TESTING

A. Contractor shall engage testing and inspection agency to perform acceptance tests. Equipment to be tested is noted as "Testing by Testing Agency" in technical specification sections. Perform in accordance with Section 26 0812 – Power Distribution Acceptance Tests and Section 26 0813 – Power Distribution Acceptance Test Tables.

B. Contractor shall perform acceptance testing. Equipment to be tested is noted as "Testing by Electrical Contractor" in technical specification sections. Perform in accordance with Section 26 0812 – Power Distribution Acceptance Tests and Section 26 0813 – Power Distribution Acceptance Test Tables or as outlined in technical specification sections.

C. When testing is to be witnessed by Architect/Engineer or Inspector, notify them at least 10 days prior to testing date.

D. 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.

E. Contractor is responsible for certifying in writing equipment and system test results. Certification shall include identification of portion of system tested, date, time, test criteria and name and title of person signing test certification documents.

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.

3.10 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.

3.11 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 26 01 26

MAINTENANCE TESTING OF ELECTRICAL SYSTEMS

PART 1 – GENERAL
1.1 RELATED WORK
1.2 DESCRIPTION
1.3 INITIAL ACCEPTANCE TEST AND INSPECTION
1.4 WORK NOT INCLUDED
1.5 APPLICABLE CODES, STANDARDS AND REFERENCES
1.6 SUBMITTALS
PART 2 – PRODUCTS
PART 3 – EXECUTION

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 0000 - General Electrical Requirements.

1.2 DESCRIPTION

A. Test the following systems:
1. Medium voltage distribution equipment from point of service.
2. 480Y/277 V substations.
3. 208Y/120 V substations.
4. Power distribution monitoring, control and relay equipment.
5. Overcurrent protection device settings.
6. Starters feeding motors 40 hp or greater.
7. Motors 40 hp or greater.
8. Feeders from service point through feeders serving panelboards of 400 A or greater.
9. Emergency or standby diesel driven generators.
10. Grounding system from service point through branch panelboard feeders.
11. Computer room grounding system.

1.3 INITIAL ACCEPTANCE TEST AND INSPECTION

A. Perform acceptance test per National Electrical Testing Association Standard ATS - 1987 except as modified herein.
B. Perform on-site testing after equipment installation, unless otherwise noted.
C. Provide material, equipment, labor, and technical supervision to perform such tests and inspections.
D. Provide test power required.
E. Coordinate testing schedule and equipment availability with Owner.
F. Notify Owner 1 week before testing.
G. Prepare test results with comparison to industry and manufacturer's values and tolerances.
H. Assure electrical equipment is operational and within industry and manufacturer's tolerances, and is installed in accordance with Contract Documents.
I. Provide recommendations for suitability of continued energization.

1.4 WORK NOT INCLUDED

A. Prime mover testing (turbines or engines) will be performed by others.
B. Uninterruptible Power Systems.

1.5 APPLICABLE CODES, STANDARDS AND REFERENCES

A. Perform inspections and tests in accordance with the following Codes and Standards:
1. National Electrical Code - NEC
2. National Electrical Manufacturer's Association - NEMA
3. American Society for Testing and Materials - ASTM
4. American National Standards Institute - ANSI
5. Institute of Electrical and Electronic Engineers - IEEE
6. National Electrical Testing Association - NETA
7. State and Local Codes and Ordinances
8. Insulated Cable Engineers Association - ICEA
9. Association of Edison Illuminating Companies - AEIC

10. OSHA - Part 1910: Subpart S - 1910.308

B. Perform inspections and tests in accordance with the following references.
1. Project Design Specifications
2. Project Design Drawings
3. Manufacturer's instruction manuals
4. Manufacturer's shop drawings

C. Qualifications of Testing Agency
1. Member of NETA.
2. Meet Federal Department of Commerce requirements for independent testing laboratory accreditation.
3. Submit proof of above qualifications to Engineer.

1.6 SUBMITTALS

A. Provide 5 copies of complete testing report using NETA printed forms. Test report includes the following: summary of project, description of equipment tested, description of test, test results, conclusion and recommendation, and signature of responsible test organization authority.

B. Submit completed report to Engineer no later than 30 days after completion of testing, unless directed otherwise.

PART 2 - PRODUCTS

2.1 NOT APPLICABLE TO THIS SECTION

PART 3 - EXECUTION

3.1 THE FOLLOWING INDICATES APPLICABLE NETA STANDARD ATS - 1987 SECTIONS FOR THIS PROJECT.

ELECTRICAL ACCEPTANCE TESTS

5. GENERAL
   - 5.1 Test Instrument Calibration
   - 5.2 Test Report
     - Add at paragraph 5.2.2.: 5 copies of Test Report
   - 5.3 Safety & Precautions

8. INSPECTION AND TEST PROCEDURES:
   - 8.1 Metal Enclosed Switchgear and Switchboard Assemblies
   - 8.2 Transformers
     - 8.2.1 Transformers - Dry Type
       - Delete all "optional" references
     - 8.2.3 Small Transformers - Dry Type, Air Cooled (600V and Below)
   - 8.3 Cables
     - 8.3.1 Cables - Low Voltage - 600 Maximum
     - 8.3.2 Cables - Medium and High Voltage - 69 kV Maximum
       - Delete "optional" references
   - 8.4 Metal Enclosed Busways
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     - 8.4.2 Electrical Tests
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   - 8.5 Switches
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   - 8.6 Circuit Breakers
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       - 8.6.2.3 Circuit Breakers - Medium Voltage - Vacuum

8.9 Protective Relays
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8.13 Grounding Systems
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10. THERMOGRAPHIC SURVEY

Delete "optional" reference at paragraph 10.5.4

11. TABLES

END OF SECTION

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SECTION 26 01 91
ELECTRICAL SYSTEMS COMMISSIONING REQUIREMENTS

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PART 1 - GENERAL

1.1 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 0573 – Power System Studies
D. Section 26 0812 – Power Distribution Acceptance Tests
E. Section 26 0813 – Power Distribution Acceptance Test Tables
F. Section 26 1216 – Dry-Type, Medium-Voltage Transformers
G. Section 26 2200 – Low-Voltage Transformers
H. Section 26 2413 – Switchboards
I. Section 26 2816 – Enclosed Switches and Circuit Breakers
J. Section 26 2913 – Enclosed Controllers
K. Section 26 3213 – Engine Generators
L. Section 26 3623 – Automatic Transfer Switches

1.1 DESCRIPTION

A. This Section includes the minimum requirements by Div 26 Contractor to support the commissioning process of electrical systems. In addition, Div 26 Contractor shall provide commissioning support to Div 20, 21, 22, 23, 25, 27, and 28 Contractors as necessary to meet the minimum requirements of mechanical, fire protection, and controls systems commissioning.
B. Refer to Section 26 0812 and Section 26 0813 for additional information on Div 26 Contractor testing requirements.
C. Electrical commissioning is defined as the process for ensuring that the Electrical System is installed and performing according to design intent and meets building operational performance expectations as defined in Construction Documents. In addition, electrical commissioning ensures adequate documentation of installation, start-up, functional testing and Owner training. The results of electrical commissioning will uncover operational performance deficiencies, and offer optimization to performance of the Electrical System.

1.2 DEFINITIONS

A. Level 1 Commissioning:
   1. This shall be considered the Factory Acceptance Testing (FAT).
   2. FAT phase of commissioning process is intended to provide a performance baseline from a controlled environment that is repeatable under field conditions, it allows for additional equipment tests to be performed above and beyond what is feasible in field conditions and can prevent equipment delivery with un-repairable defects.
B. Level 2 Commissioning:
   1. This shall be considered the Component & Device Start-Up.
   2. Component start-up phase of commissioning process is intended to verify that individual components and devices have been constructed, delivered and installed properly and in good condition, and function as designed. This level of acceptance phase includes Installation Verification Checklists (IVC's), startup reports, and test reports.

C. Level 3 Commissioning:
   1. This shall be considered the Equipment Level Testing.
   2. Equipment Level Testing (also described as vendor start-up) phase of commissioning process is intended to confirm that installed equipment functions as intended.

D. Level 4 Commissioning:
   1. This shall be considered the Systems Level Testing.
   2. System level testing phase of commissioning process is intended to confirm that entire systems are functioning per design intent and controlling automatically.

E. Level 5 Commissioning:
   1. This shall be considered the Integrated System Level Testing.
   2. Integrated system level testing phase of commissioning process is intended to simulate performance of systems operating together as designed (to include major facility level events). This level of testing will include validation of redundancy, failure mode scenarios and confirmation of proper interaction between mechanical, electrical, control and life safety systems.

F. Design Phase:
   1. This shall be considered the phase of project prior to construction bid award, most typically prior to Issued for Construction set of documents.

G. Construction Phase:
   1. This shall be considered the phase of the project following the Design Phase and prior to Acceptance Phase. This most typically is during all construction activity prior to Level 3 Commissioning and before equipment is ready to be commissioned. It is possible for certain systems to be in Construction Phase while others are in Acceptance Phase.

H. Acceptance Phase:
   1. This shall be considered the phase of the project past Construction Phase and prior to Occupancy Phase. This most typically is during Levels 3, 4, and 5 Commissioning. It is possible for certain systems to be in Construction Phase while others are in Acceptance Phase.

I. Occupancy Phase:
   1. This shall be considered the phase of the project once the facility is occupied and the infrastructure is revisited (typically 10 months after occupancy) to ensure the performance is consistent and additional system tuning is not required.

J. Basis of Design (BOD): Documentation of design criteria and decisions made to meet design intent. Describes systems, components, conditions, and methods chosen to define intent of Owner.

K. Commissioning Agent (CxA): Consultant who facilitates commissioning program and directs and coordinates day-to-day commissioning activities. Commissioning Agent reports directly to Owner.

L. Commissioning Plan (CP): Manual providing documentation of roles and responsibilities and structured means of scheduling, coordination and documentation for commissioning process.

M. Deferred Functional Test: Functional performance test performed after substantial completion due to conditions that preclude test from being performed in normal sequential order of project delivery.

N. Deficiency / Non Compliance / Non Conformance: Condition of a component, piece of equipment, or system that is not in compliance with Contract Documents.

O. Factory Testing: Testing of equipment at factory by Manufacturer.

P. Functional Performance Test (FPT): Test of dynamic function and operation of equipment and systems. Systems are tested under various conditions, such as low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, fire alarm, power failure, etc. Systems are run through specified sequences of operation. Components are verified to be responding in accordance with contract documents.

Q. Indirect Indicator: Indicator of response or condition by a secondary intangible method, such as a reading from a control system graphical interface reporting some device to be in some state.

R. Installation Verification and Start-Up Checklist (IV Checks): List of items to inspect and elementary component tests that verify proper installation of equipment. Checklists are primarily static inspections and procedures to prepare equipment or system for initial operation and is a coordinated document representing efforts of subcontractors and Prime Contractor.

S. Monitoring: Recording of parameters of equipment operation using data loggers or trending capabilities of control systems.

T. Seasonal Performance Test: Functional Performance Test executed at time of year such that system(s) experience conditions closer to design conditions. Includes combination of trend log analysis and on-site testing as appropriate.

U. Simulated Condition: Condition created for testing component or system.

V. Simulated Signal: Disconnecting sensor and using signal generator to send amperage, resistance, or pressure to transducer and/or PLC system to simulate sensor value.

W. Startup: Initial start or activation of dynamic equipment, including executing installation verification checklists.

X. Installation Contractor (Sub-Contractor): Contractor who is under contract to Construction Manager who provides and/or installs building components and systems.
Y. Trending: Monitoring controls points of systems as a function of time using building control system.
Z. Vendor: Supplier of equipment.

1.3 SCOPE OF ELECTRICAL COMMISSIONING

A. Electrical Systems to be commissioned include:
   1. All Electrical Distribution Equipment
   2. Switchboards
   3. Distribution Panels
   4. Panelboards
   5. Low Voltage Transformers
   6. Generators
   7. Automatic Transfer Switches
   8. Electrical Meters
B. Ensure all tested electrical equipment, both contractor and Owner supplied, is operational and within industry and manufacturer's tolerances and is installed in accordance with design specifications.

1.4 COORDINATION

A. The installation schedule for the electrical systems included in the commissioning program shall be such that the commissioning requirements can be met without impacting the construction schedule.
B. Construction Manager shall be responsible for equipment calibration certificates.

1.5 SUBMITTALS

A. Test Reports: Include the following:
   1. Summary of project
   2. Description of equipment tested
   3. Equipment used to conduct the test
   4. Description of test
   5. Test results, as compared to manufacturers' or industry accepted standards and tolerances
   6. Conclusions and recommendations
   7. Signature of responsible test organization authority
B. List of equipment used to perform tests. Identify the following:
   1. Type
   2. Manufacturer
   3. Model number
   4. Serial number
   5. Date of last calibration
   6. Documentation of calibration leading to NIST standards

PART 2 - PRODUCTS

2.1 TESTING EQUIPMENT

A. Provide industry standard test equipment to verify readings and test system and equipment performance. This test equipment will also be made available to CxA. Generally, no equipment will be required beyond that required to perform Contractors work under these Contract Documents.
B. The following testing equipment will be required at minimum:
   1. Portable loadbank and associated SO cabling with connectors. Loadbank shall be resistive type that is air-cooled.
      a. Portable. Self-contained and supported to be installed on surfaces inside building. Portable loadbank is either mobilized inside a suitcase or with permanently installed casters. Typical rating is 20-400kW. Provide quantity as required for generator full load testing.
      b. Exterior. Typically shipped to site inside a vehicle or on trailer to be installed in exterior locations. Typical rating is 500-3000kW. Provide quantity as required for generator full load testing.
      c. Loadbank shall be provided with appropriate step-loads at a minimum to simulate 10%, 25%, 50%, 75%, 100% of the capacity of loadbank.
      d. Provide all work for loadbank to function. This includes, but is not limited to, external control circuit, external fan circuit.

PART 3 - EXECUTION

3.1 COMMISSIONING SCOPE

A. Provide Level 1 commissioning for the following equipment:
   1. All Electrical Distribution Equipment
   2. Switchboards
   3. Generators
   4. Automatic Transfer Switches

B. Provide Level 2 commissioning for the following equipment:
   1. All Electrical Distribution Equipment

C. Provide Level 3 commissioning for the following equipment:
   1. All Electrical Distribution Equipment
   2. Switchboards
   3. Distribution Panels
   4. Panelboards
   5. Low Voltage Transformers
   6. Generators
   7. Automatic Transfer Switches
   8. Electrical Meters

D. Provide Level 4 commissioning for the following equipment:
   1. Switchboards
   2. All Electrical Distribution Equipment
   3. Low Voltage Transformers
   4. Generators
   5. Automatic Transfer Switches

E. Provide Level 5 commissioning for the following equipment:
   1. All Electrical Distribution Equipment
   2. Switchboards
   3. Low Voltage Transformer
   4. Generators
   5. Automatic Transfer Switches
   6. Electrical Meters

3.2 COMMISSIONING RESPONSIBILITIES

A. Responsibilities of contractors are provided as follows:
   1. Construction Manager (CM)
      a. Include requirements for commissioning in each purchase order or subcontract written.
      b. Ensure acceptable representation, with the means and authority to assist CxA in coordination and execution of commissioning program.
      c. Attend commissioning kick-off meeting and other commissioning team meetings. Ensure appropriate representation at these meetings.
      d. Incorporate commissioning milestones and activities including functional performance testing into master construction schedule. Maintain and update schedule, as needed, such that it is an accurate representation of construction progress through completion of functional performance testing and resolution of punch list issues. Also incorporate durations for scheduled training in schedule.
      e. Review and provide comment on Commissioning Plan and Functional Performance Test procedures developed by CxA.
      f. Take lead role in coordinating completion and documentation of IVCs.
      g. Coordinate this activity with knowledgeable staff of contractors and submit single comprehensive document to CxA.
      h. Forward completed IVCs to CxA at least 3 workdays prior to schedule FPT.
      i. Coordinate Contractor participation in execution of Training Plan.
      j. Provide CxA with required documentation from commissioning activities and submittal request.
      k. Schedule, coordinate and assist CxA in seasonal or deferred testing and deficiency corrections required by specifications.
   2. Installation Contractors:
      a. Ensure acceptable representation, with the means and authority to assist CxA in coordination and execution of commissioning program.

b. Attend commissioning kick-off meeting and other commissioning team meetings scheduled by CxA.
c. Assist CxA with developing a comprehensive commissioning schedule during regularly scheduled commissioning meetings.
d. Complete commissioning activities as scheduled in master construction schedule.
e. Complete IVCs and submit with supporting documentation.
f. Provide certified and calibrated instrumentation required to take measurements of system and equipment performance during Functional Performance Testing.
g. Ensure installation work is complete, is in compliance with Contract Documents, and ready for Functional Performance Testing.
h. Execute inspections, tests, and Functional Performance Tests as described in contract documents and Commissioning Plan. Operate systems and equipment to demonstrate proper sequences of operation.
i. Review Commissioning Plan and Functional Performance Test procedures.
j. Provide required training for Owner personnel.
k. Provide documentation according to contract documents.
l. Execute seasonal or deferred Functional Performance Testing. Address deficiencies identified during functional testing in a timely manner.

3. Controls Contractor:
   a. Ensure acceptable representation, with the means and authority to assist CxA in coordination and execution of commissioning program.
   b. Completely install and thoroughly inspect, startup, test, adjust, calibrate, and document systems, equipment, devices, sensors, etc. controlled by building automation system. Provided documented point-to-point check out of system prior to functional performance testing.
   c. Assist CxA during Functional Performance Testing. Assistance shall generally include the following:
      1) Attend Cx progress and coordination meetings.
      2) Prepare and submit required draft forms and systems information.
      3) Set up trend logs of system operation at discretion of CxA.
      4) Demonstrate system operation to the CxA.
      5) Provide instrumentation, in calibration, necessary for verification and Functional Performance Testing.
      6) Manipulate control systems to facilitate verification and Functional Performance Testing.
      7) Provide one dedicated controls technician who is totally familiar with controls installation on project to work with CxA during functional performance testing.
      8) Provide onsite programmer(s), in addition to those dedicated to functional testing, to correct deficiencies in control sequences during commissioning period.

END OF SECTION

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SECTION 26 0477
ELEVATOR POWER MODULE DISCONNECT SWITCH

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2.2 POWER MODULE SWITCH
PART 3 – EXECUTION
3.1 INSTALLATION
3.2 FIELD QUALITY CONTROL
3.3 CLEANING

PART 1 - GENERAL

1.1 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 0529 – Hangers and Supports for Electrical Systems
E. Section 26 0533 – Raceways and Boxes for Electrical Systems
F. Section 26 0812 – Power Distribution Acceptance Tests
G. Section 26 0553 – Electrical Systems Identification
H. Section 26 0573 – Power System Studies
I. Section 26 2416.13 – Lighting and Appliance Panelboards
J. Section 26 2416.16 – Distribution Panelboards
K. Section 26 2726 – Wiring Devices
L. Section 26 2813 – Fuses
M. Section 26 2816 – Enclosed Switches and Circuit Breakers

1.2 DESCRIPTION

A. This Section includes Power Module Switch(es), and accessories required to distribute electrical power to elevators.

1.3 REFERENCE STANDARDS

A. ANSI/ASMEK A17.1, 102.2(4)
B. NETA ATS
C. NEMA AB 1 – Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures
D. NEMA FU 1 – Low Voltage Cartridge Fuses
E. NEMA KS 1 – Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
F. NFPA 70 – National Electrical Code
G. UL 98 – Enclosed and Dead Front Switches
H. UL 486A – 468B – Wire Connectors
I. UL 512 - Fuseholders

1.4 SUBMITTALS

A. Product Data:
   1. Include catalog cutsheet information showing voltage, amperage, short circuit current ampere rating, enclosure type and dimensions, configurations, and methods of mounting and installation. Submit listing of all types, sizes and quantity of fuses which will be installed including the location of each.
B. Manufacturer's Installation Instructions:
   1. Wiring diagrams detailing wiring for power and control systems and differentiating between manufacturer-installed and field-installed wiring. 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. Qualification data for firms and persons specified in the "Quality Assurance" Article to demonstrate their capabilities and experience.
D. Closeout Submittals:
1. Project Record Documents:
a. Record actual locations with ratings of installed Power Modules Switches.
2. Operation and Maintenance Data:
a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
b. Include spare parts data listing, source, and current prices of replacement parts and supplies.
c. Include Manufacturer Seismic Qualification Certification and Installation Seismic Qualification Certification.
E. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.

1.5 QUALITY ASSURANCE
A. Testing Agency Qualifications: In addition to the requirements specified in Division 1 Section –Quality Control, an independent testing agency shall meet OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907, or shall be a full member company of the International Electrical Testing Association (NETA).
1.1 Testing Agency's Field Supervisor: Person currently certified by NETA or the National Institute for Certification in Engineering Technologies, to supervise on-site testing specified in Part 3.
A. Obtain all elevator power module switch(es) from a single manufacturer.
B. Comply with NFPA 70 for components and installation.
C. Listing and Labeling: Provide disconnect switches and circuit breakers specified in this Section that are listed and labeled.
1. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Bussmann
B. Eaton
C. Littelfuse

2.2 POWER MODULE SWITCH
A. Provide Power Module Switch in a single NEMA 1 enclosure with all necessary relay(s), control transformer and other options as required and as shown on drawings.
B. The Power Module Switch shall have an ampere rating as shown on the drawings and shall include a horsepower rated switch with shunt trip capabilities.
C. The Power Module Switch shall include as an accessory, a control power transformer with a primary voltage rating of 480 volts and a 120 volt secondary.
D. The module shall have been successfully tested to a short circuit rating with Low-Peak Class J fuses at 200,000 amps RMS Symmetrical.
E. All switches shall have a shunt trip capabilities at 120V AC for remote fire safety signal. Since fire safety control voltage is normally 24 V DC, include for each shunt trips one control power transformer and relay to activate shunt trip solenoid.
F. Provide fire alarm voltage monitoring relay.
G. All switches shall include a key to test switch, green "ON" pilot light and two normally open and two normally closed mechanical interlock auxiliary contacts.

PART 3 - EXECUTION

3.1 INSTALLATION
A. Install power module switches in locations as indicated, according to manufacturer's written instructions.
B. Install switches level and plumb.
C. Install wiring between switches and any control, and indication devices.

D. Connect switches and components to wiring system as indicated and instructed by manufacturer.
E. Identify each power module switch according to requirements specified in Division 26 Section – Electrical Systems Identification. Attach nameplate to exterior of each switch using small corrosion-resistant metal screws or rivets. Do not use contact adhesive.
F. Install the top of the switch handle a minimum of 3'-6" and maximum of 6'-6" above finished floor.
G. Power Module Switch mounting and seismic restraints:
    1. Fasten switches firmly to walls and structural surfaces, ensuring they are permanently and mechanically anchored.
    2. Anchor and fasten switches 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 power module switch.
    4. When not located directly on wall, install support frame of steel slotted channel anchored to floor and ceiling structure.

3.2 FIELD QUALITY CONTROL

A. Inspect for physical damage, proper alignment connections, anchorage, and grounding.
B. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.
C. Test disconnect switches and/or enclosed circuit breakers per requirements in Sections 26 0812 – Power Distribution Acceptance Tests and 26 0813 – Power Distribution Acceptance Test Tables.
D. Interpret test results in writing and submit to Engineer.

3.3 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, vacuum dirt and construction debris, and repair damaged finish including chips, scratches, and abrasions to match original finish, using manufacturer-supplied paint kit. Do not use compressed air to assist in cleaning.

END OF SECTION

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SECTION 26 05 19

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

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3.4 REMOTE CONTROL AND SIGNAL CIRCUITS
3.5 CONNECTORS, SPLICES AND TERMINALS
3.6 CABLE TIES
3.7 FIELD QUALITY CONTROL

PART 1 - GENERAL

1.1 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
D. Section 26 0593 - Electrical Systems Firestopping
E. Section 26 0812 - Power Distribution Acceptance Tests
F. Section 26 0813 - Power Distribution Acceptance Test Tables

1.2 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.

1.3 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 3 – Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (ICEA S-19-81).
D. NEMA WC 5 – Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (ICEA S-61-402).
E. NEMA WC 70 – Non-Shielded Power Cable 2000 V or less for the Distribution of Electrical Energy (ICEA S-95-668).
F. NFPA 70 – National Electrical Code.
G. UL 44 – Thermoset-Insulated Wires and Cables.
H. UL 83 – Thermoplastic-Insulated Wires and Cables.
I. UL 486A-486B – Wire Connectors.
J. UL 486C – Splicing Wire Connectors.

K. UL 486D – Standard for Insulated Wire Connector Systems for Underground Use or in Damp or Wet Locations.
L. UL 486E – Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors.

1.4 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.

1.5 QUALITY ASSURANCE
A. Regulatory Requirements:
1. Comply with NFPA 70 for components and installation.
2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
B. 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.

1.6 DELIVERY, STORAGE, AND HANDLING
A. Store in clean, dry space. Protect from dirt, fumes, water, corrosive substances, and construction debris.

1.7 WARRANTY
A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.
B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. General Cable Corporation
B. Cerrowire
C. Southwire Company

2.2 DESCRIPTION
A. NEMA WC 70; single copper conductor insulated wire; 600V rated insulation; 90°C maximum operating temperature for dry and wet or damp locations.
1. Thermoplastic-insulated wires and cables: NEMA WC 5, UL 83;
a. Type THHN (Dry locations)
b. THWN (in areas of high moisture, damp locations, below grade, in concrete).
2. Thermoset-insulated wires and cables: NEMA WC 3, UL 44; Type XHHW (in damp locations and below grade).

2.3 REMOTE CONTROL AND SIGNAL CIRCUITS
A. Class 1
1. Copper conductor, single insulated wire.
2. Insulation type THHN (dry locations), THHW (high moisture areas) 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 XLE, rated 105°C, 300 V insulation class.
   3. UL listed for use in space in which circuits will be installed.

2.4 FIRE RATED CABLE

A. Fire rated type MC cable shall have a continuously welded and corrugated copper sheath, annealed copper conductors. Cable shall be UL listed as 2 hour fire resistive. Cabling shall be installed based on UL listed electrical circuit integrity system requirements. RSCC Wire & Cable LLC VitaLink only.
   1. Splices - 1 Hr. Rating – Refer to UL Electrical Circuit Integrity System No. 120 installation requirements and manufacturer installation requirements for more information and additional requirements.

B. Fire rated type MI mineral-insulated cable shall be nickel-clad copper conductor, magnesium oxide insulated and copper alloy sheathed, rated 600 volts, with either factory installed terminations or field termination kits from the same manufacturer as the cable. Cable shall be UL labeled as 2 hour fire resistive. Cabling shall be installed per UL listed electrical circuit integrity system requirements and manufacturer installation requirements. Pentair Pyrotenax Brand Model System 1850 only.

C. Fire resistive RHW-2 power cables shall be UL listed as 2-hour fire resistive. Cabling shall be installed per UL listed electrical circuit integrity system requirements. Draka Cableteq USA Inc, Type RHW-2 Lifeline Brand.
   1. UL Electrical Circuit Integrity System No. 25A –Refer to UL Electrical Circuit Integrity System requirements and manufacturer installation requirements for more information and additional requirements.
      a. Shall be routed directly horizontal only to be used as 2-hour fire resistive.
   2. UL Electrical Circuit Integrity System No. 25B - Refer to UL Electrical Circuit Integrity System requirements and manufacturer installation requirements for more information and additional requirements.
      a. Directly horizontal installations are 2-hour fire resistive.
      b. Vertical installations are limited to 1-hour fire resistive.
   3. UL Electrical Circuit Integrity System No. 25C - Refer to UL Electrical Circuit Integrity System requirements and manufacturer installation requirements for more information and additional requirements.
      a. Horizontal or vertical installation.

D. Fire resistive low voltage cable shall be copper No. 14AWG minimum. Cable shall be UL listed as 2-hour fire resistive. Cabling shall be installed per UL listed electrical circuit integrity system requirements. Comtran Cable LLC Type FPLR/CL3R/CMR Vitalink Brand, Radix Wire Co Type FPL Duralife Brand.
   1. Comtran Cable LLC, Refer to UL Electrical Circuit Integrity System No. 40, 40A installation requirements and manufacturer installation requirements for more information and additional requirements.
   2. Comtran Cable LLC Pull Box, Refer to UL Electrical Circuit Integrity System No. 40A installation requirements and manufacturer installation requirements for more information and additional requirements.
   3. Radix Wire Co Type FPL Duralife Brand cable splice - Refer to UL Electrical Circuit Integrity System No. 28A installation requirements and manufacturer installation requirements for more information and additional requirements.
   4. Radix Wire Co Type FPL Duralife Brand Pull Box – Refer to UL Electrical Circuit Integrity System No. 28A installation requirements and manufacturer installation requirements for more information and additional requirements.

2.5 CONNECTORS, SPLICES, AND TERMINALS

A. Manufacturers:
   1. AFC Cable Systems, Inc.
   2. Hubbell Power Systems, Inc.
   3. O-Z/Gedney; EGS Electrical Group LLC.
   4. 3M; Electrical Products Division
   5. Tyco Electronics Corp.

B. Description: UL 486A-486B, UL 486C, UL 486D, UL 486E; factory-fabricated connectors, splices, and terminals of size, ampacity rating, material, type, and class for application and service indicated.

2.6 TERMINATIONS

A. Compression set, bolted or screw type lug, or direct to bolted or screw type terminal.

2.7 PLASTIC CABLE TIES

A. Nylon or approved; locking type; metallic ties not permitted.

PART 3 - EXECUTION

3.1 INSTALLATION OF CONDUCTORS AND CABLES

A. Install conductors in a raceway system, unless otherwise specified or indicated.

B. Install conductors only after:

1. Building interior is enclosed and weather tight.
2. Mechanical work likely to damage conductors has been completed.
3. Raceway installation is complete and supported.

C. Pull conductors into raceway at same time.

D. Neatly train and lace conductors inside boxes, equipment, and panelboards.

E. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

F. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

G. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

H. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible. Protect exposed cables from damage.

I. Support cables above accessible ceiling using plastic cable ties to support cables from structure. 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.

3.2 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. 208Y/120 V circuits over 100' in length: Increase wire size one size for each 100' of length. Increase conduit size as required.
2. 480Y/277 V circuits over 150' in length: Increase wire size one size for each 150' of length. Increase conduit size as required.

3.3 CONDUCTOR INSULATIONS AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type XHHW-2, rated 90°C for wet locations, single conductors in raceway.

B. Exposed Feeders: Type XHHW-2, rated 90°C for wet locations, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THWN, rated 75°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. Exposed Branch Circuits: Type XHHW-2, rated 90°C for dry and wet or damp locations, single conductors in raceway.

F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN rated 90°C for dry and wet or damp locations, single conductors in raceway.
G. 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.
H. Motor Circuit Branch Wiring and Associated Control Wiring: Type THHN, rated 90°C for dry and damp locations, single conductors in raceway.
I. Wiring in Fluorescent Fixture Channels: Type THHN, 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. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

3.4 REMOTE CONTROL AND SIGNAL CIRCUITS

A. Sizing – #16 AWG minimum.
B. Installation:
   1. Install cables in cable tray and cable rings.
   2. Provide protection for exposed cables where subject to damage.
   3. Support cables above accessible ceilings; do not rest on ceiling tiles.
   4. Use suitable cable fittings and connectors.

3.5 CONNECTORS, SPLICES, AND TERMINALS

A. Connectors:
   1. Except where equipment is furnished with bolted or screw type lug, use compression set pressure connectors with insulating covers. Use compression tools and die compatible with connectors being installed.
   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.

3.6 CABLE TIES

A. Neatly bundle conductors and cables together for support. Size cable ties sufficiently to accommodate the multiple cables being supported.

3.7 FIELD QUALITY CONTROL

A. Test 600 volt conductors and cables per requirements in Sections 26 0812 – Power Distribution Acceptance Tests and 26 0813 – Power Distribution Acceptance Test Tables.

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 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

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PART 1 - GENERAL

1.1 RELATED WORK
A. Section 26 0533 - Raceway and Boxes for Electrical Systems
B. Section 26 0812 - Power Distribution Acceptance Tests
C. Section 26 0813 - Power Distribution Acceptance Test Tables

1.2 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.
B. Maximum resistance to ground shall be less than 25 ohms.
C. Refer to Grounding Riser Diagram.

1.3 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

1.4 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.

1.5 SUBMITTALS

A. Product Data: For each type of product indicated.
B. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features, including the following:
   1. Test wells
   2. Ground rods
   3. Ground rings
   4. Grounding arrangements and connections for separately derived systems
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 grounding connections for separately derived systems based on NETA MTS, 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.

1.6 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70.
   2. Comply with UL 467 for grounding and bonding materials and equipment.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store products in clean, dry space. Protect from dirt, fumes, water, corrosive substances, and construction debris.

1.8 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

2.1 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 and dimensions as indicated on drawings.

2.2 CONNECTORS

A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Electro-tin plated copper or copper alloy, bolted pressure-type, with at least two bolts.
   1. Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

D. Compression Connectors: Irreversible type.

2.3 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel 3/4” in diameter by 10 ft in length.

2.4 TELECOMMUNICATIONS BUSBARS

A. Material: Copper
   1. 1/4” thick

B. Pre-drilled
   1. 3/8” diameter
   2. Hole spacing per ANSI Joint Standard TIA-607-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) and Telecommunications Grounding Busbar (TGB) as indicated on drawings.

2.5 TELECOMMUNICATIONS GROUNDING CONDUCTORS

A. Material: Stranded copper.

B. Provide insulated bonding conductors.
   1. Green Jacket or Black Jacket marked with Green Tape or Green adhesive labels per NEC Guidelines.

C. Size:
   1. Bonding Conductor for Telecommunications (BCT; TMGB to Grounding Electrode) as indicated on drawings.
   2. Telecommunications Bonding Backbone (TBB; TMGB to TGB) as indicated on drawings.

2.6 TELECOMMUNICATIONS GROUNDING CONNECTIONS

A. Mechanical Connectors:
   1. Connector Body:
      a. High-strength, high-conductivity cast copper alloy.
      b. 2-bolt type.
   2. Bolts, nuts, washers, and lock-washers: 300 series stainless steel:
      a. Supplied as part of connector body.
      b. Split-bolt connector types are not allowed.
   3. Connector:
      a. Meet or exceed UL 467.
      b. Clearly marked with catalog number, conductor size, and manufacturer.

B. Compression Connectors:
   1. Connector Body: Pure wrought copper.
   2. Conductivity shall be no less than 99% by IACS Standards.
   3. Connector:
      a. Meet or exceed performance requirements of IEEE 837, latest revision.
      b. Filled with an oxide-inhibiting compound.
      c. Clearly marked with manufacturer, catalog number, conductor size, and required compression tool settings.
   4. Connection shall be irreversible.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for. #8 AWG and smaller, and stranded conductors for #6 AWG and larger, unless otherwise indicated.

B. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

C. Grounding Bus:
   1. Install bus on insulated spacers 1”, minimum, from wall; 6” above finished floor.
   2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down to specified height above floor, and connect to horizontal bus.

D. Conductor Terminations and Connections:
   1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
   2. Underground Connections: Welded connectors, except at test wells and as otherwise indicated.
   3. Connections to Ground Rods at Test Wells: Bolted connectors.
   4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING OVERHEAD LINES

A. Comply with IEEE C2 grounding requirements.

B. Install 2 parallel ground rods if resistance to ground by a single, ground-rod electrode exceeds 25 ohms.

C. Drive ground rods until tops are 12” below finished grade in undisturbed earth.

D. Ground-Rod Connections: Install bolted connectors for underground connections and connections to rods only where located within test well.

E. Lightning Protection Grounding Conductors: Separate from other grounding conductors.

F. Secondary Neutral and Transformer Enclosure: Interconnect and connect to grounding conductor.

G. Protect grounding conductors running on surface of wood poles with molding extended from grade level up to and through communication service and transformer spaces.

3.3 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4” will extend above finished floor. If necessary, install ground rod before manhole is placed and provide #1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof PVC sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2” above to 6” below concrete. Seal floor opening with waterproof, nonshrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, catch basins, metallic cover frame and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with #4 AWG minimum, stranded, copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.

D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with transformer and switches by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than #2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6” from the foundation. Install as indicated on drawings.

3.4 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with feeders and branch circuits. Install for each branch circuit neutral originating from panelboards, including lighting circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
   1. Feeders and branch circuits.
   2. Lighting circuits.
   3. Receptacle circuits.
   4. Single-phase motor and appliance branch circuits.
   5. Three-phase motor and appliance branch circuits.
   6. Flexible raceway runs.
   7. Armored and metal-clad cable runs.
   8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
   9. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.
   10. X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.

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. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

E. Duplex receptacles of any amperage: Install separate jumper between grounding terminal on device and metallic box.

F. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.

G. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.

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 switchboards/switchgear: 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 insulated grounding conductor (sized as indicated on drawings) in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
   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 5/8" x 10'-0" copperweld grounding rods arranged as indicated on drawings.
   1. Ground bus shall be horizontal 1/4" x 2" copper bar. Bolt to wall at 10' intervals with 1" stand-offs at each bus support.
   2. Install No. #4/0 copper grounding conductor from ground bus to each ground rod.

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 1/2" x 8'-0" ground rod, ground clamp and No. 3 stranded copper conductor concealed and attached to pole and base.

3.5 SEQUENCING, SCHEDULING

A. Permanently attach service grounds before permanent building service is energized.
B. Permanently attach equipment grounds prior to energizing equipment.

3.6 INSTALLATION

A. Connections: Exposed and visible for inspection at all times. Do not install insulation over ground connections.
B. Identify all grounding conductors by system and room number of termination at building grounding electrode point.
C. 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.
D. 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.
E. Ground Rods: Drive rods until tops are a minimum of 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.
F. 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.
G. 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.
H. 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. Bond metal grounding conductor conduit or sleeve to conductor at each end. 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.
I. 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.
J. Grounding for Steel Building Structure: Install as indicated on drawings.
K. Bond steel columns at bases using #4/0 copper conductor to column footing rebar.
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 and to steel columns.
   1. Install tinned-copper conductor as indicated on drawings.
   2. Bury ground rods not less than 24" from building foundation and 30" below grade.
   3. Install additional ground rods to meet project ohm requirement.
O. Concrete-Encased Grounding Electrode: Fabricate according to NFPA 70, using a minimum of 20' of bare copper conductor not smaller than #4 AWG.
   1. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to grounding electrode external to concrete.
P. Equipment Grounding Conductor: Terminate in panelboard at green wire ground bus.
Q. Multiple Conductors on Single Lug: Not permitted. Terminate each grounding conductor on its own terminal lug.
R. Flexible Metallic Conduit, Non-Metallic Rigid Conduit, or Liquid Tight Flexible Conduit: Install green wire grounding conductor with phase conductors in conduit.

3.7 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 tool accordance with manufacturer's instructions. Install Compression Connectors with compression, -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.

3.8 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. Test grounding systems per requirements in Section 26 0812 – Power Distribution Acceptance Tests and 26 0813 – Power Distribution Acceptance Test Tables.
C. Interpret test results in writing and submit to Engineer.
D. Inspect completed system by commissioning authority, prior to backfilling.

END OF SECTION

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SECTION 26 05 29
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

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PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 0533 – Raceway and Boxes for Electrical Systems
B. Section 26 0536 – Cable Trays for Electrical Systems
C. Section 26 0548 – Vibration and Seismic Controls for Electrical Systems
D. Section.26 1113 – Primary Unit Substations
E. Section 26 1213 – Liquid-Filled, Medium-Voltage Transformers
F. Section 26 1216 – Dry-Type, Medium-Voltage Transformers
G. Section 26 1219 – Pad-Mounted, Liquid-Filled, Medium-Voltage Transformers
H. Section 26 1223 – Network, Medium-Voltage Transformers
I. Section 26 1316 – Medium-Voltage Fusible Interrupter Switchgear
J. Section 26 1319 – Medium-Voltage Vacuum Interrupter Switchgear
K. Section 26 1323 – Medium-Voltage Pad-Mounted Switchgear
L. Section 26 1829 – Medium-Voltage Enclosed Bus
M. Section 26 1839 – Medium-Voltage Motor Controllers
N. Section 26 2200 – Low-Voltage Transformers
O. Section 26 2300 – Low-Voltage Switchgear
P. Section 26 2413 – Switchboards
Q. Section 26 2416.13 – Lighting and Appliance Panelboards
R. Section 26 2416.16 – Distribution Panelboards
S. Section 26 2419 – Motor-Control Centers
T. Section 26 2500 – Enclosed Bus Assemblies
U. Section 26 2600 – Power Distribution Units
V. Section 26 2816 – Enclosed Switches and Circuit Breakers
W. Section 26 2913 – Enclosed Controllers
X. Section 26 3213 – Engine Generators
Y. Section 26 3300 – Battery Equipment
Z. Section 26 3353.13 – Static Uninterruptible Power Supply
AA. Section 26 3353.23 – Central Battery Invertors
BB. Section 26 3623 – Automatic Transfer Switches
CC. Section 26 5000 – Lighting

1.2 DESCRIPTION

A. Section includes the following:
1. Manufactured hangers and supports for individual raceways and cables, slotted channel and angle systems for multiple conduit runs, and most electrical equipment that is not floor mounted.
2. Construction requirements for concrete housekeeping pads for floor-mounted electrical equipment.
3. Equipment mounts for acoustical noise and vibration control.

1.3 REFERENCE STANDARDS

A. AWS D1.1/D1.1M – Structural Welding Code-Steel.
B. ASTM A 36/A 36M – Carbon Structural Steel.
C. ASTM A 325 – Structural Bolts, Steel, Heat Treated, 120/105 ksi 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.

1.4 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: Signed and sealed by an Engineer registered and licensed in the State of Wisconsin 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.

1.5 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, “Structural Welding Code – Steel.”
B. Comply with NFPA 70.
C. Certification:
    1. Installer of PVC-coated hangers and supports shall be certified by a PVC conduit manufacturer.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of 5 times the applied force.

B. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
   1. Finishes
      a. Metallic Coatings:
         1) Factory standard primed, galvanized 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. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16" diameter holes at a maximum of 8" o.c., in at least one surface.
   1. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
   2. Fitting and Accessory Materials: Same as channels and angles.
   3. Rated Strength: Selected to suit applicable load criteria.
   4. Manufacturers:
      a. Allied Support Systems; Power-Strut Unit
      b. Cooper B-Line, Inc.; A division of Cooper Industries
      c. Fabco Plastics Wholesale Limited
      d. Seasafe, Inc.
      e. Approved equal

D. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

E. Raceway and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

F. PVC Raceway Support Devices: ANSI C80.1, UL6, ETL PVC-001.

G. Support for 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.

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 for seismic load application shall be approved by ICC-ES Evaluation Reports to resist seismic loads and selected to meet project seismic design requirements. Refer to Section 20 0549 – Seismic Anchorage and Restraints and Structural drawings.
f. Anchors shall be zinc plated in accordance with ASTM B633.
g. Select anchors with load ratings based on cracked concrete conditions.
h. 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
i. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated or stainless steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
1) Manufacturers:
a) Cooper B-Line, Inc.; A division of Cooper Industries
b) Empire Tool and Manufacturing Co., Inc.
c) Hilti Inc.
d) ITW Ramset/Red Head; A division of Illinois Tool Works, Inc.
e) MKT Fastening, LLC.
f) Approved equal

2. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
3. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.

J. Beam Clamps: C-clamps are allowed 3/8" or smaller and only for static loading such conduits. Provide locknut for hanging rod at clamp. C-clamps are not allowed for open web steel joist applications nor seismic applications.
K. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
L. Toggle Bolts: All-steel springhead type.
M. Hanger Rods:
1. MSS SP-58; threaded steel, with adjusting and lock nuts; galvanized finish.

2.2 FABRICATED METAL FRAMING EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural steel shapes, shop or field fabricated to fit dimensions of supported equipment.
B. Materials: Comply with requirements in Division 05 Section “Metal Fabrications” for steel shapes and plates; not be lighter than 12 ga.
C. Finish: Epoxy paint.
D. Manufacturers: Same as in paragraph 2.1.B.3 above.

2.3 CONTINUOUS INSERT CHANNELS

A. Length and support capabilities to be suitable for application.
B. Brackets, inserts and accessories suitable for channel insert selected.
C. Manufacturers:
1. Unistrut; Tyco International, Ltd.
2. Cooper B-Line, Inc.; A division of Cooper Industries
3. Michigan Hanger Co., O-Strut Division
4. Anvil International, Inc.
5. Approved equal

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70.

1. Size steel hanger rods for individual hangers and trapeze supports as indicated in the following schedule. Total weight of equipment shall not exceed limits indicated.

Maximum Loads (lbs)	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 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 single-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.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements, except as specified in paragraphs below.

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

C. 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: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

E. Do not support raceway by other raceway.

F. Do not support equipment or raceway from metal roof decking or floor decking.

G. Do not impose weight of electrical equipment, raceways, or lighting fixtures on support provided for other trades or systems.

H. 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.

I. Suspend hangers by means of hanger rods. Perforated band iron and flat wire (strap iron) are not allowed.

J. Use conduit-mounting pedestals for piping on roof. Install bottom of pedestal flat on roof deck and insulate exterior of pedestal, flush and counter flush.

K. Minimize use of concrete anchors and inserts after concrete pour.
L. Punching, drilling, welding of building structural steel or welding attachment to building structural steel is not allowed, unless approved by structural engineer.
M. Use tools approved for use with PVC-coated conduits and fittings.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Division 05 Section “Metal Fabrications” for site-fabricated metal supports.
B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE HOUSEKEEPING PADS

A. Construct concrete housekeeping pads for all floor-mounted electrical equipment.
B. Dimensions: 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.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
    1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
B. Touchup: Comply with requirements in Division 09 Section “Painting” for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
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 26 05 33

RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

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PART 1 - GENERAL

1.1 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 0548 – Vibration and Seismic Controls for Electrical Systems
E. Section 26 0553 – Electrical Systems Identification
F. Section 26 0593 – Electrical Systems Firestopping
G. Section 26 2726 – Wiring Devices
H. Section 27 0553 – Communications Systems Identification
I. Section 27 1100 – Communications Equipment Room Fittings
J. Section 27 1300 – Communications Backbone Cabling
K. Section 27 1500 – Communications Horizontal Cabling

1.2 DESCRIPTION

A. Section includes raceways, fittings, wireways, wall ducts, indoor service poles, outlet boxes, pull and junction boxes, floor boxes, tap boxes and raceway seals.

1.3 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. NEMA TC 13 – Electrical Nonmetallic Tubing (ENT)
Q. NFPA 70 – National Electrical Code
R. TIA-569-B – Commercial Building Standard for Telecommunications Pathways and Spaces
S. UL 1 – Flexible Metal Conduit
T. UL 6 – Electrical Rigid Metallic Conduit-Steel
U. UL 6A – Electrical Rigid Metallic Conduit-Aluminum and Stainless Steel
V. UL 360 – Liquid-Tight Flexible Steel Conduit
W. UL 514A – Metallic Outlet Boxes
X. UL 514B – Conduit, Tubing, and Cable Fittings
Y. UL 514C – Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
Z. UL 651 – Schedule 40 and 80 Rigid PVC Conduit and Fittings
AA. UL 797 – Electrical Metallic Tubing-Steel
BB. UL 870 – Wireways, Auxiliary Gutters, and Associated Fittings
CC. UL 1242 – Electrical Intermediate Metal Conduit-Steel
DD. UL 1660 – Liquid-Tight Flexible Nonmetallic Conduit
EE. UL 2024 – Optical Fiber and Communication Cable Raceway

1.4 SUBMITTALS

A. Product Data:
   1. Raceways
   2. Fittings
   3. Wireways
   4. Wall ducts
   5. Indoor service poles
   6. Outlet boxes
   7. Pull and junction boxes
   8. Floor boxes
   9. Tap boxes
   10. 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.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. Comply with NFPA 70.
   2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

B. Certification:
   1. Installer of PVC-coated conduits and fitting shall be certified by a PVC conduit manufacturer.

1.6 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.

1.7 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.1 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 and intermediate metal conduit: NEMA RN 1, ANSI C80.1, UL 6, ETL PVC-001; plastic cap protector caps

E. Fittings (couplings, conduit bodies, connectors and bushings): NEMA FB 1, UL 514B; steel; threaded; connectors with double locknuts and steel insulating bushings, thermoplastic insulating bushings for conduits 2" and smaller; conduit bodies cover: stamped steel with stainless steel screws and neoprene gaskets; PVC coated to match conduit.

F. Fittings Manufacturers: Cooper Crouse-Hinds; Carlon Electric Products/Prime Conduit Inc.; O-Z/Gedney; Appleton; Hubbell;

2.2 ELECTRICAL METALLIC TUBING (EMT)

A. ANSI C80.3, UL 797; galvanized steel tubing

B. Fittings (couplings, conduit bodies, and connectors): NEMA FB I, UL 514B; steel, watertight gland compression type or steel concrete-tight set-screw type connectors with double locknuts and insulated throat; conduit bodies cover: stamped steel, with stainless steel screws and neoprene gaskets. Indentor, drive-on, die-cast or pressure cast fittings not permitted.

C. Fittings Manufacturers: Same as manufacturers listed in 2.1.F.

2.3 FLEXIBLE METAL CONDUIT (FMC)

A. UL 1; interlocked steel

B. Fittings: NEMA FB I, UL 514B; steel

2.4 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)

A. UL 360; interlocked steel, with PVC jacket

B. Fittings: NEMA FB 1, UL 514B; steel

2.5 RIGID NONMETALLIC CONDUIT (RNC)

A. NEMA TC 2, UL 651; Schedule 40 PVC

B. Fittings: NEMA TC 3, UL 651

2.6 ELECTRICAL NONMETALLIC TUBING (ENT)

A. NEMA TC 13; hand-bendable, corrugated PVC conduit
B. Fittings: NEMA TC 3

2.7 LIQUIDTIGHT FLEXIBLE NONMETALLIC CONDUIT (LFNC)

A. UL 1660; flexible conduit with a plastic sheath
B. Fittings: UL 514B

2.8 STAINLESS STEEL CONDUIT

A. UL 6A
B. Type 304
C. Fittings: Threaded

2.9 METAL WIREWAYS

A. NEMA 250, UL 870; sheet metal troughs with hinged or removable cover, Type 1, unless otherwise indicated.
B. 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.
C. Wireways Covers: Screw-cover type
D. Knockouts: none
E. Finish: Manufacturer's standard enamel finish
F. Manufacturers: Hoffman; Square D Co.; Approved equal

2.10 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, aluminum, Type FD, with gasketed cover
   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;

2.11 OUTLET BOXES FOR COMMUNICATIONS

A. Minimum outlet box size: 4-11/16" square by 2-1/8" deep minimum, unless otherwise noted on drawings.
   1. Total depth of the assembly including the trim ring shall not be less than 2-1/2".

2.12 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;

2.13 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.

2.14 TAP BOXES

A. Multi-tap connectors as indicated on drawings.
B. Manufacturers: Ilsco; Approved equal

2.15 EXPANSION FITTINGS

A. Malleable iron, hot dip galvanized allowing 4" (±2") raceway movement.
B. Manufacturers: OZ/Gedney AX Series; or equivalent by manufacturer listed in 2.1.F.

2.16 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.

2.17 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

2.18 CABLE SUPPORTS

A. Manufacturers: OZ/Gedney Type S; or equivalent by manufacturer listed in 2.1.F.

2.19 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.

2.20 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: Stainless steel. Include two for each sealing element.
   3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

PART 3 - EXECUTION

3.1 COORDINATION

A. Coordinate with Architect/Engineer size and location of required built-in openings in building structure, including those sleeved, formed or core drilled.
B. Coordinate with Architect/Engineer cutting, removing, or piercing general or mechanical insulation, fire-rated walls, ceilings or steelwork.
C. Verify with Architect/Engineer all surface raceway installations except in mechanical, electrical, 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.

3.2 EXAMINATION

A. Examine surfaces to receive raceways and boxes for compliance with installation tolerances and other conditions affecting performance of raceway’s installation. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.3 INSTALLATION

A. Raceways:
1. Comply with ANSI/NECA 1 and NFPA 70 for installation requirements applicable to products specified in Part 2 except where requirements on drawings or in this Section are stricter.
2. Arrange raceways to maintain headroom and present neat appearance.
3. Raceway routing is shown in approximate locations, unless dimensioned. Route to complete raceway installation before starting conductor installation.
4. Keep raceways at least 12” away from parallel runs of fuels, 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.
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 subject to vibration, noise transmission, or movement; and for transformers and motors.
    a. Use LFMC in damp or wet locations subject to severe physical damage.
    b. 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: [3/4"] [1"] [1-1/4"], 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. Install insulated bushings on end of each raceway.
    d. Use UL listed metallic grounding clamps, when terminating raceway on cable tray.
    e. Install flush two-gang box with trim ring for each communications outlet or as noted on drawings.
    f. 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.
    g. 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.
    h. 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.
    i. Do not install 90-degree condulets. Install continuous radius sweeps of 45° minimum for 90-degree bends.
    j. Do not install continuous sections longer than 100 ft.
    k. Install nylon pull cord in empty raceways. Leave at least 12" of slack at each end of pull wire. Cap raceways at both ends.
24. Optical fiber Communications Cable Raceway (Innerduct):
    a. Minimum innerduct size: 1", unless otherwise noted on drawings.
    b. Extend innerduct to termination and/or storage enclosure.
    c. Install couplings designed for innerduct size and type where innerduct enters termination and/or storage enclosure.
    d. Splice innerduct segments using couplings designed for that purpose, where not installed in a continuous length.
    e. Install 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.
    f. Label innerduct at 10' foot intervals with tags indicating cable types and quantities contained therein.

B. Wireways and Wall Ducts:
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. Indoor Service Poles:
1. Install wiring devices and communications outlets of type, quantity and spacing as indicated on drawings.
2. Maintain ground continuity throughout entire pole length per requirements in Section 26 0526 – Grounding and Bonding for Electrical Systems.
3. 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's 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.
4. Identify communication outlets per requirements in Section 27 0553 – Communications Systems Identification.
5. Neatly cut openings in ceiling panels. Install trim plate.

D. 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.
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 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.

E. 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.

F. 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.

G. Floor Boxes:
1. Set metal floor boxes level and flush with finished floor surface.
2. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.
3. Use cast floor boxes for installations in slab on grade.
4. Install floor boxes and fittings to preserve fire-resistant rating of slabs and other elements, using materials and methods specified in Section 26 0593 – Electrical Systems Firestopping.
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.

H. 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.

I. Raceway Penetration Seals:
1. Seal space outside of sleeves with grout for penetrations of concrete and masonry.
2. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint. Refer to Division 07 Section “Maintenance of Joint Protection” for materials and installation.
3. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials. Comply with Section 26 0593 – Electrical Systems Firestopping.
4. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.
5. Aboveground, Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1” annual clear space between pipe and sleeve for installing mechanical sleeve seals.
6. Underground, Exterior-Wall Penetrations: Install cast-iron “wall pipes” for sleeves. Size sleeves to allow for 1” annual clear space between raceway and sleeve for installing mechanical sleeve seals.
7. Sleeve-Seal Installation: Use type and number of sealing elements recommended by manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
8. Provide chrome- or nickel-plated escutcheons where raceways pass through walls, floors or ceilings and are exposed in finished areas. Size escutcheons to fit raceways for finished appearance. Finished areas shall not include mechanical/electrical rooms, janitor’s closets, storage rooms, etc., unless suspended ceilings are specified.
9. Remove temporary sleeves, if used for form wall openings, prior to installation of permanent materials.

J. 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.

K. Raceway and Outlet Boxes Sealing in Bio-sensitive Areas:
1. Where outlet boxes and raceways are recessed mounted, seal box to adjacent wall, ceiling, or floor surface with silicone caulk.
2. Where outlet boxes and raceways are surface mounted:
   a. Seal box to adjacent wall, ceiling, or floor surface with continuous bead of silicone caulk.
   b. Seal both sides of surface-mounted raceway to adjacent surfaces with silicone caulk. Where raceways are threaded rigid steel on minimum 3/4” standoffs, sealing of raceway sides is not required.
3. Install gasketed device cover plates with additional continuous bead of silicone caulk between device plate and adjacent wall, ceiling, or floor surface.
4. After wiring is installed, surround wiring with 1” barrier of silicone caulk around conductors within device box hub.
5. Silicone Caulk: Resistant to microbiological growth.
6. No escutcheons are allowed where raceways pass through walls, floors or ceilings and are exposed in finished areas. Cut and patch holes to within 1/4” of raceway and seal opening with sprayable vinyl, flexible PVC coating equal to Cocoon material.

L. Sleeve Installation for Electrical Penetrations:
1. Coordinate sleeve selection and application with selection and application of firestopping specified in Section 26 0593 – Electrical Systems Firestopping.
2. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
3. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
4. Rectangular Sleeve Minimum Metal Thickness:
   a. For sleeve cross-section rectangle perimeter less than 50” and no side greater than 16”, thickness shall be 0.052”.
   b. For sleeve cross-section rectangle perimeter equal to, or greater than, 50” and 1 or more sides equal to, or greater than, 16”, thickness shall be 0.138”.
5. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies, unless openings compatible with firestop system used are fabricated during construction of floor or wall.
6. Cut sleeves to length for mounting flush with both surfaces of walls.
7. Extend sleeves installed in floors 2” above finished floor level.
8. Size pipe sleeves to provide 1/4” annular clear space between sleeve and raceway, unless sleeve seal is to be installed.

3.4 CONCRETE DUCT INSTALLATION

A. Support ducts on duct spacers.
1. Spacer Installation:
   a. Provide spacers close enough to prevent sagging and deforming of ducts, with not less than 4 spacers per 20 ft of duct. Secure spacers to earth and to ducts to prevent floating during concreting. Stagger spacers approximately 6” between tiers. Tie entire assembly together using tie wires and reinforcing steel. Install base and intermediate spacers at every coupling point of each duct line for a separation horizontally and vertically per NEC.
2. Pouring Concrete: Space concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct bank application.
3. Forms: Use forms of materials and in a manner acceptable to Architect.

4. Minimum Space between Ducts: 3”
5. Concrete: 3000 psi, 28-day strength

3.5 APPLICATION

A. Raceway uses permitted and not permitted per NFPA 70 requirements and as described below.
B. Rigid Metal Conduit (RMC) permitted to be installed as follows:
   1. Installations below grade and or under concrete slabs
   2. All locations except corrosive atmospheres
   3. Hazardous locations
   4. Locations requiring mechanical protection
C. Intermediate Metallic Conduit (IMC) permitted to be installed as follows:
   1. Installation below grade and in or under concrete slabs
   2. All locations, except corrosive atmospheres
   3. Hazardous locations
   4. Locations requiring mechanical protection
D. PVC Coated Conduit permitted to be installed as follows:
   1. In corrosive atmospheres
   2. In exterior environments needing additional protection
   3. Use PVC coated elbows
E. Electrical Metallic Tubing (EMT) permitted to be installed as follows:
   1. Interior partitions
   2. Above suspended ceilings
   3. 1.8 m (6 ft) AFF in exposed areas of mechanical equipment rooms
   4. Sizes 2” and smaller except as approved
F. Flexible Metal Conduit (FMC) permitted to be installed as follows:
   1. Use flexible metal conduit not over 4 ft in length for final connections for:
      a. Vibrating equipment (including transformers and hydraulic, pneumatic, electric solenoid, or motor-driven equipment) in dry locations.
      b. Final connections to recessed luminaires in lengths not to exceed 6 ft.
      c. FMC shall only be used above accessible ceilings.
G. Liquid Tight Flexible Metal Conduit (LFMC) permitted to be installed as follows:
   1. Use liquid tight flexible conduit, not over 4 ft in length, for final connections to:
      a. Vibrating equipment (including transformers and hydraulic, pneumatic, electric solenoid, or motor-driven equipment) in wet locations.
      b. Instruments and control devices
H. Rigid Nonmetallic Conduit (RNC) permitted to be installed as follows:
   1. Direct burial, concrete encased
   2. Direct burial, in sand fill on bottom and top
   3. Corrosive atmospheres
I. Stainless Steel Conduit
J. Optical Fiber/Communication Cable Raceway (Innerduct) permitted to be installed as follows:
   1. To segment conduits, thereby increasing their capacity
   2. As protection to backbone fiber optic cables installed in cable tray or cable support hooks
   3. As protection to fiber optic cable(s) within telecommunications equipment room
   4. As identified on drawings
K. One-half inch raceway permitted:
   1. Between controller and its control or pilot device
   2. Between lighting switch and nearest outlet for luminaire
   3. Control wiring where mounted on equipment where conduit must follow contour of equipment
   4. Protective and signal systems where noted
   5. Where shown on plans

3.6 RACEWAY WIRING METHODS

A. In Concrete: Install thickwall nonmetallic conduit or PVC coated rigid steel conduit; cast or nonmetallic boxes.
B. Outdoor Locations, Above Grade: Install rigid (steel) conduit or intermediate metal conduit install cast metal or nonmetallic outlet, pull, and junction boxes.
C. In Slab Above Grade: Not acceptable
D. Wet and Damp Locations: Install rigid metal conduit or intermediate metal conduit; install cast metal or nonmetallic outlet, junction, and pull boxes. Install flush mounting outlet boxes in finished areas.
E. Concealed Dry Locations: Install electrical metallic tubing install sheet metal boxes; install flush mounting outlet boxes in finished areas; install hinged enclosure for large pull boxes.

F. Exposed Dry Locations: Install rigid metal conduit or intermediate metal conduit; install sheet metal or cast boxes; install flush mounting outlet boxes in finished areas; install hinged enclosure for large pull boxes.
G. Exposed Subject to Damage: Install rigid steel conduit or intermediate metal conduit.

3.7 FIELD QUALITY CONTROL

A. Inspect raceway, boxes, indoor service poles, and wireways for physical damage, proper alignment, supports and seismic restraints, where applicable.
B. Replace any damaged component of the raceway system, or install new raceway system.
C. Inspect components, wiring, connections and grounding.

3.8 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.

3.9 ADJUSTING

A. Adjust flush-mounted boxes pre-pour and after-pour to be flush with finished materials.
B. Install knockout closures in unused openings in boxes.
C. Align adjacent wall-mounted outlet boxes for switches and similar devices.
D. Adjust outlet boxes to allow luminaires to be positioned as indicated on drawings.

3.10 CLEANING

A. Clean interior and exterior of boxes, wireways, and indoor poles to remove dust, debris and other material.

END OF SECTION

SECTION 26 05 33
ELECTRICAL SYSTEMS IDENTIFICATION

PART 1 – GENERAL
1.1 RELATED WORK
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PART 2 – PRODUCTS
2.1 RACEWAY AND METAL CLAD CABLE IDENTIFICATION MATERIALS
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PART 1 - GENERAL

1.1 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 1216 – Dry-Type, Medium-Voltage Transformers
G. Section 26 2200 – Low-Voltage Transformers
H. Section 26 2413 – Switchboards
I. Section 26 2416.13 – Lighting and Appliance Panelboards
J. Section 26 2416.16 – Distribution Panelboards
K. Section 26 2726 – Wiring Devices
L. Section 26 2816 – Enclosed Switches and Circuit Breakers
M. Section 26 2913 – Enclosed Controllers
N. Section 26 3213 – Engine Generators
O. Section 26 3623 – Automatic Transfer Switches
P. Section 26 4300 – Surge Protective Devices
Q. Section 28 3113 – Detection and Alarm Systems
R. Section 28 3116 – Multiplexed Fire Detection and Alarm Systems

1.2 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.

1.3 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

1.4 SUBMITTALS

A. Product Data: For each electrical identification product indicated.
B. Nameplate Schedule: Prior to making nameplates, submit a complete schedule to Architect for approval indicating nameplate size, lettering size, color and actual nameplate information.
C. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

1.5 QUALITY ASSURANCE

A. Comply with ANSI A13.1 and ANSI C2.
B. Comply with NFPA 70.
C. Comply with 29 CFR 1910.145.

1.6 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout project.
B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
C. Coordinate installation of identifying devices with location of access panels and doors.
D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 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.

2.2 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, 0.015" 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.

2.3 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 installations.

2.4 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/cm2
      e. Personnel protective equipment (PPE) class
      f. Voltage shock hazard
      g. Limited shock approach boundary
      h. Restricted shock approach boundary
      i. Prohibited shock approach boundary

2.5 INSTRUCTION SIGNS AND POSTED DRAWINGS

A. Instruction Signs: Engraved, laminated acrylic or melamine plastic, minimum 1/16" thick for signs up to 20 sq 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.

2.6 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".

2.7 WIRING DEVICES IDENTIFICATION

A. Refer to Section 26 2726 – Wiring Devices for requirements.

2.8 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, type 6/6 nylon cable ties.
   1. Minimum Width: 3/16"
   2. Tensile Strength: 50 lb minimum
   3. Temperature Range: -40°F to 185°F
   4. Color: Black, except where used for color-coding

B. Paint: Paint materials and application requirements are specified in Division 09 – Finishes painting Sections.

C. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - <u>EXECUTION</u>

3.1 APPLICATION

A. 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 or snap-around 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.

B. Accessible Raceways and Cables of Auxiliary Electrical Systems: Identify the following systems with color-coded, [elf-adhesive vinyl tape applied in bands or snap-around, color-coding bands:
   1. Fire Alarm System (including covers of pull and junction boxes): Red
   2. Fire-Suppression Supervisory and Control System: Red and yellow
   3. Combined Fire Alarm and Security System: Red and blue
   4. Security System: Blue and yellow
   5. Mechanical and Electrical Supervisory System: Green and blue
   6. Telecommunication System: Green and yellow

C. Power-Circuit Conductor Identification: For primary and secondary conductors No. 1/0 AWG and larger in vaults, pull and junction boxes, manholes, and handholes use color-coding conductor tape and write-on tags. Identify source and circuit number of each set of conductors or other appropriate number or letter to expedite future tracing and troubleshooting. For single conductor cables, identify phase in addition to the above. Phase identification shall be consistent throughout the system.

D. Branch-Circuit Conductor Identification: Where there are conductors for more than three branch circuits in same junction or pull box, use color-coding conductor tape. Identify each ungrounded conductor according to source and circuit number.

E. Conductors to Be Extended in the Future and Spare Conductors: Attach write-on tags to conductors and list source and circuit number.

F. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.
   1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
   2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
   3. Coordinate identification with project drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.

G. 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.

H. 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.

I. Emergency Electrical System Junction and Pull Boxes:
1. Identify with spray-painted covers as follows:
a. 480/277 V circuits: Red/Brown
b. 120/208 V circuits: Red/White

J. Equipment Identification Nameplates: On each unit of equipment, install unique designation nameplate that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply nameplates to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
1. Nameplate Instructions:
a. Indoor Equipment: Engraved, laminated acrylic or melamine nameplate. Unless otherwise indicated, provide a single line of text with 1/2" high letters (1/4" where space is limited) on 1-1/2" high nameplate; where 2 lines of text are required, use nameplates sized 2" high.
b. 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 switchboards, and 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. Voice and data cable terminal equipment
o. Fire alarm control panel and annunciators
p. Security and intrusion-detection control stations, control panels, terminal cabinets, and racks
q. Monitoring and control equipment
r. Terminals, racks, and patch panels for voice and data communication and for signal and control functions
s. 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”

K. For service entrance equipment, provide a nameplate identifying the maximum available fault current and “as of” effective date.
1. Example: “MAXIMUM AVAILABLE FAULT CURRENT 33,500A AS OF 2017/06/15.”

L. Access Panel Identification: Furnish typewritten charts with identification and location of access panels serving equipment and incorporate in O&M Manuals.

3.2 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Install non-adhesive signs and plastic nameplates parallel to equipment lines; attach with screws and auxiliary hardware appropriate to the location and substrate. Secure to inside surface of door or panelboard that is recessed in finished locations.

F. Posted Drawings and Operating Instructions: Mount drawings and operating procedures on the wall immediately adjacent to the piece of equipment for which the instructions apply. If sufficient wall space is available, mount directly to one of the sheet metal panels of the equipment.

G. Warning Signs: Install warning signs where there is hazardous exposure or danger associated with access to or operation of electrical facilities. Provide text of sufficient clarity and lettering of sufficient size to convey adequate information at each location; mount permanently in an appropriate and effective location. Comply with ANSI A13.1 standard color and design.
1. Operational Tags: Where needed for proper and adequate information on operation and maintenance of electrical systems, provide tags of plasticized card stock, either preprinted or hand printed to convey the message; example: “DO NOT OPEN THIS SWITCH WHEN BREAKER IS CLOSED.”

H. System Identification Color Banding for Raceways and Cables: Each color band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50 ft maximum intervals in straight runs, and at 25 ft maximum intervals in congested areas.

I. Color-Coding for Phase 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
e. Equipment Ground: Green
3. Colors for 480/277 V Circuits:
a. Phase A (left bus in panelboard): Brown
b. Phase B (center bus in panelboard): Orange
c. Phase C (right bus in panelboard): Yellow
d. Neutral: Gray
e. Equipment Ground: Green
4. Field-applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6” from terminal points and in boxes where splices or taps are made. Apply last two runs of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

J. Aluminum Wraparound Marker Nameplates and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

K. Painted Identification: Prepare surface and apply paint according to Division 09 – Finishes painting Sections.

END OF SECTION

SECTION 26 05 73
POWER SYSTEM STUDIES

PART 1 – GENERAL
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PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 0553 – Electrical Systems Identification
B. Section 26 0812 – Power Distribution Acceptance Tests
C. Section 26 0813 – Power Distribution Acceptance Test Tables
D. Section 26 2200 – Low-Voltage Transformers
E. Section 26 2413 – Switchboards
F. Section 26 2416.13 – Lighting and Appliance Panelboards
G. Section 26 2416.16 – Distribution Panelboards
H. Section 26 2813 – Fuses
I. Section 26 2816 – Enclosed Switches and Circuit Breakers
J. Section 26 2913 – Enclosed Controllers
K. Section 26 3623 – Automatic Transfer Switches

1.2 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.
D. Provide studies and reports prior to manufacture of the electrical distribution equipment. Electrical contractor is responsible for cost and schedule impacts for replacement of equipment and devices for equipment manufactured prior to approval of power system studies.
E. Equipment submittals for any portion of the electrical distribution system will not be approved until the coordination study is complete and the equipment submittals indicate compliance with the study recommendations, including selective coordination of all equipment connected to and downstream of three paralleled generators down to 0.01 seconds.

1.3 REFERENCE STANDARDS

A. ANSI C57.12.10 – American National Standard for Transformers-230 kV and Below 833/958-8333/10 417 kVA, Single-Phase, and 750/862-60 000/80 000/100 000 kVA, Three-Phase, w/o Load Tap Changing; and 3750/4687-60 000/80 000 kVA with Load Tap Changing-Safety Requirements
B. ANSI C57.12.22 – American National Standard for Transformers-Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers with High-Voltage Bushings, 2500 kVA & Smaller: High-Voltage, 34 500 GrdY/19 920 V & Below; Low Voltage, 480 V & Below-Requirements

C. ANSI C57.12.40 – American National Standard for Secondary Network Transformers-Subway and Vault Types (Liquid Immersed)-Requirements
D. ANSI C57.12.90 – General Requirements for Liquid-Immersed Distribution Power and Regulating Transformers
E. ANSI C57.96 – Distribution and Power Transformers, Guide for Loading Dry-Type (Appendix to ANSI C57.12 Standards)
F. IEEE 141 – Recommended Practice for Electric Power Distribution for Industrial Plants
G. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings
H. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
I. IEEE 399 – Recommended Practice for Power System Analysis
J. IEEE 620 – Guide for the Presentation of Thermal Limit Curves for Squirrel Cage Induction Machines
K. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems
L. IEEE 1584 – Guide for Performing Arc-Flash Hazard Calculations
M. IEEE C37.010 – Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
N. IEEE C37.20.1 – IEEE Standard for Metal-Enclosed, Low-Voltage Power Circuit Breaker Switchgear
O. IEEE 37.46 – American National Standard Specifications for Power Fuses and Fuse-Disconnecting Switches
P. IEEE C57.12 – General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers
Q. IEEE C57.96 – IEEE Guide for Loading Dry-Type Distribution and Power Transformers
R. ICEA P-32-382 – Short-Circuit Characteristics of Insulated Cable
S. ICEA P-45-482 – Short-Circuit Performance of Metallic Shielding and Sheaths of Insulated Cable
T. NEMA MG 1 – Motors and Generators
U. NFPA 70 – National Electrical Code (NEC)
V. NFPA 70B – Recommended Practice for Electrical Equipment Maintenance
W. NFPA 70C – Hazardous Locations Classification
X. NFPA 70E – Standard for Electrical Safety in Workplace

1.4 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:
   1. Electrical one-line drawing drafted in computer software program with component names.
      a. Drawing maximum 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

1.5 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.

C. Perform study under the direct supervision and control of a Registered Professional Electrical Engineer licensed in the State of Wisconsin with a minimum of 5 yrs recent experience in performing protective device coordination studies, arc flash calculations, and electrical system analysis.

D. Comply with IEEE 242 for short circuit currents and coordination time intervals.

E. Comply with IEEE 399 for general study procedures.

F. Comply with IEEE 1584 for arc flash calculations.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Computer Software Developers: Subject to compliance with requirements, provide products by one of the following:

B. Basis of Design Product:

1. CYME International, Inc.
2. ESDA Micro Corporation
3. SKM Systems Analysis, Inc.
4. ETAP

2.2 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

A. Comply with IEEE 399 and IEEE 1584.

B. Analytical features of fault current study computer software program shall include “mandatory,” “very desirable,” and “desirable” features as listed in IEEE 399 Table 7-4.

C. Computer software program shall be capable of plotting and diagramming time-current characteristic curves as part of its output. Computer software program reports device settings and ratings of all overcurrent protective devices and demonstrates selective coordination by computer-generated, time-current coordination plots.

D. Arc Flash Calculations: Software program capable of calculating Arc Flash Incident Energy (AFIE) levels and flash protection boundary distances.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices for coordination are indicated on drawings.

B. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

C. Provide the study based on the actual electrical equipment supplied for the project.

3.2 POWER SYSTEM DATA

A. Gather and tabulate the following input data to support coordination study:

1. Product Data for overcurrent protective devices specified in other Division 26 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with power riser diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Impedance of utility service entrance(s).
3. Power Riser Diagrams: In hard copy and electronic copy formats, showing the following:
   a. Circuit breaker and fuse-current ratings and types
   b. Relays and associated power and current transformer ratings and ratios

c. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios
d. Generator kilovolt amperes, size, voltage, and source impedance
e. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length
1) Prior to equipment purchase, utilize conservative lengths (up/down included) based on planned conduit routing to validate equipment ratings. Final study to utilize contractor provided as-built lengths to confirm equipment ratings.
f. Busway ampacity and impedance
g. Motor horsepower and code letter designation according to NEMA MG 1
h. Load current that is the basis for sizing continuous ratings of circuits for cables and equipment

4. Data sheets to supplement power riser diagrams, cross-referenced with tag numbers on diagrams, showing the following:
a. Special load considerations, including starting inrush currents and frequent starting and stopping
b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability
c. Motor full-load current, locked-rotor current, service factor, starting time, type of start, and thermal-damage curve
d. Generator thermal-damage curve
e. Ratings, types, and settings of utility company's overcurrent protective devices
f. Special overcurrent protective device settings or types stipulated by utility company
g. Time-current characteristic curves of devices indicated to be coordinated
h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers
i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays
j. Panelboards, switchboards, automatic transfer switch ampacity, and interrupting rating in amperes rms symmetrical
1) Automatic transfer switch withstand rating to comply with UL 1008. Equivalent trip curves are not accepted for specific breaker rated equipment – exact breaker and associated trip unit must be listed on UL certification.

3.3 FAULT CURRENT STUDY

A. Calculate maximum available short circuit current in amperes rms symmetrical at circuit breaker positions of electrical power distribution system. Provide calculation for a current immediately after initiation and for a three-phase bolted short circuit at the following:
1. Switchboard bus
2. Distribution panelboard
3. Branch circuit panelboard
4. Disconnect switch
5. Enclosed circuit breaker
6. Automatic transfer switch
7. Variable Frequency Drive (VFD)
8. Enclosed controllers

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 141, 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. Medium-Voltage Circuit Breakers: IEEE C37.010
   3. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.20.1
   4. 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.

3.4 COORDINATION STUDY

A. Perform coordination study using approved computer software program. Prepare a written report using results of fault current study. Comply with IEEE 399.
   1. Calculate maximum and minimum 1/2-cycle short circuit currents.
   2. Calculate maximum and minimum interrupting duty (5 cycles to 2 seconds) short circuit currents.
   3. Calculate maximum and minimum ground-fault currents.

B. Comply with NFPA 70 for overcurrent protection of circuit elements and devices.

C. Comply with IEEE 141, IEEE 241, 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 down to 0.01 seconds. Change specific circuit breakers (type, frame, trip-unit, etc.) and equipment bus rating as necessary to meet this requirement.

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
      i. Medium-voltage equipment relays
   4. 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.

3.5 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/cm2

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.

3.6 FIELD QUALITY CONTROL

A. Inspect, set, test, and calibrate the protective relays, circuit breakers, fuses, and other applicable devices per requirements in Section 26 0812 – Power Distribution Acceptance Tests and Section 26 0813 – Power Distribution Acceptance Test Tables.

B. Upon final approval of study, provide weatherproof vinyl or polyester arc flash label for all electrical equipment defined above. Label shall include calculated flash protection boundary, incident energy in cal/cm2 at working distance (mm working distance based on equipment class, per IEEE 1584), required PPE level, limited approach, restricted approach, equipment name, company name/logo who performed the study, available fault current, and date label was produced.
    1. Label to comply with ANSI Z535. Use “WARNING” (ANSI safety orange background with an orange exclamation point safety symbol) for all arc flash levels.
    2. Per NFPA 70E 130.5(C), due to use of incident energy analysis method, PPE categories shall not be provided on labels unless site specific standard PPE categories differ from incident energy levels noted in NFPA 70E Table 130.7(C)(16).
    3. Include verbiage on label noting study should be re-examined once every (5) years or upon modifications to electrical system.

3.7 ADJUSTING

A. Make modifications to equipment, as required, to accomplish conformance with equipment evaluation study.

B. Adjust relay and overcurrent protective device settings according to recommended settings table provided by overcurrent protective device coordination study.

C. Notify Owner/Engineer in writing of any required major modifications.

3.8 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

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SECTION 26 05 93
ELECTRICAL SYSTEMS FIRESTOPPING

PART 1 – GENERAL
1.1 RELATED WORK
1.2 DESCRIPTION
1.3 REFERENCE STANDARDS
1.4 PERFORMANCE REQUIREMENTS
1.5 SUBMITTALS
1.6 QUALITY ASSURANCE
1.7 DELIVERY, STORAGE, AND HANDLING
1.8 PROJECT CONDITIONS
1.9 COORDINATION
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PART 2 – PRODUCTS
2.1 MANUFACTURERS
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PART 3 – EXECUTION
3.1 EXAMINATION
3.2 PREPARATION
3.3 INSTALLATION
3.4 IDENTIFICATION
3.5 FIELD QUALITY CONTROL
3.6 CLEANING

PART 1 - GENERAL

1.1 RELATED WORK
A. Section 07 8413 – Penetration Firestopping
B. Section 26 0533 – Raceways and Boxes for Electrical Systems

1.2 DESCRIPTION
A. Section includes through-penetration firestop systems for penetrations through fire-resistance-rated constructions (walls, partitions, floors, and ceilings) including both empty openings and openings containing electrical penetrating items, including but not limited to raceways, cables, cable trays, busways, and wireways.

1.3 REFERENCE STANDARDS
A. ASTM E-814 – Standard Test Method for Fire Tests of Through-Penetration Firestops
B. UL 1479 - Fire Tests of Through-Penetration Firestops
C. UL 2079 - Tests For Fire Resistance of Building Joint Systems

1.4 PERFORMANCE REQUIREMENTS
A. Provide firestop system to resist spread of fire, resist passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated.
B. Firestop systems shall be UL Classified for the application and correspond to those indicated by reference to designations listed by UL Fire Resistance Directory.
C. Conform to applicable Code requirements of Authority Having Jurisdiction.
D. For through-penetration firestop systems exposed to view, traffic, moisture, and physical damage, provide products that, after curing, do not deteriorate when exposed to these conditions.

1.5 SUBMITTALS
A. Product Data: For each type of product indicated.

B. Shop Drawings: For each through-penetration firestop system, show each type of construction condition penetrated, relationships to adjoining construction, and type of penetrating item. Include firestop design designation of qualified testing and inspecting agency that evidences compliance with requirements for each condition indicated.
   1. Submit documentation, including illustrations, from a qualified testing and inspecting agency that is applicable to each through-penetration firestop system configuration for construction and penetration items, including documentation of UL certification for firestop systems.

C. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

D. Material Safety Data Sheets provided with product delivered to job site.

E. Certification of compliance with Building Codes of the State of Project location.

F. Inspection reports

1.6 QUALITY ASSURANCE

A. Installer Qualifications: A firm experienced in installing through-penetration firestop systems similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful performance.

B. Firestopping tests shall be performed by a qualified testing and inspecting agency, or another agency performing testing and follow-up inspection services for firestop systems acceptable to Authorities Having Jurisdiction.

C. Manufacturer's representative shall be on-site during initial installation of firestop systems to train appropriate Contractor personnel in proper selection and installation procedures.

1.7 DELIVERY, STORAGE AND HANDLING

A. Deliver through-penetration firestop system products to Project site in original, unopened containers or packages with intact and legible manufacturers' labels identifying product, type and manufacturer, and UL Label where applicable.

B. Store and handle materials for through-penetration firestop systems to prevent their deterioration or damage due to moisture, temperature changes, contaminants, or other causes.

C. Handle in accordance with recommended procedures, precautions, or remedies described in material safety data sheets as applicable.

1.8 PROJECT CONDITIONS

A. Do not install through-penetration firestop systems when ambient or substrate temperatures are outside limits permitted by through-penetration firestop systems' manufacturers or when substrates are wet due to rain, frost, condensation, or other causes.

B. Ventilate through-penetration firestop systems per manufacturers' written instructions by natural means or, where this is inadequate, forced-air circulation.

1.9 COORDINATION

A. Coordinate construction of openings and penetrating items to ensure that through-penetration firestop systems are installed according to specified requirements.

B. Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate through-penetration firestop systems.

C. Notify Owner's inspecting agency at least 7 days in advance of through-penetration firestop system installations; confirm dates and times on days preceding each series of installations.

D. Do not cover up through-penetration firestop system installations that will become concealed behind other construction until each installation has been examined by building inspector, if required by Authorities Having Jurisdiction.

1.10 SEQUENCING

A. Sequence work to avoid interferences with building finishes and installation of other products.

1.11 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. 3M (Fire Protection Products Division), Hilti Inc, Tremco (Sealant/Weatherproofing Division), Nelson Firestop Products, Specified Technologies Inc, RectorSeal Corporation

2.2 MATERIALS

A. Firestop Products: UL 1479, ASTM E-814 tested for specific fire-rated construction conditions conforming to construction assembly type, penetrating item type, annular space requirements and fire-rating involved for each separate instance; materials shall not contain flammable solvents.

B. Firestop Systems: Produced by the same manufacturer.

C. Accessories: Components for each through-penetration firestop system that are needed to install fill materials and to comply with Part 1 “Performance Requirements” Article. Accessories include the following items:

1. Permanent forming/damming/backing materials
2. Temporary forming materials
3. Substrate primers
4. Collars
5. Steel sleeves

D. Fill Materials: Including the following:

1. Firestop putty, caulk sealant, intumescent wrap strips, intumescent firestop collars, firestop mortars, pillows/bags, or a combination of these products to provide a UL-listed system for each application required for this Project; mineral wool backing where specified in manufacturer’s application detail.

E. Mixing

1. For those products requiring mixing before application, comply with through-penetration firestop system manufacturer’s written instructions for accurate proportioning of materials, water (if required), type of mixing equipment, selection of mixer speeds, mixing containers, mixing time, and other items or procedures needed to produce products of uniform quality with optimum performance characteristics for application indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for opening configurations, penetrating items and other conditions affecting performance of firestopping.

B. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Clean out openings immediately prior to installing through-penetration firestop system to comply with firestop system manufacturer’s written instructions.

B. Provide masking and temporary covering to prevent soiling of adjacent surfaces by firestopping materials.

C. Comply with manufacturer’s recommendations for temperature and humidity conditions before, during and after installation of firestopping.

3.3 INSTALLATION

A. Comply with “System Performance Requirements” Article in Part 1 and with firestop system manufacturer’s written installation instructions and drawings for products and applications indicated.

B. Install forming/damming/backing materials and other accessories of types required to support fill materials during application as required. After installing fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not indicated as permanent components of firestop systems.

C. Avoid multiple penetrations of common fire barrier opening. Seal each penetration in accordance with manufacturer’s UL installation details. When multiple penetrations are unavoidable, seal openings with appropriate UL Classified firestopping systems.

D. Provide fire stopping for all openings in rated room walls and rated floors including cores, sleeves and structural openings.

3.4 IDENTIFICATION

A. Identify through-penetration firestop systems with pressure-sensitive, self-adhesive, preprinted vinyl labels. Attach labels permanently to surfaces of penetrated construction on both sides of each firestop system installation where labels will be visible to anyone seeking to remove penetrating items or firestop systems. Include the following information on labels:
   1. The words: “Warning—Through-Penetration Firestop System—Do Not Disturb. Notify Building Management of Any Damage.”
   2. Contractor’s name, address, and phone number
   3. Through-penetration firestop system designation of applicable testing and inspecting agency
   4. Date of installation
   5. Through-penetration firestop system manufacturer’s name
   6. Installer’s name

3.5 FIELD QUALITY CONTROL

A. Inspecting Agency: Owner will engage a qualified independent inspecting agency to inspect through-penetration firestop systems and to prepare test reports.

B. Inspecting agency will state in each report whether inspected through-penetration firestop systems comply with or deviate from requirements.

C. Provide certification by Installer that all through-penetration firestop systems have been firestopped in accordance with applicable Building Codes of the State of Project location.

D. Proceed with enclosing through-penetration firestop systems with other construction only after inspection reports are issued and firestop installations comply with requirements.

E. Where deficiencies are found, repair or replace through-penetration firestop systems so they comply with specifications.

3.6 CLEANING

A. Clean surfaces adjacent to sealed holes and joints to be free of excess firestop materials and soiling as work progresses.

END OF SECTION

SECTION 26 08 12
POWER DISTRIBUTION ACCEPTANCE TESTS

PART 1 – GENERAL
1.1 RELATED WORK
1.2 DESCRIPTION
1.3 REFERENCE STANDARDS
1.4 SUBMITTALS
1.5 QUALITY ASSURANCE
PART 2 – PRODUCTS (NOT APPLICABLE TO THIS SECTION)
PART 3 – EXECUTION
3.1 PREPARATION
3.2 FIELD QUALITY CONTROL

PART 1 - GENERAL

1.1 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 0573 – Power System Studies
D. Section 26 0813 – Power Distribution Acceptance Test Tables
E. Section 26 2200 – Low-Voltage Transformers
F. Section 26 2413 – Switchboards
G. Section 26 2500 – Enclosed Bus Assemblies
H. Section 26 2816 – Enclosed Switches and Circuit Breakers
I. Section 26 2913 – Enclosed Controllers
J. Section 26 3213 – Engine Generators
K. Section 26 3623 – Automatic Transfer Switches

1.2 DESCRIPTION

A. Section includes acceptance testing requirements for assessing the suitability for service and reliability of the power distribution system.
B. Contractor to ensure all tested electrical equipment, both contractor and Owner supplied, is operational and within industry and manufacturer's tolerances and is installed in accordance with design specifications.
C. Tests and inspections shall be performed after installation.
D. Tests and inspections shall determine suitability for energization.
E. Electrical systems shall pass tests prior to substantial completion or Owner occupancy.
F. This specification requires contractor to engage services of testing agency.
G. All tests tables referenced in this specification provided in Section 26 0813 – Power Distribution Acceptance Test Tables.
H. Items to be tested and inspected as follows:
   1. 600-volt conductors and cables
   2. Engine generator
   3. Dry type transformers (small)
   4. Switchboard
   5. Low-voltage insulated-case/molded-case circuit breakers
   6. Low-voltage disconnect switches
   7. Automatic transfer switches
   8. Grounding systems
   9. Instrument transformers
   10. Thermographic survey

1.3 REFERENCE STANDARDS

A. ANSI/IEEE C2 – National Electrical Safety Code
B. ANSI/IEEE C37 – Guides and Standards for Circuit Breakers, Switchgear, Relays, Substations, and Fuses
C. ANSI/IEEE C37.04 – Standard Rating Structure for AC High Voltage Circuit Breaker
D. ANSI/IEEE C57 – Distribution, Power, and Regulating Transformers
E. ANSI/IEEE C57.13.1 – Guide for Field Testing of Relaying Current Transformers
F. ANSI/IEEE C57.13.3 – Grounding of Instrument Transformer Secondary Circuits and Gases

G. ANSI/IEEE C57.104 – Guide for the Interpretation of Gases Generated in Oil-immersed Transformers
H. ANSI/IEEE C62 – Surge Protection
I. ANSI/IEEE Std. 43 – IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery
J. ANSI/IEEE Std. 48 – Standard Test Procedure and Requirements for High-Voltage Alternating-Current Cable Terminations
K. ANSI/IEEE Std. 81 – Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
L. ANSI/IEEE Std. 141 – IEEE Recommended Practice for Electrical/Power Distribution for Industrial Plants (IEEE Red Book)
M. ANSI/IEEE Std. 142 – IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems (IEEE Green Book)
N. ANSI/IEEE Std. 241 – IEEE Recommended Practice for Electrical Power Systems in Commercial Buildings (IEEE Gray Book)
O. ANSI/IEEE Std. 242 – IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (IEEE Buff Book)
P. ANSI/IEEE Std. 399 – IEEE Recommended Practice for Power Systems Analysis (IEEE Brown Book)
Q. ANSI/IEEE Std. 400 – Guide for Making High-Direct-Voltage Tests on Power Cable Systems in the Field
R. ANSI/IEEE Std. 446 – IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications (IEEE Orange Book)
S. ANSI/IEEE Std. 493 – IEEE Recommended Practice for the Design of Reliable Industrial and Commercial Power Systems (IEEE Gold Book)
T. ANSI/IEEE Std. 1100 – IEEE Recommended Practice for Powering and Grounding Sensitive Electronic Equipment (IEEE Emerald Book)
U. ASTM D877 – Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
V. ASTM D823 – Standard Practices for Sampling Electrical Insulating Liquids
W. ASTM D924 – Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids
X. ASTM D971 – Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Methods
Y. ASTM D974 – Standard Test Method for Acid and Base Number by Color-Indicator Titration
Z. ASTM D1298 – Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
AA. ASTM 1500 – Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)
BB. ASTM D1524 – Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field
CC. ASTM D1816 – Standard Test Method for Dielectric Breakdown Voltage of Insulating Oils of Petroleum Origin Using VDE Electrodes
DD. ASTM D2285 – Standard Test Method for Interfacial Tension of Electrical Insulating Oils of Petroleum Origin Against Water by the Drop-Weight Method
EE. ASTM D3612 – Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography
FF. ASTM D3613 – Standard Practice for Sampling Insulating Liquids for Gas Analysis and Determination of Water Content
GG. NETA – Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems
HH. NEMA AB 4 – Guidelines for Inspection and Preventive Maintenance of Molded-Case Circuit Breakers Used in Commercial and Industrial Applications
II. NEMA MG1 – Motors and Generators
JJ. NFPA 70 – National Electrical Code
KK. NFPA 70B – Recommended Practice for Electrical Equipment Maintenance
LL. NFPA 70E – Electrical Safety Requirements for Employee Workplaces
MM. NFPA 101 – Life Safety Code
NN. NFPA 110 – Emergency and Standby Power Systems
OO. NIST – National Institute of Standards and Technology
PP. OSHA – Part 1910 – Subpart S – 1910.308 – Special Systems

1.4 SUBMITTALS

A. Test Reports: Include the following:
   1. Summary of project
   2. Description of equipment tested
   3. Equipment used to conduct the test

4. Description of test
5. Test results, as compared to manufacturers' or industry accepted standards and tolerances
6. Conclusions and recommendations
7. Signature of responsible test organization authority

B. List of equipment used to perform tests. Identify the following:
1. Type
2. Manufacturer
3. Model number
4. Serial number
5. Date of last calibration
6. Documentation of calibration leading to NIST standards

1.5 QUALITY ASSURANCE

A. Qualifications of Testing Agency:
1. Testing firm shall be a corporately and financially independent testing organization that can function as an unbiased testing authority, professionally independent of the manufacturer, supplier, and installers of equipment or system evaluated by the testing firm.
2. Testing firm shall be regularly engaged in testing of electrical equipment, devices, installations and systems.
3. Testing firm shall meet Federal Occupational Safety and Health Administration (OSHA) requirements for accreditation of independent testing laboratories.
4. On-site technical person shall be currently certified by the International Electrical Testing Association in electrical power distribution system testing.
5. Testing firm shall use technicians who are regularly employed by the firm for testing services.
6. Testing firm shall submit proof of above qualifications with bid documents when requested.

PART 2 - PRODUCTS

2.1 NOT APPLICABLE TO THIS SECTION.

PART 3 - EXECUTION

3.1 PREPARATION

A. Documentation: Deliver the following to testing firm, minimum two weeks prior to commencement of testing:
1. Complete set of electrical plans and specifications, with available short circuit indicated on power riser diagrams.
2. Approved submittals and shop drawings of equipment being tested.
3. Pertinent change orders.
4. Evaluation, overcurrent protective device coordination and arc flash studies, per requirements in Section 26 0573 – Power System Studies.

B. Schedule: Notify Owner and Engineer 10 working days prior to performance of any tests.

C. Coordination: Coordinate with Construction Manager/Owner/Engineer the testing schedule and availability of equipment ready for testing.

D. Test Power: Provide test power (including specialized) for equipment testing before and after service energizing.

3.2 FIELD QUALITY CONTROL

A. Inspection and Test Procedures: Comply with NETA.
1. 600 V Conductors and Cables:
a. Visual and Mechanical Inspection:
1) Compare cable data with drawing and specifications.
2) Inspect exposed sections of cables for physical damage.
3) Verify tightness of accessible bolted electrical connections by calibrated torque wrench in accordance with manufacturer's published data or Table 12.
4) Perform thermographic survey of bolted electrical connections in accordance with paragraph "Thermographic Survey."
5) Inspect compression-applied connectors for correct cable match and indentation.

6) Verify visible cable bends meet or exceed ICEA and manufacturer's minimum allowable bending radius.
7) For cables are terminated through window-type current transformers, provide an inspection to verify neutral and ground conductors are correctly placed for operation of protective devices.
8) Inspect for correct identification and arrangements.
9) Inspect jacket and insulation condition.

b. Electrical Tests:
1) Perform insulation-resistance test using megohm meter. Applied potential to be 1000 VDC. Individually test each conductor with other conductors grounded. Test duration shall be one minute.
2) Perform continuity tests to insure correct cable connection.

c. Test Values:
1) Insulation-resistance values should not be less than 50 megohms.

2. Engine Generator:

a. Visual and Mechanical Inspection:
1) Compare equipment nameplate data with drawings and specifications.
2) Inspect physical and mechanical condition.
3) Inspect correct anchorage and grounding.
4) Inspect air baffles, filter media, and cooling fans.
5) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 12.
6) Confirm correct application of manufacturer's recommended lubricants.

b. Electrical and Mechanical Tests:
1) Perform insulation-resistance test on generator winding with respect to ground in accordance with ANSI/IEEE Standard 43. Calculate polarization index.
2) Test protective relay devices in accordance with paragraph "Protective Relays."
3) Perform phase-rotation test to determine compatibility with load requirements.
4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
5) Perform vibration baseline test. Plot amplitude versus frequency for each main bearing cap.
6) Conduct performance test in accordance with NFPA Standard 110, Section 7-13 (Installation Acceptance).
7) Verify correct functioning of governor and regulator.
8) Verify function and temperature regulation for battery and engine heaters.

c. Test Values:
1) Polarization index values shall be in accordance with ANSI/IEEE Standard 43.
2) Vibration levels shall be in accordance with manufacturer's published data.
3) Performance tests shall conform to manufacturer's published data and NFPA 110.
4) Vibration amplitudes shall not exceed values shown in Table 10.
5) Bolt-torque levels shall be in accordance with Table 12, unless otherwise specified by manufacturer.

3. Dry Type Transformers (Small):

a. Visual and Mechanical Inspection:
1) Compare equipment nameplate data with drawings and specifications.
2) Inspect physical and mechanical condition.
3) Inspect anchorage, alignment, and grounding.
4) Verify that resilient mounts are free and that any shipping brackets have been removed.
5) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 12.
6) Verify that as-lift tap connections are as specified.

b. Electrical Tests:
1) Perform insulation-resistance tests winding-to-winding and each winding-to-ground with test voltage in accordance with Table 5. Calculate dielectric absorption ratio or polarization index.

c. Test Values:
1) Bolt-torque levels should be in accordance with Table 12, unless otherwise specified by manufacturer.
2) Insulation-resistance test values at one minute should be in accordance with Table 5.

3) The dielectric absorption or polarization index shall be greater than 1.0 and shall be recorded for future reference.

4. Low-Voltage Switchboard Assemblies:
   a. Visual and Mechanical Inspection:
      1) Compare equipment nameplate data with drawings and specifications.
      2) Inspect physical and mechanical condition.
      3) Confirm correct application of manufacturer's recommended lubricants.
      4) Verify appropriate anchorage, required area clearances, grounding and correct alignment.
      5) Inspect doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.
      6) Verify fuse and/or circuit breaker sizes and types correspond to drawings and coordination study as well as to circuit breaker's address for microprocessor-communication packages.
      7) Verify that current and potential transformer ratios correspond to drawings.
      8) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench. Refer to manufacturer's published data or Table 12 for proper torque values.
      9) Perform thermographic survey of bolted electrical connections in accordance with paragraph "Thermographic Survey."
      10) Confirm correct operation and sequencing of electrical and mechanical interlock systems.
         a) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
         b) Make key exchange with devices operated in off-normal positions.
      11) Inspect insulators for evidence of physical damage or contaminated surfaces.
      12) Verify correct barrier and shutter installation and operation.
      13) Exercise active components.
      14) Inspect mechanical indicating devices for correct operation.
      15) Verify filters are in place and/or vents are clear.
      16) Perform visual and mechanical inspection of instrument transformers, in accordance with paragraph "Instrument Transformers."
      17) Inspect control power transformers.
         a) Inspect physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
         b) Verify that primary and secondary fuse ratings or circuit breakers match drawings.
         c) Verify correct functioning of draw-out disconnecting and grounding contacts and interlocks.
   b. Electrical Tests:
      1) Perform tests on all instrument transformers in accordance with paragraph "Instrument Transformers."
      2) Perform resistance tests through bus joints with low-resistance ohmmeter. Joints that cannot be directly measured due to permanently installed insulation wrap shall be indirectly measured from closest accessible connection.
      3) Perform insulation-resistance tests in each bus section, phase-to-phase and phase-to-ground for one minute in accordance with Table 1.
      4) Perform over-potential test on each bus section, each phase-to-ground with phases not under test grounded, in accordance with manufacturer's published data. In the absence of any published data, Table 2 shall apply. Test voltage shall be applied for one minute.
      5) Perform insulation-resistance tests at 1000 VDC on control wiring. Test duration shall be one minute. Do not perform this test on wiring connected to solid-state components. Follow manufacturer's recommendation.
      6) Perform current injection tests on the entire current circuit in each section of switchgear.
         a) Perform current tests by primary injection, where possible, with magnitudes such that minimum of 1.0 amp flows in secondary circuit.
         b) Where primary injection is impractical, utilize secondary injection with minimum current of 1.0 amp.
         c) Test current at each device.

7) Determine accuracy of meters and calibrate watt-hour meters in accordance with paragraph "Electrical Metering." Verify multipliers.
8) Perform phasing check on double-ended switchboard/switchgear to insure correct bus phasing from each source.
9) Perform the following tests on control power transformers:
   a) Perform insulation-resistance tests. Perform measurements from winding-to-winding and each winding-to-ground. Test voltages shall be in accordance with Table 1 unless otherwise specified by manufacturer.
   b) Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to correct secondary voltage. Confirm potential at all devices.
   c) Verify correct secondary voltage by energizing primary winding with system voltage. Measure secondary voltage with secondary wiring disconnected.
   d) Verify correct function of control transfer relays located in switchboard/switchgear with multiple control power sources.
10) Potential Transformer Circuits:
   a) Perform insulation-resistance tests. Perform measurements from winding-to-winding and each winding-to-ground. Test voltages shall be in accordance with Table 1, unless otherwise specified by manufacturer.
   b) Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to correct secondary voltage.
   c) Verify secondary voltage by energizing primary winding with system voltage. Measure secondary voltage with secondary wiring disconnected.
11) Verify operation of switchgear/switchboard space heaters.

c. Test Values:
1) Bolt-torque levels shall be in accordance with Table 12, unless otherwise specified by manufacturer.
2) Compare bus connection resistances to values of similar connections.
3) Insulation-resistance values for bus, control wiring, and control power transformers shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 1. Values of insulation resistance less than this table or manufacturer's minimum should be investigated. Over-potential tests should not proceed until insulation-resistance levels are raised above minimum values.
4) Bus insulation shall withstand the over-potential test voltage applied.
5) Contact resistance values shall not exceed high limit of normal range as indicated in manufacturer's published data. If manufacturer's data is not available, investigate values that deviate from similar bus by more than 50% of lowest value.

5. Low-Voltage Insulated-Case/Molded-Case Circuit Breakers, 225A and Larger:
a. Visual and Mechanical Inspection:
1) Compare nameplate date with drawings and specifications.
2) Inspect circuit breaker for correct mounting.
3) Check cell fit, element alignment and racking mechanism for draw-out breakers.
4) Operate circuit breaker to insure smooth operation.
5) Inspect case for cracks or other defects.
6) Verify tightness of accessible bolted electrical connections and/or cable connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 12.
7) Inspect mechanism contacts and arc chutes in unsealed units.

b. Electrical Tests:
1) Perform a contact-resistance test.
2) Perform insulation-resistance test at 1000 VDC from pole-to-pole and from each pole-to-ground with breaker closed and across open contacts of each phase. Test duration shall be one minute. Use a minimum test voltage in accordance with Table 1 or manufacturer's published data.
3) Perform insulation-resistance test at 1000 VDC on all control wiring. Test duration shall be one minute. Do not perform the test on wiring connected to solid-state components. Follow manufacturer's recommendation.
4) Perform adjustments for final trip settings in accordance with overcurrent protective device coordination study.

5) Perform long-time delay time-current characteristic tests by passing 300% rated current through each pole separately, unless series testing is required to defeat ground fault functions.
6) Determine short-time pickup and delay by primary current injection.
7) Determine ground-fault pickup and time delay by primary current injection.
8) Determine instantaneous pickup current by primary injection using run-up or pulse method.
9) Verify correct operation of auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and anti-pump function.
10) Verify trip unit calibrations by secondary injection.
11) Determine minimum operation voltage on shunt trip and close coils in accordance with Table 20.
12) Check charging mechanism.

c. Test Values:
1) Bolt-torque levels shall be in accordance with Table 12, unless otherwise specified by manufacturer.
2) Compare microhm or millivolt drop values to adjacent poles or similar breakers. Investigate deviations of more than 50% of lowest value. Investigate any value exceeding manufacturer's recommendations.
3) Circuit breaker insulation-resistance shall be in accordance with Table 1.
4) Control wiring insulation-resistance shall comply with manufacturer's published data. In the absence of manufacturer's published data, use Table 1. Values of insulation resistance less than this table or manufacturer's minimum shall be investigated.
5) Trip characteristic of breakers shall fall within manufacturer's published time-current characteristic tolerance band, including adjustment factors. If manufacturer's curves are not available, trip times shall not exceed the value shown in Table 7. Circuit breakers exceeding specified trip time at 300% of pickup shall be tagged defective.
6) For molded-case circuit breakers, instantaneous pickup values shall be within manufacturer's published data or tolerances shown in Table 8.
7) Minimum operation voltages on shunt trip and close coils shall be in accordance with manufacturer's published data. In the absence of manufacturer's data, refer to Table 20.

6. Low-Voltage Disconnect Switches:
a. Visual and Mechanical Inspection:
1) Compare equipment nameplate data with drawings and specifications.
2) Inspect physical and mechanical condition.
3) Inspect anchorage, alignment, grounding, and required clearances.
4) Verify correct blade alignment, blade penetration, travel stops, and mechanical operation.
5) Verify that fuse sizes and types are in accordance with drawings, short-circuit and overcurrent protective device coordination studies.
6) Verify that each fuse has adequate mechanical support and contact integrity.
7) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 12.
8) Perform thermographic survey of accessible bolted electrical connection in accordance with paragraph "Thermographic Survey."
9) Verify operation and sequencing of interlocking systems.
10) Verify correct phase barrier installation.
11) Verify correct operation of all indicating and control devices.
12) Confirm correct application of manufacturer's recommended lubricants.

b. Electrical Tests:
1) Measure contact resistance across each switchblade and fuseholder.
2) Perform insulation-resistance test at 1000 VDC from pole-to-pole and from each pole-to-ground. Test duration shall be one minute. Use a minimum test voltage in accordance with Table 1 or manufacturer's published data.
3) Measure fuse resistance.
4) Perform ground fault test, if applicable.

c. Test Values:
1) Compare bolted connection resistances to values of similar connections.
2) Bolt-torque levels should be in accordance with Table 12, unless otherwise specified by the manufacturer.

3) Compare microhm or millivolt drop values to adjacent poles or similar switches. Investigate deviations of more than 50% of lowest value. Investigate any value exceeding manufacturer's recommendations.
4) Minimum insulation-resistance shall be in accordance with manufacturer's published data or Table 1.
5) Investigate fuse-resistance values that deviate from each other by more than 15%.

7. Automatic Transfer Switches:
   a. Visual and Mechanical Inspection:
      1) Compare equipment nameplate data with drawings and specifications.
      2) Inspect physical and mechanical condition.
      3) Confirm correct application of manufacturer's recommended lubricants.
      4) Verify manual transfer warnings are attached and visible.
      5) Verify tightness of control connections.
      6) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 12.
      7) Perform thermographic survey of accessible bolted electrical connections in accordance with paragraph "Thermographic Survey."
      8) Perform manual transfer operation.
      9) Verify positive mechanical interlocking between normal and alternative sources.
      10) Inspect anchorage, alignment, grounding and required clearances.
   b. Electrical Tests:
      1) Measure contact resistance.
      2) Perform insulation-resistance tests, phase-to-phase and phase-to-ground, with switch in both source positions. Test duration shall be one minute. Use a test voltage in accordance with Table 1 or manufacturer's published data. For control devices that cannot tolerate test voltage, follow manufacturer's recommendation.
      3) Verify settings and operation of control devices.
      4) Calibrate and set relays and timers in accordance with paragraph "Protective Relays."
      5) Verify phase rotation, phasing and synchronized operation as required by the application.
      6) Perform automatic transfer tests:
         a) Simulate loss of normal power.
         b) Return to normal power.
         c) Simulate loss of emergency power.
         d) Simulate all forms of single-phase conditions.
      7) Verify correct operation and timing of following functions:
         a) Normal source voltage-sensing relays.
         b) Engine start sequence.
         c) Time delay upon transfer.
         d) Alternate source voltage-sensing relays.
         e) Automatic transfer operation.
         f) Interlocks and limit switch function.
         g) Time delay and retransfer upon normal power restoration.
         h) Engine cool down and shutdown feature.
   c. Test Values:
      1) Bolt-torque levels shall be in accordance with Table 12, unless otherwise specified by manufacturer.
      2) Insulation-resistance test voltage and minimum values shall be in accordance with Table 1.
      3) Compare microhm values to adjacent poles or similar switches. Investigate deviations of more than 50% of lowest value. Investigate any value exceeding manufacturer's recommendations.
8. Grounding Systems:
   a. Visual and Mechanical Inspection:
      1) Verify ground system is in compliance with drawings, specifications, and NFPA 70.
      2) Inspect physical and mechanical condition.
      3) Inspect anchorage.
   b. Electrical Tests:
      1) Perform fall-of-potential or alternative test in accordance with ANSI/IEEE 81 on the main grounding electrode or system.

2) Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and/or derived neutral points.
3) Make resistance measurements in dry weather not earlier than 48 hours after rainfall.

c. Test Values:
1) The resistance between the main grounding electrode and ground should be no greater than five ohms. (Reference ANSI/IEEE 142.) Investigate any values above five ohms and notify Engineer immediately for further instructions.
2) Investigate point-to-point resistance values that exceed 0.5 ohm.

9. Instrument Transformers:
a. Visual and Mechanical Inspection:
1) Compare equipment nameplate data with drawings and specifications.
2) Inspect physical and mechanical condition.
3) Verify correct connection of transformers with system requirements.
4) Verify adequate clearance between primary and secondary circuit wiring.
5) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 12.
6) Perform thermographic survey of bolted electrical connections in accordance with paragraph "Thermographic Survey."
7) Verify required grounding and shorting connections provide contact.
8) Verify correct operation of transformer withdrawal mechanism and grounding operation.
9) Verify correct primary and secondary fuse sizes for potential transformers.
10) Confirm correct application of manufacturer's recommended lubricants.

b. Electrical Tests – Current Transformers:
1) Perform insulation-resistance test of current transformer and wiring-to-ground at 1000 VDC. Do not perform this test on wiring connected to units with solid-state components. Follow manufacturer's recommendations.
2) Perform polarity test of each current transformer.
3) Perform ratio-verification test using voltage or current method in accordance with ANSI/IEEE C57.13.1.
4) Perform excitation test on transformers used for relaying applications in accordance with ANSI/IEEE C57.13.1.
5) Measure current circuit burdens at transformer terminal and determine total burden.
6) When applicable, perform insulation-resistance and dielectric withstand tests on primary winding with secondary grounded. Test voltages shall be in accordance with Tables 5 and 9 respectively.
7) Verify that current circuits are grounded and have only one grounding point in accordance with ANSI/IEEE C57.13.3.

c. Electrical Tests – Voltage Transformers:
1) Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Test voltages shall be applied for one minute in accordance with Table 5. For units with solid-state components, follow manufacturer's recommendation.
2) Perform polarity test on each transformer to verify polarity marks or H1-X1 relationship as applicable.
3) Perform turns ratio test on all tap positions, if applicable.
4) Measure potential circuit burdens at transformer terminals and determine total burden.
5) Perform dielectric withstand test on primary windings with secondary windings connected to ground. Dielectric voltage shall be in accordance with Table 9. Test voltage shall be applied for one minute.

d. Test Values:
1) Insulation-resistance measurement on instrument transformer shall not be less than that shown in Table 5.
2) Bolt-torque levels shall be in accordance with Table 12, unless otherwise specified by the manufacturer.
3) Polarity results shall agree with system drawings.
4) Compare measured burdens to calculated burdens supplied by Owner.
5) Ratio accuracies shall be within 0.5% of nameplate or manufacturer's published data.
6) Insulation shall withstand over-potential test voltage applied.

10. Thermographic Survey:
    a. Visual and Mechanical Inspection:
        1) Inspect physical, electrical, and mechanical conditions.
        2) Remove all necessary covers prior to thermographic inspection.
        3) Equipment to be inspected shall include all current-carrying devices. Provide report including the following:
            a) Discrepancies.
            b) Temperature difference between area of concern and reference area.
            c) Cause of temperature difference.
            d) Areas inspected. Identify inaccessible and unobservable areas and equipment.
            e) Identify load conditions at time of inspection.
            f) Provide photographs and thermogram of deficient area.
    b. Test Parameters:
        1) Inspect distribution systems with imaging equipment capable of detecting minimum temperature difference of 2°F at 86°F.
        2) Equipment shall detect emitted radiation and convert detected radiation to visual signal.
        3) Thermographic surveys should be performed during periods of maximum possible loading but not less than 40% of rated load of the electrical equipment being inspected. Refer to NFPA 70B, Section 20.17 (Infrared Inspection).
    c. Test Results:
        1) Temperature differences of 2°F to 5 °F indicate possible deficiency and warrant investigation.
        2) Temperature differences of 7°F to 27°F indicate deficiency; repair as time permits.
        3) Temperature differences of 29°F and above indicate major deficiency; repair immediately.
        4) Suggested actions based on temperature rise can be found in Table 18.

B. Test Reports:
1. Testing firm shall do the following:
    a. Prepare test report, including description of equipment tested, description of test, test results, conclusions and recommendations, retesting results, list of test equipment used and calibration date.
    b. Show test results in comparison to industry and manufacturer's values and tolerances.
    c. Interpret test results in writing and give recommendations for acceptance or rejection upon consultation with Engineer and prior to energizing equipment.
    d. Assure electrical equipment is operational and within industry and manufacturer's tolerances, and is installed in accordance with contract documents.
    e. Assure suitability of energization.
    f. Report to the Owner and Engineer any system, material, or workmanship that is found defective on the basis of acceptance tests.
    g. Retest equipment when required.
    h. Maintain written record of tests.
    i. Utilize safety practices during the tests in accordance with:
        1) Acceptable state and local safety operating procedures
        2) Owner's safety practices
        3) OSHA
        4) NFPA 70E
    j. Perform tests with apparatus de-energized and grounded, except where otherwise specifically required ungrounded by test procedures.
    k. Assemble and certify final test report.
    l. Provide 4 copies of complete test report.
    m. Attach label to all tested equipment with indication of date tested and testing firm name.
2. Contractor shall do the following:
    a. Investigate, replace, or repair any fault in material or in any part of the installation revealed by the tests.
    b. Deliver one copy of each test report directly to Engineer within 30 days after completion of testing, unless directed otherwise. Insert a copy of each test report in the equipment operation and maintenance manuals.

C. Test Equipment:
   1. Test Instrument Calibration:
      a. Testing firm shall have calibration program that assures test instruments are maintained with rated accuracy.
      b. Instruments shall be calibrated in accordance with the following frequency schedule:
         1) Field instruments: Analog, 6 months maximum; Digital, 12 months maximum
         2) Laboratory instruments: 12 months
         3) Leased specialty equipment: 12 months where accuracy is guaranteed by lessor
      c. Dated calibration labels shall be visible on test equipment.
      d. Records, which show date and results of instruments calibrated or tested, must be kept up-to-date.
      e. Up-to-date instrument calibration instructions and procedures shall be maintained for test instrument.
      f. Equipment used for field testing shall be more accurate than instrument being tested.
      g. Calibrating standard applied to testing equipment shall be of higher accuracy than instrument tested.

END OF SECTION

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POWER DISTRIBUTION ACCEPTANCE TEST TABLES

TABLE 1
Insulation Resistance Test Values
Electrical Apparatus And Systems

Voltage Rating	Minimum DC Test Voltage	Recommended Minimum Insulation Resistance In Megohms
250	500	25
600	1,000	100
1,000	1,000	100
2,500	1,000	500
5,000	2,500	1,000
8,000	2,500	2,000
15,000	2,500	5,000
25,000	5,000	20,000
34,500 and above	15,000	100,000

See Table 14 for temperature correction factors.

TABLE 5
Transformer Insulation-Resistance
Acceptance Test Voltage and Minimum Results

Transformer Coil Rating Type in Volts	Minimum DC Test Voltage	Recommended Minimum Insulation Resistance in Megohms	
		Liquid Filled	Dry
0 - 600	1000	100	500
601 - 5000	2500	1000	5000
5001 - 15000	5000	5000	25000

See Table 14 for Temperature Correction Factors.
NOTE: Since insulation resistance depends on insulation rating (kV) and winding capacity (kVA), values obtained should be compared to manufacturer's test data.

TABLE 7
Molded-Case Circuit Breakers
Values for Inverse Time Trip Test

(At 300% of Rated Continuous Current of Circuit Breaker)

Range of Rated Continuous Current Amperes	Maximum Trip Time in Seconds For Each Maximum Frame Rating[1]	
	250V	251 - 600V
0-30	50	70
31-50	80	100
51-100	140	160
101-150	200	250
151-225	230	275
226-400	300	350
401-600	----------	450
601-800	----------	500
801-1000	----------	600
1001-1200	----------	700
1201-1600	----------	775
1601-2000	----------	800
2001-2500	----------	850
2501-5000	----------	900

Reproduction of Table 5-3 from NEMA Standard AB4-1996.

[1] For integrally-fused circuit breakers, trip times may be substantially longer if tested with the fuses replaced by solid links (shorting bars).

TABLE 8
Instantaneous Trip Setting Tolerances for Field Testing of Marked Adjustable Trip Circuit Breakers

	Tolerances of High and Low Settings	
Ampere Rating	**High**	**Low**
Adjustable	+40%	-30%
Non-adjustable	+25%	-25%

Reproduction of Table 5-4 from NEMA publication AB4-1996.

For circuit breakers with nonadjustable instantaneous trips, tolerances apply to the manufacturer's published trip range, i.e., +40% on high side, -30% on low side.

TABLE 9
Instrument Transformer Dielectric Tests
Field Acceptance

Nominal System (kV)	BIL (kV)	Applied Potential Tests Field Test Voltage (kV)	
		AC	DC[1]
0.6	10	3	4
1.2	30	7.5	10
2.4	45	11.25	15
5.0	60	14.25	19
8.7	75	19.5	26
15	95	25.5	34
15	110	25.5	34
25	125	30	40
25	150	37.5	50
34.5	150	37.5	50
34.5	200	52.5	70

Derived from Paragraph 8.8.2 and Tables 2 and 7 of ANSI/IEEE C57.13-1993 (Standard Requirements for Instrument Transformers).

[1] DC potential tests are not recommended for transformers rated higher than 200 kV BIL. DC tests may prove beneficial as a reference for future testing. In such cases the test direct voltage should not exceed the original factory test RMS alternating voltages.

TABLE 10
Maximum Allowable Vibration Amplitude

RPM @ 60 Hz	Velocity in/s peak	Velocity mm/s	RPM @ 60 Hz	Velocity in/s peak	Velocity mm/s
3600	0.15	3.8	3000	0.15	3.8
1800	0.15	3.8	1500	0.15	3.8
1200	0.15	3.8	1000	0.13	3.3
900	0.12	3.0	750	0.10	2.5
720	0.09	2.3	600	0.08	2.0
600	0.08	2.0	500	0.07	1.7

Derived from NEMA publication MG 1-1998, Section 7.8.1, Table 7-1. Table is unfiltered vibration limits for resiliently mounted machines. For machines with rigid mounting, multiply the limiting values by 0.8.
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TABLE 11
Overpotential Test Voltages for Electrical Apparatus Other than Inductive Equipment

Nominal System (Line) Voltage[1] (kV)	Insulation Class	AC Factory Test (kV)	Maximum Field Applied AC Test (kV)	Maximum Field Applied DC Test (kV)
1.2	1.2	10	6.0	8.5
2.4	2.5	15	9.0	12.7
4.8	5.0	19	11.4	16.1
8.3	8.7	26	15.6	22.1
14.4	15.0	34	20.4	28.8
18.0	18.0	40	4.0	33.9
25.0	25.0	50	30.0	42.4
34.5	35.0	70	42.0	59.4
46.0	46.0	95	57.0	80.6
69.0	69.0	140	84.0	118.8

[1] Intermediate voltage ratings are placed in the next higher insulation class.

TABLE 12

U.S. Standard
Bolt Torques for Bus Connections
Heat-Treated Steel – Cadmium or Zinc Plated

Grade	SAE 1 & 2	SAE 5	SAE 7	SAE 8
Minimum Tensile (psi)	64K	105K	133K	150K
Bolt Diameter In Inches	Torque (Foot Pounds)			
1/4	4	6	8	8
5/16	7	11	15	18
3/8	12	20	27	30
7/16	19	32	44	48
1/2	30	48	68	74
9/16	42	70	96	105
5/8	59	96	135	145
3/4	96	160	225	235
7/8	150	240	350	380
1.0	225	370	530	570

Bolt Torques for Bus Connections
Silicon Bronze Fasteners[1]
Torque (Foot Pounds)

Bolt Diameter in (Inches)	Nonlubricated	Lubricated
5/16	15	10
3/8	20	14
1/2	40	25
5/8	55	40
3/4	70	60

[1] Bronze alloy bolts shall have a minimum tensile strength of 70,000 psi.

TABLE 12 (CONT.)

Bolt Torques for Bus Connections
Aluminum Alloy Fasteners[2]
Torque (Foot Pounds)

Bolt Diameter in Inches	Lubricated
5/16	8.0
3/8	11.2
1/2	20.0
5/8	32.0
3/4	48.0

[2] Aluminum alloy bolts shall have a minimum tensile strength of 55,000 psi.

Bolt Torques for Bus Connections
Stainless Steel Fasteners[3]
Torque (Foot Pounds)

Bolt Diameter in Inches	Uncoated
5/16	14
3/8	25
1/2	45
5/8	60
3/4	90

[3] Bolts, cap screws, nuts, flat washers, locknuts: 18-8 alloy.
Belleville washers: 302 alloy.

TABLE 14
Insulation Resistance Conversion Factors For
Conversion of Test Temperature to 20°C

Temperature		Multiplier	
°C	°F	Apparatus Containing Immersed Oil Insulations	Apparatus Containing Solid Insulations
0	32	0.25	0.40
5	41	0.36	0.45
10	50	0.50	0.50
15	59	0.75	0.75
20	68	1.00	1.00
25	77	1.40	1.25
30	86	1.98	1.58
35	95	2.80	2.00
40	104	3.95	2.50
45	113	5.60	3.15
50	122	7.85	3.98
55	131	11.20	5.00
60	140	15.85	6.30
65	149	22.40	7.90
70	158	31.75	10.00
75	167	44.70	12.60
80	176	63.50	15.80

TABLE 18
Thermographic Survey
Suggested Actions Based on Temperature Rise

Temperature difference (TD) based on comparisons between similar components under similar loading	Temperature difference (TD) based upon comparisons between component and ambient air temperatures	Recommended action
1°C to 3°C	1°C to 10°C	Possible deficiency; warrants investigation
4°C to 15°C	11°C to 20°C	Indicates probably deficiency; repair as time permits
-- -- --	21°C to 40°C	Monitor until corrective measures can be accomplished
>15°C	>40°C	Major discrepancy; repair immediately

Temperature specifications vary depending on the exact type of equipment. Even in the same class of equipment (i.e., cables) there are various temperature ratings. Heating is generally related to the square of the current; therefore, the load current will have a major impact on)T. In the absence of consensus standards for TD, the values in this table will provide reasonable guidelines.

An alternative method of evaluation is the standards-based temperature rating system as discussed in Chapter 8.9.2, Conducting an IR Thermographic Inspection, *Electrical Power Systems Maintenance and Testing*, by Paul Gill, PE, 1998.

It is a necessary and valid requirement that the person performing the electrical inspection be thoroughly trained and experienced concerning the apparatus and systems being evaluated as well as knowledgeable of thermographic methodology.

TABLE 19
Overpotential Test Voltages
Electrical Apparatus Other than Inductive Equipment

Nominal System (Line) Voltage[a] (kV)	Insulation Class	AC Factory Test (kV)	Maximum Field Applied AC Test (kV)	Maximum Field Applied DC Test (kV)
1.2	1.2	10	6.0	8.5
2.4	2.5	15	9.0	12.7
4.8	5.0	19	11.4	16.1
8.3	8.7	26	15.6	22.1
14.4	15.0	34	20.4	28.8
18.0	18.0	40	24.0	33.9
25.0	25.0	50	30.0	42.4
34.5	35.0	70	42.0	59.4

a. Intermediate voltage ratings are placed in the next higher insulation class.

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TABLE 20
Rated Control Voltages and their Ranges for Circuit Breakers

The maximum voltage is measured at the point of user connection to the circuit breaker [see Notes (9) (10)] with no operating current flowing, and the minimum voltage is measured with maximum operating current flowing.

Rated Control Voltages and their Ranges for Circuit Breakers					
	Direct Current Voltage Ranges (1)(2) Volts, DC			RATED CONTROL VOLTAGE (60 Hz)	ALTERNATING CURRENT (1)(2)(3)(5) CLOSING, TRIPPING, AND AUXILIARY FUNCTIONS
	CLOSING AND AUXILIARY FUNCTIONS		OPENING FUNCTIONS ALL TYPES		
RATED CONTROL VOLTAGE (8)	INDOOR CIRCUIT BREAKERS	OUTDOOR CIRCUIT BREAKERS		SINGLE PHASE	SINGLE PHASE
24	---	---	14-28	120	104-127 (4)
48	38-56	36-56	28-56	240	208-254 (4)
125	100-140	90-140	70-140	Polyphase	Polyphase
250	200-280	180-280	140-280		180Y/104-
---	---	---	---	208Y/120	220Y/127
---	---	---	---	240	208-254

Derived from Table 8, ANSI C37.06-2000, *AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis – Preferred Ratings and Related Required Capabilities.*

RATED CONTROL VOLTAGES AND THEIR RANGES FOR CIRCUIT BREAKERS Solenoid-Operated Devices	
RATED VOLTAGE	Closing Voltage Ranges for Power Supply
125 DC	90 – 115 or 105 – 130
250 DC	180 – 230 or 210 – 260
230 AC	190 – 230 or 210 - 260

Notes:

(1) Electrically operated motors, contactors, solenoids, valves, and the like need not carry a nameplate voltage rating that corresponds to the control voltage rating shown in the table as long as these components perform the intended duty cycle (usually intermittent) in the voltage range specified.

(2) Relays, motors, or other auxiliary equipment that function as a part of the control for a device shall be subject to the voltage limits imposed by this standard, whether mounted at the device or at a remote location.

(3) Includes supply for pump or compressor motors. Note that rated voltages for motors and their operating ranges are covered by ANSI/NEA MG-1-1978.

(4) Includes heater circuits.

(5) Voltage ranges apply to all closing and auxiliary devices when cold. Breakers using standard auxiliary relays for control functions may not comply at lower extremes of voltage ranges when relay coils are hot, as after repeated or continuous operation.

(6) Direct current control voltage sources, such as those derived from rectified alternating current, may contain sufficient inherent ripple to modify the operation of control devices to the extent that they may not function over the entire specified voltage ranges.

(7) This table also applies for circuit breakers in gas-insulation substation installations.

(8) In cases where other operational ratings are a function of the specific control voltage applied, tests in C37.09 may refer to the "Rated Control Voltage." In these cases, tests shall be performed at the levels in this column.

(9) For an outdoor circuit breaker, the point of user connection to the circuit breaker is the secondary terminal block point at which the wires from the circuit breaker operating mechanism components are connected to the user's control circuit wiring.

(10) For an indoor circuit breaker, the point of user connection to the circuit breaker is either the secondary disconnecting contact (where the control power is connected from the stationary housing to the removable circuit breaker), or the terminal block point in the housing nearest to the secondary disconnecting contact.

(11) Some solenoid operating mechanisms are not capable of satisfactory performance over the range of voltage specified in the standard; moreover, two ranges of voltage may be required for such mechanisms to achieve an acceptable standard of performance.

(12) The preferred method of obtaining the double range of closing voltage is by use of tapped coils. Otherwise, it will be necessary to designate one of the two closing voltage ranges listed above as representing the condition existing at the device location due to battery or lead voltage drop or control power transformer regulation. Also, caution should be exercised to ensure that the maximum voltage of the range used is not exceeded.

END OF SECTION

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SECTION 26 09 23
LIGHTING CONTROL DEVICES

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1.4 SUBMITTALS
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2.11 SELF-CONTAINED AUTOMATIC TIMER SWITCHES
2.12 FINISHES
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3.1 INSTALLATION
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PART 1 - GENERAL

1.1 RELATED WORK
A. Section 26 0000 - General Electrical Requirements
B. Section 26 5000 - Lighting

1.2 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.

1.3 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.

1.4 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.

1.5 QUALITY ASSURANCE

A. Obtain devices from one source and by single manufacturer.
B. Regulatory Requirements:
   1. Comply with NFPA 70 for components and installation.
   2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory unopened packaging until ready for installation.

1.7 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.
B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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. UL 924 Emergency Bypass/Control Device: Acuity Brands Controls, Hubbell, Leviton, Wattstopper, LVS
   5. Exterior Photocells: Cooper Controls, Hubbell, Intermatic, Leviton, Paragon, Tork
   6. Timeclocks: Intermatic, Paragon, Tork
   7. Self-Contained Automatic Timer Switches: Acuity Brands Controls, Cooper Controls, Hubbell, Leviton, Philips, Wattstopper
B. It is the responsibility of Electrical Contractor to ensure devices submitted meet or exceed functional intent and design quality standards.

2.2 FABRICATION AND MANUFACTURE

A. Devices shall be UL listed for loads and voltages as indicated in contract drawings and specifications.

2.3 WALL BOX DIMMERS

A. Dimmers shall:
   1. Operate in ambient temperature range of 32°F to 104°F.
   2. Be linear slide or pushbutton preset or programmable dimmers with power-failure memory.
   3. Incorporate separate control of intensity and ON/OFF.
   4. Include voltage compensation circuitry that adjusts firing angle of dimmer to compensate light output for variations in AC line voltage. Dimmers in which firing angle is held constant with varying AC line voltage shall not be acceptable.
   5. Provide smooth and continuous IESNA Square Law Dimming Curve throughout entire dimming range.
   6. Incorporate filter network to minimize interference (RFI) with radio, audio, and video equipment.
   7. Incorporate air-gap switch to meet requirements of UL 20 for air-gap switches in incandescent dimmers.

B. Fluorescent dimmers shall:
   1. Be rated to control 430 mA rapid start, 800 mA high output or 265 mA lamps.
   2. Be approved by ballast manufacturer for control of ballasts provided.
   3. Contain relay to automatically remove power to circuit feeding dimming ballast when dimmer is OFF.
   4. Incorporate circuitry to prevent lights from momentarily "flashing" when dimmer is turned on or OFF.
   5. Different lamp lengths or one and two lamp ballasts on same circuit shall track evenly with no perceptible difference in light levels for same type of lamps.
   6. Dimmers and lamps shall have a dimming range from 100% down to 10% light output.
   7. Refer to Section 26 5100 - Interior Lighting for solid state dimming ballast specification.

C. 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 5100 – Interior Lighting for solid state dimming ballast/driver specification.

2.4 LOW-VOLTAGE SWITCHES

A. Low voltage switches shall:
   1. Mount in a single or double gang box.
   2. Be capable of multi-way switching.

2.5 OCCUPANCY AND VACANCY SENSORS

A. Sensors shall:
   1. Operate with all lamp and ballast combinations; including magnetic, hybrid, and solid-state ballasts/drivers.
   2. Operate with ultrasonic, microphonic, passive infrared or presence technologies as indicated on drawings.
   3. Have visible LED to indicate occupant detection.
   4. Have adjustable time delay 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 on drawings.
   6. Be provided with ceiling, wall or wall switch style mounting as indicated on drawings.
   7. Have daylight filter to ensure PIR sensor is insensitive to short-wavelength waves emitted by the sun.
   8. Incorporate by-pass switch to enable lighting to be turned on if sensor fails.

B. Occupancy Sensor shall:
   1. Provide automatic ON, automatic OFF operation where indicated on drawings.

C. Vacancy Sensor shall:
   1. Provide manual ON, automatic OFF operation where indicated on drawings.

2.6 AMBIENT LIGHT SENSORS

A. Ambient light sensors shall:
   1. Incorporate photoconductive cell to measure light levels between 1 and 1,000 footcandles.
   2. Be adjustable with deadband feature to prevent cycling of lighting from minor changes in cloud cover.
   3. Have adjustable time delay range from 3 to 5 minutes.
   4. Not permit lighting systems to be turned on if enough daylight is present.
   5. Incorporate by-pass switch to enable lighting to be turned on if sensor fails.

2.7 POWER PACKS

A. Sensor power packs shall:
   1. Be self-contained transformer relay modules.
   2. Have universal rated voltage inputs 120-277 VAC, 60 Hz.
   3. Have normally closed dry contacts rated for switching 120-277 volts, 60 Hz. 20 amp loads. Provide 24VDC output capable of controlling low-voltage occupancy sensors.

2.8 UL 924 EMERGENCY BYPASS/CONTROL DEVICES

A. UL 924 listed bypass relays shall:
   1. Be 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.

2.9 EXTERIOR PHOTOCELLS

A. Photocells shall:
   1. Have universal rated voltage inputs 120-277 VAC, 60 Hz.
   2. Be rated for up to 2,000 watts.
   3. Have cadmium sulfide, 1” diameter cell.
   4. Have SPST normally closed contacts.
   5. Have a minimum delay of 3 minutes to prevent false switching.

B. ON/OFF adjustment shall be done by moving light selector with range from 2 to 50 footcandles.

C. Operational temperature range shall be -40°F to 140°F.

D. Enclosure shall be die cast zinc, gasketed for maximum weatherproofing.

E. Enclosure shall include positioning lug on top.

F. Mounting shall be for 1/2” conduit nipple.

2.10 TIMECLOCKS

A. Timeclocks shall:
   1. Be multi-purpose, 7-day, 365-day advance single and skip a day, combination 2-channel electronic astronomical time clock with SPDT switching configuration.
   2. Have universal rated voltage inputs 120-277 VAC, 60 Hz.
   3. Be capable of programming in AM/PM or 24-hour format by jumper selection or digital setting, in one-minute resolution, using 2 buttons for basic settings.
   4. Have 365-day and/or holiday selection capabilities, with 16 single date and 5 holiday selection options and user selectable daylight savings/standard time functions.
   5. Have 72-hour memory backup with rechargeable battery and charger.
   6. Have manual override, ON/OFF to the next scheduled event, using one button for each channel.
   7. Have operational temperature range of -40°F to 150°F.
   8. Have a maximum allowed over-ride period no greater than 2 hours.

B. Contacts shall be rated 10 amp resistive at 120/250 VAC, 7.5 amps inductive at 120/250 VAC, 5 amps inductive at 30 VDC and up to 1/2 hp at 250 VAC.

C. Display shall be LCD type.

D. Enclosure shall be rated for installation location.

2.11 SELF-CONTAINED AUTOMATIC TIMER SWITCHES

A. Timer switches shall:
   1. Have universal rated voltage inputs 120-277 VAC, 60 Hz.
   2. Be programmable to turn lights OFF after a preset time.
   3. Have a ground wire and ground strap for safety with a latching air gap relay switching mechanism.
   4. Use Zero Crossing Circuitry to increase the relay life, protect from the effects of inrush current.
   5. Be compatible with all electronic ballasts, motor loads, LEDs and LED drivers, compact fluorescent and inductive loads. Triac and other harmonic generating devices shall not be allowed.

6. Have no minimum load requirement and shall be capable of controlling 0 to 800 watt incandescent, fluorescent @ 100/120 VAC, 50/60 Hz; 0 to 1200 watts fluorescent @ 230/277 VAC, 50/60 Hz; 1/6 hp @ 125 VAC. LED with internal or external driver@ 100/120VAC.
7. Have the option for light flash warning at five minutes before the timer runs out and again when the countdown reaches one minute.
8. Have the option for a beep warning that shall sound every five seconds once the time switch countdown reaches one minute.
9. Have manual feature for timer reset where pressing the ON/OFF switch for more than 2 seconds resets the timer to the programmed time-out period.
10. Have a feature that shows the timer's countdown.
11. Have the calibration switch for setting time-out, time scroll, one second light flash, and beep warning shall be concealed to prevent tampering of adjustments and hardware.
12. Have a maximum allowed over-ride period no greater than 2 hours.
13. Be capable of operating as an ON/OFF switch.
14. Utilize terminal style wiring.
15. Have a 100% OFF override switch with no leakage current to the load.

2.12 FINISHES

A. Color:
   1. Wall box dimmers, low-voltage switches, occupancy sensors, ambient light sensors and device cover plates: white

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install devices at heights scheduled, and as indicated on drawings.
B. Install wall devices vertically on latch side of door within 6" of frame edge, unless otherwise noted.
C. Install ceiling devices as shown on drawings and as recommended by device manufacturer.
D. Ceiling mounted occupancy sensors shall be located minimum of 6 ft from supply air diffusers.
E. Install devices plumb, level with finished surfaces and free from blemishes.
F. Verify device locations prior to rough in.
G. Control wiring shall be low voltage, Class II wiring, electrically isolated from power wiring by a Class II transformer.
H. Provide separate neutral conductor for each dimmer.
I. Wiring shall be in conduit.
J. Electrical Contractor shall be responsible for final adjustment and testing of all devices.

3.2 TESTING

A. Verify proper location and operation of all devices.
B. Verify dimmers function without:
   1. Producing lamp flicker or audible noise.
   2. Interference of audio and visual equipment.
C. Adjust occupancy sensors for a 15 minute time delay.
D. Adjust occupancy sensor sensitivity such that movement outside range of coverage shall not trigger sensor.
E. Adjust ambient light sensor to maintain illuminance level equal to light level from controlled lighting in the space when no daylight is present or as indicated per drawings. Demonstrate ambient light sensor(s) control lighting as specified.

END OF SECTION

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SECTION 26 22 00
LOW-VOLTAGE TRANSFORMERS

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PART 1 - GENERAL

1.1 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 25 0533 – Raceway and Boxes for Electrical Systems
E. Section 26 0553 – Electrical Systems Identification
F. Section 26 0812 – Power Distribution Acceptance Tests
G. Section 26 0813 – Power Distribution Acceptance Test Tables

1.2 DESCRIPTION

A. Section includes dry type distribution and buck-boost transformers rated 600V and less, with capacities up to 300 kVA.

1.3 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

1.4 SUBMITTALS

A. Product Data:
   1. Include rated nameplate data, capacities, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.
B. Shop Drawings:
   1. For each transformer size and type:
      a. Physical dimensions, including bolting templates, weight, and center of gravity
      b. Loads, method of field assembly, components, and location and size of each field connection
      c. Wiring Diagrams: Power, signal, and control wiring
      d. kVA rating

e. Primary taps
f. Insulation class and temperature rise
g. Efficiency values measured at 0, 25, 50, 75, and 100% load
h. Impedance value – X/R and %Z
i. Sound level
j. "K" factor listing, where applicable

C. Submit 1/4" scale electrical room floor plans with transformer locations.
D. Manufacturer's Installation Instructions:
1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
E. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
F. Output Settings Report: Record output voltages and tap settings.
G. Closeout Submittals:
1. Project Record Documents:
a. Record actual locations of transformers.
2. Operation and Maintenance Data:
a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
b. Include spare parts data listing, source, and current prices of replacement parts and supplies.
c. Include in emergency, operation and maintenance manuals.
d. Include manufacturer's Seismic Qualification Certification, Installation Seismic Qualification Certification, manufacturer's Ultra Quiet Transformers Sound Level Certification, where applicable, and Output Settings Report.

1.5 QUALITY ASSURANCE
A. Obtain transformers from one source and by single manufacturer.
B. Regulatory Requirements:
1. Comply with NFPA 70 for components and installation.
2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.6 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.

1.7 WARRANTY
A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.
B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Square D

2.2 DISTRIBUTION TRANSFORMERS
A. Fabrication:
1. NEMA ST 20, UL 1561
2. Factory assembled and tested
3. Air-cooled, for 60 Hz service
4. Two winding dry type

5. Coils:
   a. Continuous wound construction and impregnated with non-hydroscopic, thermosetting varnish.
   b. Conductors: Continuous windings without splices, except for taps, and encapsulated wire resin compound to seal out moisture and air.
   c. Materials: Copper
   d. Separate primary and secondary
   e. Internal Connections: Braised or pressure type
6. Cores: High-grade silicon steel, non-aging, with high magnetic permeability, low eddy current losses and low hysteresis. Magnetic flux densities below saturation point. Core laminations clamped with steel members, one leg per phase.
7. Rubber vibration absorbing mounts to isolate base of enclosure from core and coil assembly.
8. Transformer neutral visibly grounded to enclosures with flexible grounding conductor.

B. Enclosure:
1. NEMA 250
2. Type 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
4. Insulation Class and Winding Temperature Rise:
   a. Transformers 15kVA and smaller: Class 185°C, with 115°C temperature rise above 40°C ambient temperature, capable of carrying 15% continuous overload without exceeding 150°C rise.
   b. Transformers 25kVA – 112.5kVA: Class 220°C, with 115°C temperature rise above 40°C ambient temperature, capable of carrying 15% continuous overload without exceeding 150°C rise.
   c. Transformers above 112.5kVA: Class 220°C, with 80°C temperature rise above 40°C ambient temperature, capable of carrying 30% continuous overload without exceeding 150°C.
5. Top of Enclosure Temperature: Maximum 35°C above 40°C ambient temperature at warmest point at full load.
6. K-Factor Rating: UL 1561, as indicated.

D. Primary Taps:
1. Transformers rated 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.

2.3 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

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure and ambient temperature requirements for each transformer.
B. Examine areas and surface to receive transformers for compliance with requirements, installation tolerances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.
C. Verify space indicated for transformers' mounting meets code-required working clearances.
D. Notify Architect/Engineer of any discrepancies prior to submittal of product data and shop drawings.
E. Verify that ground connections are in place and requirements in Section 26 0526 – Grounding and Bonding for Electrical Systems have been met.
F. Verify with manufacturer that "touch-up" paint kit is available for repainting.

3.2 INSTALLATION

A. Install transformers in accordance with ANSI/NECA 1.
B. Install level and plumb within 1/2 degree, and at least 6" from the adjacent wall or structure to insure proper ventilation, in accordance with manufacturer's written instruction, and in compliance with recognized industry practices.
C. Transformer mounting, seismic restraints, and vibration control:
   1. Mount transformers on floor.
   2. Floor mounting:
      a. Secure to floor via isolation pads between floor brackets (per manufacturer recommendations) and transformer.
      b. Mount on spring isolator.
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. Connect each transformer to rigid conduit system with 12" to 36" of flexible liquid-tight metal conduit. 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.

3.3 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.

3.4 FIELD QUALITY CONTROL

A. Inspect transformers for physical damage, proper alignment, anchorage, grounding, connections, and installation.
B. Test transformers per requirements in Sections 26 0812 – Power Distribution Acceptance Tests and 26 0813 – Power Distribution Acceptance Test Tables.
C. Interpret test results in writing and submit to Engineer.

D. Output Settings Report: Prepare a written report recording output voltages and tap settings and submit to Engineer.

3.5 REPAINTING

A. Remove paint splatters and other marks from surface of equipment.

B. Touch-up chips, scratches, or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Owner.

3.6 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 h of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10% and not being lower than nameplate voltage minus 3% at maximum load conditions.

B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5%, at secondary terminals.

3.7 CLEANING

A. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.

END OF SECTION

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SECTION 26 24 13
SWITCHBOARDS

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PART 1 - GENERAL

1.1 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 0548 – Vibration and Seismic Controls for Electrical Systems
E. Section 26 0553 – Electrical Systems Identification
F. Section 26 0573 – Power System Studies
G. Section 26 0812 – Power Distribution Acceptance Tests
H. Section 26 0813 – Power Distribution Acceptance Test Tables
I. Section 26 0913 – Electrical Power Monitoring and Control
J. Section 26 2813 – Fuses
K. Section 26 4300 – Surge Protective Devices

1.2 DESCRIPTION

A. Section includes free-standing, dead-front type low-voltage distribution switchboards.

1.3 REFERENCE STANDARDS

A. ANSI/IEEE C37.13 – Low-Voltage AC Power Circuit Breakers Used in Enclosures
B. ANSI/NECA 400 – Recommended Practice for Installing and Maintaining Switchboards
C. IEEE C62.41.1 Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
D. IEEE C62.41.2 Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits
E. NFPA 70 – National Electrical Code
F. NEMA AB 1 – Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
G. NEMA AB 3 – Molded-Case Circuit Breakers and Their Applications
H. NEMA FU 1 – Low-Voltage Cartridge Fuses

I. NEMA KS 1 – Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
J. NEMA PB 2 – Dead-Front Distribution Switchboards
K. NEMA PB 2.1 – General Instructions for Proper Handling, Installation and Maintenance of Dead-Front Distribution Switchboards Rated 600 Volts or Less
L. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
M. UL 98 – Enclosed and Dead-Front Switches
N. UL 486A-486B – Wire Connectors
O. UL 489 – Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
P. UL 869A – Reference Standard for Service Equipment
Q. UL 891 – Dead-Front Switchboards
R. UL 1053 – Ground-Fault Sensing and Relaying Equipment
S. UL 1066 – Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures

1.4 SUBMITTALS

A. Product Data: For switchboard, components and accessories indicated:
   1. Include data on features and components and complete description; submit catalog cut sheets showing voltage, size, rating and size of surge protective devices, switching and overcurrent protective devices.
   2. Features, characteristics, factory settings and time-current curves of individual protective devices, auxiliary components and ground fault relaying.
B. Shop Drawings:
   1. For switchboard specified in this Section:
      a. General Arrangement:
         1) Indicate front, plan, and side views of switchboards; access requirements (front, side, rear); overall dimensions and components list; shipping splits and weights.
         2) Front elevation indicating location of devices and instruments.
         3) Sections through switchboard showing space available for conduits.
      b. Conduit entrance locations and requirements.
      c. Nameplate legends.
      d. Configuration, size and number of bus bars for each phase and current rating of buses.
      e. Ground bus.
      f. Neutral bus.
      g. Short circuit ratings of switchboards and overcurrent protective devices, and bus withstand rating.
      h. Instrument details; enclosure types and details.
      i. Wiring diagrams: power, signal and control wiring.
      j. Utility company's metering provisions with indication of approval by utility company.
      k. Descriptive documentation of optional barriers specified for electrical insulation and isolation.
      l. UL listing for series rating of installed devices.
   2. Contractor to submit 1/4" scale floor plans with switchboard locations and required clearances and service space around equipment.
C. Manufacturer's Installation Instructions:
   1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
D. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
E. Complete review of this specification noting for each paragraph whether proposed equipment complies with project specifications or deviates. Justification must be given for each deviation.
F. Closeout Submittals:
   1. Project Record Documents:
      a. Record actual locations, configurations, and ratings of switchboard and major components on single-line diagrams and plan layouts.
   2. Operation and Maintenance Data:
      a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
      b. Include manufacturer's written instructions for testing and adjusting overcurrent protective devices.
      c. Include spare parts data listing, source, and current prices of replacement parts and supplies.
      d. Include Manufacturer Seismic Qualification Certification and Installation Seismic Qualification Certification.

e. Include time-current curves, including selectable ranges for each type of overcurrent protective device.

1.5 QUALITY ASSURANCE

A. Obtain switchboards from one source and by single manufacturer.

B. Regulatory Requirements:

1. Comply with NFPA 70 for components and installation.
2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, fumes, water, corrosive substances, construction debris, and traffic. Provide temporary heaters in switchboards as required to prevent condensation.

B. Deliver switchboards individually wrapped for protection, and mounted on shipping skids. Mark crates, boxes, and cartons clearly to identify equipment. Show crate, box, or carton identification number on shipping invoices.

C. Handle switchboards in accordance with NEMA PB 2.1 and ANSI/NECA 400. Use factory-installed lifting provisions. Handle carefully to avoid damage to switchboard internal components, enclosure, and finish.

1.7 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - <u>PRODUCTS</u>

2.1 MANUFACTURERS

A. Square D

2.2 RATINGS

A. Nominal system voltage: As indicated on the drawings or scheduled.

B. Main bus continuous amp: As indicated on the drawings or scheduled.

C. Short circuit current rating: as indicated on drawings.

D. Brace switchboard components to withstand mechanical forces for symmetrical fault current shown.

2.3 CONSTRUCTION

A. NEMA PB 2, UL 891

B. Free-standing, dead-front type; vertical sections bolted together; sides and rear covered with removable bolt-on covers; adequate ventilation within enclosure; supporting frame: steel rigidly fastened together, with same outside dimensions as the enclosure.

C. Adequate strength and rigidity necessary to resist conditions of use to which it may be subjected and to support equipment, devices and appurtenances contained therein.

D. Incoming lug locations: Top or bottom, as coordinated by electrical contractor.

E. UL service entrance label.

F. Environmental Limitations:

1. Ambient temperatures: Not exceeding 40°C.
2. Temperature rise: Not to exceed 65°C over a 40°C ambient environment, with no derating required.

G. Device Mounting and Type:

1. Front accessible switchboard: Rear aligned for placement against the wall:
   a. Main device: Panel mounted circuit breaker
   b. Feeder devices: Panel mounted circuit breakers
   c. Devices: Front removable; load connections: Front accessible.

H. Bus:

1. Material: Copper; copper: 98% conductivity. The bus bars shall have sufficient cross-sectional area to meet UL 891 temperature rise requirements through actual tests. The bus bars shall be standard density rated for 1000 amperes per square inch copper.

2. Connections:
   a. Bolted:
      1) Not fewer than 4 bolts for each 4” x 4” contact.
      2) Not fewer than 2 bolts for each 2” x 2” contact.
      3) Grade 5 bolts and conical spring-type washers.
      4) Clamp joints are not allowed.
3. Sizing: Standard size, based on 65°C over 40°C.
4. Main Phase Buses: Three phase, 4 wire; fully rated; uniform capacity for entire length of switchboard; ampacity as indicated on drawings; rated for the main protective device frame size or main incoming conductors.
5. All feeder device line and load connection straps: Rated to carry current rating of device frame (not trip rating).
6. Support for Buses: Mounted on high-impact, non-tracking insulated supports; joints in the vertical bus are not permitted.
7. Bus arrangement: A-B-C (left to right, top to bottom, front to rear).

I. Ground Bus: Extend length of switchboard.
1. 1/4” x 2” minimum-size, hard-drawn copper of 98 percent conductivity, equipped with pressure connectors for feeder ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection.

J. Neutral Bus: 100% of the ampacity of phase buses, equipped with pressure connectors for outgoing circuit neutral cables. Bus extensions for busway feeder neutral bus are braced.

K. Main incoming compartment.

L. Hinged Front Doors: Allow access to metering and accessory compartments; concealed hinges; fastened by head bolts.

M. Cable Supports: For each vertical section.

N. Dimensions: 90” maximum height, excluding floor sills, lifting members and pull boxes. Length and depth indicated scaled on the drawing are maximum allowed.

O. Line and Load Terminations: Mechanical type accessible from front only of switchboard, suitable for conductor materials and sizes as indicated on drawings; suitable for number, size and trip ratings.

P. Enclosure: Steel, NEMA 250, Type 1

2.4 SERVICE ENTRANCE

A. UL 869A

B. Switchboards labeled as suitable for use as service entrance equipment, where applicable, with incoming line isolation barriers, and a removable neutral bond to switchboard ground for solidly grounded wye systems.

C. Surge arrestors on all phases: per requirements in Section 26 4300 – Surge Protective Devices.

2.5 SHORT CIRCUIT CURRENT RATING

A. Switchboard with minimum short circuit current rating as indicated on drawings.

B. Switchboards: Marked with their maximum short circuit current rating at supply voltage.

C. Switchboards: Fully rated. Series rated switchboards are not acceptable.

2.6 SURGE PROTECTIVE DEVICES (SPD)

A. Furnished under 26 4300 – Surge Protective Devices

B. IEEE C62.41.1; integrally mounted, plug-in style, solid-state, parallel-connected, suppression and filtering modules

C. Per requirements in Section 26 4300 – Surge Protective Devices

2.7 OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker: NEMA AB 1, NEMA AB 3, UL 489; lockable handle; interrupting capacity to meet available fault current.
1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit breaker frame sizes 200 A and below.
2. Electronic (solid-state microprocessor based) trip unit circuit breakers: digital true RMS sensing trip units; interchangeable in the field within the frame size (field-replaceable rating plug to determine the breaker trip rating), field-adjustable settings and the following trip functions for circuit breaker frame sizes 100 A - 1200 A:
   a. Instantaneous trip
   b. Long- and short-time pickup levels

c. Long- and short-time time delay adjustments with I2t response
d. Ground-fault pickup level, time delay, and I2t response

3. Current-Limiting Circuit Breakers: No fusible element, frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
4. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with current-limiting fuses; trip activation on fuse opening or on opening of fuse compartment door.
5. Breakers 800A and greater shall be listed for 100% of breaker's continuous ampere rating.

B. Enclosed, Insulated-Case Circuit Breaker and Accessories: NEMA AB 1, UL 489; fully rated circuit breaker with interrupting capacity rating to meet available fault current.
1. Main breaker shall be insulated-case type circuit breakers. Feeder circuit breakers 600A and above shall be insulated-case type circuit breakers.
2. Two-step, stored-energy closing; manually operated.
3. A charging handle, closed pushbutton, open pushbutton and Off/On/Charge indicator located on the breaker escutcheon and visible with the breaker compartment closed.
4. Electronic (solid-state microprocessor-based) trip units with interchangeable rating plug, trip indicators, field-adjustable settings and the following trip functions:
a. Instantaneous trip.
b. Long- and short-time pickup levels.
c. Long- and short-time time delay adjustments with I2t response.
d. Ground-fault pickup level, time delay, and I2t response.
5. Local and remote trip indication and control.
6. Shunt Trip: 120 V trip coil energized from separate circuit, set to trip at 55% of rated voltage, where indicated.

C. Circuit Breaker Electronic Trip Units general characteristics:
1. Circuit breakers, with solid-state microprocessor based trip units:
a. Unit shall consist of current sensors, solid-state trip device, and solid-state adjustable time/current curve shaping elements.
b. Trip units shall be removable to allow for field upgrades.
c. Trip units shall incorporate “True RMS Sensing.”
2. Solid-state elements shall provide functions as indicated above.
3. Adjustments shall be made using non-removable, discrete steps.
4. Sealable transparent cover shall be provided over adjustments.
5. Adjustable long-time pickup (Ir) and delay shall be available in an adjustable rating plug that is UL listed as field-replaceable. Adjustable rating plug shall allow for five minimum long-time pickup settings from 0.4 to 1.0 times the sensor plug (In). Other adjustable rating plugs shall be available for more precise settings to match the application. Long-time delay settings shall be at least three bands.
6. Short-time pickup shall allow for five minimum settings from 1.5 to 10 times Ir. Short-time delay shall be at least three bands with I2t ON and OFF.
7. Instantaneous settings on the trip units shall be available in five minimum bands from 2 to 15 times In. The instantaneous settings shall also have an OFF setting when short-time pickup is provided.
8. Trip units shall have the capability to electronically adjust the settings locally and remotely to fine increments below the switch settings. Fine increments for pickup adjustments are to be one ampere. Fine increments for delay adjustments are to be one second.
9. Trip unit shall indicate:
a. Long-time fault
b. Short-time fault
c. Instantaneous fault
d. Ground fault, where provided
10. Trip unit shall provide local trip indication and capability to indicate local and remote reason for trip, i.e., overload, short circuit or ground fault.
11. Trip unit shall contain means to conduct circuit breaker test, or via separate test kit.
12. Breaker shall be equipped with externally accessible test points to be used for field testing.
13. Trip units shall be available to provide real time metering. Metering functions include current, voltage, power and frequency.
14. Trip units shall be provided with the following standard features:
a. True RMS sensing
b. LSI
c. LSIG/Ground-fault trip, where indicated on drawings
d. Ground Fault Alarm (no trip), with external relay, where required
e. Adjustable rating plugs
f. LCD or LED – Long-time pickup

g. LCD or LED – Trip indication
h. Communications
i. LCD dot matrix display
j. Protective relay functions
k. Neutral protection
l. Incremental fine tuning of settings
m. Selectable long-time delay bands

D. Ground Fault protection equipment on breakers, where indicated: Integrally mounted relay and trip unit, push-to-test feature and ground fault indicator:
1. Ground-fault protection with at least three adjustable short-time delay settings and three trip-time delay bands; adjustable current pickup with maximum setting of 1200 amps. Arrange to provide protection for the following:
a. Three-wire circuit or system
b. Four-wire circuit or system
c. Four-wire, double-ended substation
2. Neutral current transformers shall be provided for 4-wire system.
3. Ground-fault settings for circuit breaker sensor sizes 1200 A or below shall be in nine bands from 0.2 to 1.0 times In. The ground-fault settings for circuit breakers above 1200 A shall be in minimum three bands up to 1200 A.
4. Ground-Fault Relay: UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and 3-phase current transformer/sensor.

2.8 CONTROL POWER, COMPONENTS IDENTIFICATION, AND CONTROL WIRING

A. Control Circuits: 120 V, supplied through secondary disconnecting devices from control-power transformer.
B. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control-power transformer at the line side of the associated main circuit breaker. 120 V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.
C. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
D. Control components mounted within assembly, such as relays, pushbuttons, switches, etc.: Suitably marked for identification, corresponding to appropriate designations on manufacturer's wiring diagrams.
E. Control Wiring: Factory installed, with bundling, lacing, and protection included; flexible conductors for #8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units; insulated locking spade terminals for all control connections, except where saddle type terminals, integral to a device; current transformer secondary leads, connected to short circuit terminal blocks; terminal blocks with suitable numbering strips for group of control wires leaving switchboard, with wire markers at each end of control wiring.

2.9 ACCESSORY COMPONENTS AND FEATURES

A. Furnish portable test set to test functions of solid-state trip devices without removal from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.
B. Furnish accessory set including tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
C. Furnish one portable, floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.
D. Furnish overhead circuit breaker lifting devices, mounted at top front of switchboard, with hoist and lifting yokes matching each drawout circuit breaker.
E. Furnish set of tools for manually charging circuit breaker stored energy device.
F. Lockout Devices: Circuit breakers with integral, lockout/tagout devices.

PART 3 - EXECUTION

3.1 COORDINATION

A. Instruct manufacturer about the location of incoming lugs, i.e., top or bottom feed based on incoming feeder entrance location.
B. Coordinate installation of housekeeping concrete pad based on actual equipment supplied:
1. Concrete: Per requirements in Division 03 – Concrete.
2. Dimensions: Per requirements in Section 26 0529 – Hangers and Supports for Electrical Systems.

C. Coordinate with miscellaneous trades for equipment foreign to the electrical installation to be outside of dedicated electrical space.
D. Coordinate utility company metering equipment requirements.
E. Verify with manufacturer that “touch-up” paint kit is available for repainting.

3.2 EXAMINATION

A. Examine areas and surface to receive switchboards for compliance with requirements, installation tolerances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.
B. Verify that space indicated for switchboard mounting meets code-required working clearances.
C. Notify Architect/Engineer of any discrepancies prior to submittal of product data and shop drawings.

3.3 INSTALLATION

A. Install switchboard in accordance with NEMA PB 2.1 and ANSI/NECA 400.
B. Switchboard mounting and seismic restraints:
   1. Bolt switchboards to concrete housekeeping pads, using anchor bolts in accordance with Section 26 0529 – Hangers and Supports for Electrical Systems. Cast anchor bolt inserts into pads.
   2. Install bushing assemblies for anchor bolts for seismic restraints per requirements in Section 26 0548 – Vibration and Seismic Controls for Electrical Systems.
C. Install engraved plastic nameplates under provisions of Section 26 0553 – Electrical Systems Identification for switchboard, every instrument, overcurrent protective device and disconnect device. Attach nameplate to exterior of switchboard using small corrosion-resistant metal screws and rivets. Do not use contact adhesive. Indicate switchboard manufacturer’s name and drawing number, name, amperage, voltage, phase, number of wires, short circuit current rating (amp, RMS symmetrical and MVA 3-phase symmetrical) and momentary and fault-closing ratings (amp, RMS asymmetrical). For each overcurrent protective device and disconnect device, include circuit, load and area served, voltage/phase rating, and fuse size and type, when applicable.
D. Provide framed, printed operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of switchboards.
E. Install switchboards in dedicated electrical space per NFPA 70, and as indicated on drawings.
F. Tighten electrical connectors and terminal according to equipment manufacturer’s published torque-tightening values. Where manufacturer’s torque values are not indicated, use those specified in UL 486A-486B.
G. Install fuses in fusible switch at job site per requirements in Section 26 2813 – Fuses.
H. Install surge arrestors in cable termination compartments and connect to each phase of circuit, per requirements in Section 26 4300 – Surge Protective Devices.
I. Connect surge protective devices to switchboard bus per requirements in Section 26 4300 – Surge Protective Devices.
J. Install utility company metering equipment, devices and wiring in conformance with serving utility requirements.
K. 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.
L. Apply temporary heat to maintain temperature according to manufacturer’s written instructions.

3.4 CONNECTIONS

A. Ground switchboards according to Section 26 0526 – Grounding and Bonding for Electrical Systems.
B. Connect power and control wiring according to Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables.

3.5 FIELD QUALITY CONTROL

A. Inspect switchboards for physical damage, proper alignment, connections, anchorage, seismic restraints and grounding.
B. Test continuity of each circuit.
C. Test switchboards per requirements in Sections 26 0812 – Power Distribution Acceptance Tests and 26 0813 – Power Distribution Acceptance Test Tables.
D. Interpret test results in writing and submit to Engineer.
E. Test switch operators after energizing.

3.6 REPAINTING

A. Remove paint splatters and other marks from surface of equipment.

B. Touch-up chips, scratches or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Owner.

3.7 ADJUSTING

A. Set field-adjustable circuit breakers trip settings or change the trip settings to values indicated on drawings or recommended by the overcurrent protective device coordination study per Section 26 0573 – Power System Studies.

B. Field adjustments or changing of trip setting and adjustment or replacement of equipment to comply with Section 26 0573 – Power System Studies; no additional cost to Owner.

3.8 CLEANING

A. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.

3.9 DEMONSTRATION

A. Provide training session by manufacturer for one workday at a job location, to train the Owner's personnel in the operation and maintenance of switchboards.

END OF SECTION

SECTION 26 24 16.13
LIGHTING AND APPLIANCE PANELBOARDS

PART 1 – GENERAL
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PART 1 - GENERAL

1.1 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
G. Section 26 0812 – Power Distribution Acceptance Tests
H. Section 26 0813 – Power Distribution Acceptance Test Tables
I. Section 26 4300 – Surge Protective Devices

1.2 DESCRIPTION
A. Section includes circuit breaker type lighting and appliance branch circuit panelboards as shown on drawings and as scheduled.

1.3 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

1.4 SUBMITTALS

A. Product Data:
   1. Submit catalog data showing specified features of standard products. Eliminate extraneous catalog data.

B. Shop Drawings:
   1. Submit for review prior to manufacture. Include complete description, front view, dimensions, voltage, main bus ampacity, circuit breaker arrangement and sizes, short circuit current rating, and factory settings of individual protective devices.
   2. Submit 1/4" scale electrical room floor plans with panelboard locations.

C. Partial Submittals:
   1. Panelboards shall be submitted for review together. Partial submittals of panelboards are not acceptable and will be rejected.

D. Manufacturer's Installation Instructions:
   1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

E. Test Reports:
   1. Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.

F. Closeout Submittals:
   1. Project Record Documents:
      a. Record actual locations of panelboards and record actual circuiting arrangements.
   2. Operation and Maintenance Data:
      a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
      b. Include manufacturer's written instructions for testing and adjusting overcurrent protective devices.
      c. Include time-current curves and selectable ranges for each type of overcurrent protective device.
      d. Include spare parts data listing, source, and current prices of replacement parts and supplies.
      e. Include manufacturer's Seismic Qualification Certification and Installation Seismic Qualification Certification.

1.5 QUALITY ASSURANCE

A. Obtain panelboards, overcurrent protective devices, components, and accessories from one source and by single manufacturer.

B. Regulatory Requirements:
   1. Comply with NFPA 70.
   2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.6 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.

1.7 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

1.8 MAINTENANCE

A. Extra Materials:
   1. Furnish Owner with two keys per panelboard.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Square D

2.2 LIGHTING AND APPLIANCE BRANCH CIRCUIT PANELBOARDS

A. NEMA PB 1, UL 67
B. Fabrication:
   1. Factory assembled.
   2. With door-in-door construction.
   3. Incoming feeder lugs: copper conductors.
   4. Multiple lugs to match number of conductors per phase.
   5. Sub-feed (double) lugs, or feed-through lugs where indicated.
   6. Filler plates.
   7. Wiring terminals for field installed conductors: Pressure wire connectors, except wire-binding screws for #10 AWG or smaller conductors.
C. Panelboard Buses:
   1. Copper
   2. Ampere rating as scheduled
   3. Ground bus: uninsulated, bonded to panelboard cabinet
   4. Insulated neutral bus: 100% of phase bus rating
D. Molded-Case Circuit Breakers:
   1. NEMA AB 1, UL 489
   2. Bolt-on type, labeled for 75°C copper and aluminum conductors
   3. Quick-make, quick-break, with thermal-magnetic trip.
   4. Common internal trip on multi-pole breakers. Handle-ties are not permitted.
   5. Ampere rating as scheduled
   6. Listed as Type SWD for lighting circuits
   7. Listed as Type HACR for air conditioning equipment circuits
   8. Bussing, device mounting hardware, and steel knockouts in dead front where “space” is indicated
   9. Tandem circuit breakers are not acceptable
   10. 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.
   12. Ground fault circuit interrupter (GFCI), rated at 4-6 mA trip for protection of personnel, where indicated
   13. For 200A frame size and below: thermal-magnetic trip
   14. For 225A frame size and above: electronic trip units with 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.

2.3 SHORT CIRCUIT CURRENT RATING

A. Each panelboard with minimum short circuit current rating as indicated on drawings.
B. Panelboards marked with their maximum short circuit current rating at supply voltage.
C. Panelboards: Fully rated. Series-rated panelboards are not acceptable.

2.4 SURGE PROTECTIVE DEVICES (SPD)

A. By panelboard manufacturer.
B. As indicated on drawings
C. Per requirements in Section 26 4300 – Surge Protective Devices.

2.5 SPARE CONDUITS

A. Spare conduits per requirements in Section 26 0533 – Raceway and Boxes for Electrical Systems.

PART 3 - EXECUTION

3.1 COORDINATION WITH MANUFACTURER

A. Instruct manufacturer about the location of additional wiring gutter space when required (i.e., top, bottom, right, left, or combination).

B. Instruct manufacturer about the location of main lugs or main circuit breaker (i.e., top or bottom feed based on incoming feeder entrance location).
C. Instruct manufacturer to provide multiple lugs where conductors in parallel or sub-feed (double) lugs or feed-through lugs are indicated.
D. Instruct manufacturer on the size of cross-connection cables for panelboards fed via sub-feed (double) lugs or feed-through lugs. Make cable size with ampacity equal to incoming feeder.
E. Verify that “touch-up” paint kit is available for repainting.

3.2 EXAMINATION

A. Verify that space indicated for panelboard mounting meets code-required working clearances and dedicated equipment space.
B. Notify Architect/Engineer of any discrepancies prior to submittal of product data and shop drawings.

3.3 INSTALLATION

A. Install panelboards in accordance with NECA 407 and NEMA PB 1.1.
B. Install panelboards plumb and rigid without distortion of box, in accordance with manufacturer's written instructions, and in compliance with recognized industry practices.
C. Panelboard mounting and seismic restraints:
1. 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. Coordinator 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 or rivets. Do not use contact adhesive.
1. Include panelboard name, amperage, voltage, phase, and number of wires.
H. Label spare circuits as SPARE. Leave spare breakers in OFF position.
I. Room numbers used shall be those used by Owner except as otherwise directed by Architect.
J. Install panelboard in dedicated electrical space per NFPA 70 and as shown on drawings. Coordinate with miscellaneous trades for equipment foreign to the electrical installation to be outside of dedicated electrical space.
K. Install filler plates in unused spaces.
L. Install three 3/4” spare conduits stubbed into accessible ceiling space or space designated to be ceiling space in the future for all flush-mounted panelboards. Install conduits in accordance with requirements in Section 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.

3.4 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.

3.5 FIELD QUALITY CONTROL

A. Inspect for physical damage, proper alignment, anchorage, and grounding.
B. Maintain proper phasing for multi-wire circuits.

C. Test main circuit breakers in accordance with requirements in Sections 26 0812 – Power Distribution Acceptance Tests and 26 0813 – Power Distribution Acceptance Test Tables.
D. Interpret test results in writing and submit to Engineer.
E. Check panelboards for electrical continuity of circuits and for short-circuits prior to energization.

3.6 REPAINTING

A. Remove paint splatters or other marks from surface of panelboards.
B. Touch-up chips, scratches, or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Owner.

3.7 ADJUSTING

A. Adjust fronts, covers, hinges, and locks.

3.8 CLEANING

A. Clean panelboard interiors and exteriors prior to final inspection. Remove paint splatters and other spots, dirt and debris.

END OF SECTION

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SECTION 26 24 16.16

DISTRIBUTION PANELBOARDS

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PART 1 - GENERAL

1.1 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 0812 – Power Distribution Acceptance Tests
G. Section 26 0813 – Power Distribution Acceptance Test Tables
H. Section 26 2813 – Fuses

1.2 DESCRIPTION

A. Section includes circuit breaker type and fusible switch type power distribution panelboards as shown on drawings and as scheduled.

1.3 REFERENCE STANDARDS

A. NECA 407 - Recommended Practice for Installing and Maintaining Panelboards
B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
C. NEMA AB 1 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
D. NEMA FU 1 - Low-Voltage Cartridge Fuses
E. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
F. NEMA PB 1 - Panelboards
G. NEMA PB 1.1 - General Instructions for Proper Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or Less
H. NFPA 70 - National Electrical Code
I. UL 50 - Enclosures for Electrical Equipment
J. UL 67 - Panelboards
K. UL 486A – 486B - Wire Connectors
L. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
M. UL 512 - Fuseholders

N. UL 869A - Reference Standard for Service Equipment

1.4 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.
      e. Include manufacturer's Seismic Qualification Certification and Installation Seismic Qualification Certification.

1.5 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.

1.6 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.

1.7 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

1.8 MAINTENANCE

A. Extra Materials:
   1. Furnish Owner with two keys per panelboard.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Square D

2.2 POWER DISTRIBUTION PANELBOARDS

A. NEMA PB 1, UL 67.

B. Fabrication:

1. Factory assembled
2. Individualized breaker dead-front cover with door-in-door construction
3. Incoming feeder lugs: copper conductors
4. Multiple lugs to match number of conductors per phase
5. Sub-feed (double) lugs, or feed-through lugs where indicated
6. Filler plates
7. Wiring terminals for field installed conductors: Pressure wire connectors, except wire-binding screws for #10 AWG or smaller conductors.

C. Panelboard Buses:

1. Copper
2. Ampere rating as scheduled
3. Ground bus: uninsulated, bonded to panelboard cabinet
4. Insulated neutral bus 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 100A frame size and below: thermal-magnetic trip
13. For 110A 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.
14. Locks on trip handles where indicated

E. Cabinet

1. NEMA 250, UL 50
2. NEMA Type 1, Type 3R (outdoor locations) enclosure.
3. Four-piece front (trim) surface mounted with door over the front, with concealed self-adjusting trim clamps, and complete with cylinder-type lock and catch except omit door in fusible switch panelboard
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

2.3 METERS

A. Provide separate metering compartments with digital meter in accordance with Section 26 2713 - Electrical Metering.

2.4 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.

2.5 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.

2.6 SURGE PROTECTIVE DEVICES (SPD)

A. Furnished under 26 4300 – Surge Protective Devices
B. As indicated on drawings
C. Per requirements in Section 26 4300 – Surge Protective Devices.

PART 3 - EXECUTION

3.1 COORDINATION WITH MANUFACTURER

A. Instruct manufacturer about the location of additional wiring gutter space when required, i.e. top, bottom, right, left, or combination.
B. Instruct manufacturer about the location of main lugs or main circuit breaker (i.e., top or bottom feed based on incoming feeder entrance location).
C. Instruct manufacturer to provide multiple lugs where conductors in parallel or sub-feed (double) lugs or feed-through lugs are indicated.
D. Instruct manufacturer on the size of cross-connection cables for panelboards fed via sub-feed (double) lugs or feed-through lugs. Make cable size with ampacity equal to incoming feeder.
E. Verify that “touch-up” paint kit is available for repainting.

3.2 EXAMINATION

A. Verify that space indicated for panelboard mounting meets code-required working clearances and dedicated equipment space.
B. Notify Architect/Engineer of any discrepancies prior to submittal of product data and shop drawings.

3.3 INSTALLATION

A. Install panelboards in accordance with NECA 407 and NEMA PB 1.1.
B. Install panelboards plumb and rigid without distortion of box, in accordance with manufacturer's written instructions, and in compliance with recognized industry practices.
C. Panelboard mounting and seismic restraints:
    1. 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) 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, 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.
L. Install fuses in fusible switches, per requirements in Section 26 2813 – Fuses.

3.4 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.

3.5 FIELD QUALITY CONTROL

A. Inspect for physical damage, proper alignment, anchorage, and grounding.
B. Test circuit breakers per requirements in Sections 26 0812 – Power Distribution Acceptance Tests and 26 0813 – Power Distribution Acceptance Test Tables.
C. Interpret test results in writing and submit to Engineer.
D. Check panelboards for electrical continuity of circuits and for short-circuits prior to energizing.

3.6 REPAINTING

A. Remove paint splatters or other marks from surface of panelboards.
B. Touch-up chips, scratches, or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint to Owner.

3.7 ADJUSTING

A. Adjust fronts, covers, hinges, and locks.
B. Circuit Breakers: Set field-adjustable trip settings or change the trip settings recommended by the overcurrent protective device coordination study per Section 26 0573 – Power System Studies.

3.8 CLEANING

A. Clean panelboard interiors and exteriors prior to final inspection. Remove paint splatters and other spots, dirt and debris.

END OF SECTION

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SECTION 26 27 26
WIRING DEVICES

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PART 1 - GENERAL

1.1 RELATED WORK
A. Section 26 0526 - Grounding and Bonding for Electrical Systems
B. Section 26 0553 - Electrical Systems Identification

1.2 DESCRIPTION
A. Section includes general-use snap switches, wall-box dimmers, fan speed controls, receptacles, hazardous (classified) location receptacles, pendant cord-connector devices, cord and plug sets and device cover plates.

1.3 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 FB 11 – Plugs, Receptacles, and Connectors of the Pin and Sleeve Type for Hazardous Locations
F. NEMA WD-1 – General Color Requirements for Wiring Devices
G. NEMA WD-6 – Wiring Devices - Dimensional Requirements
H. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum)
I. UL 20 – General-Use Snap Switches
J. UL 498 – Attachment Plugs and Receptacles
K. UL 943 – Ground-Fault Circuit-Interrupters
L. UL 1010 – Receptacle-Plug Combinations for Use in Hazardous (Classified) Locations
M. UL 1436 – Outlet Circuit Testers and Similar Indicating Devices
N. UL 1449 – Transient Voltage Surge Suppressors
O. UL 1472 – Solid-State Dimming Controls
P. UL 1917 – Solid-State Fan Speed Controls

1.4 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.

1.5 QUALITY ASSURANCE

A. Obtain wiring devices from one source and by single manufacturer.
B. Regulatory Requirements:
   1. Comply with NFPA 70 for components and installation.
   2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory unopened packaging until ready for installation.

1.7 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.
B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - <u>PRODUCTS</u>

2.1 MANUFACTURERS

A. Cooper Wiring Devices; a division of Cooper Industries, Inc.
B. Hubbell Incorporated; Wiring Device-Kellems
C. Leviton Manufacturing Company, Inc.
D. Pass & Seymour/Legrand; Wiring Devices & Accessories

2.2 GENERAL-USE SNAP SWITCHES

A. Comply with NEMA WD 1 and UL 20.
B. Switches: Heavy-duty (specification grade); back and side wired; flush or surface mounting; Body and Handle: thermoplastic with 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. Double pole
   4. Three-way
   5. Four-way
   6. Locator Light: Lighted handle type switch (single pole with green neon-lighted handle, illuminated when switch is "OFF.")
   7. Pilot Light: Indicator light switch (single pole with green neon-lighted handle, illuminated when switch is "ON."
   8. Locking Type: Designed to prevent tampering and unauthorized switching.
   9. Key-Operated: Single pole, with factory-supplied key in lieu of switch handle.
   10. Single-Pole, Double-Throw, Momentary Contact, Center-Off: For use with mechanically held lighting contactors.

11. Key-Operated, Single-Pole, Double-Throw, Momentary Contact, Center-Off: For use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.
12. Pendant and Through-cord: For field installation on flexible cord and provided with one “ON’ and one “OFF” position.
13. Switches for Connections to Aluminum Conductors: Comply with UL 1567.
14. Weatherproof: Toggle switch

2.3 WALL-BOX DIMMERS

A. Comply with NEMA WD 1 and UL 1472.
B. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.
   1. Power Rating: 600watts minimum
   2. Body: Thermoplastic
   3. Control: Continuously adjustable slider with single-pole or three-way switching.
   4. Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.
   5. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20% of full brightness; 277 V.

2.4 RECEPTACLES

A. Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
B. Receptacles: 125 V, 20A, heavy-duty (specification grade); back and side wired; flush or surface mounted; straight blade; 2 pole, 3 wire grounding; thermoplastic body; duplex as indicated on drawings.
   1. Ground Fault Circuit Interrupter (GFCI):
      a. Additional compliance with UL 943 Class A.
      b. Leakage current trip level: 4 to 6 mA.
      c. Trip time: .025 seconds nominal.
      d. 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. Isolated Ground (IG):
      a. Ground strap isolated from mounting strap.
      b. Ground screw connected directly to ground contacts.
   3. 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.”
   4. Tamper Resistant (TR):
      a. Requires insertion of object in both left and right contacts to energize.
      b. 2- or 3-prong plug.
   5. Twist-locking:
      a. NEMA WD 6 configuration as indicated on drawings.
   6. Switched: Upper half switched and lower half not switched.
   7. Dedicated: Labeled “Dedicated.”
   8. Special Purpose Receptacles: Specification grade, rated for voltage, amperage and NEMA configuration as noted on drawings.

2.5 DEVICE COVER PLATES

A. Single and combination types to match corresponding wiring devices:
   1. Attachment: Metal screws with head color to match plate finish.
   2. Material for Finished Spaces: Smooth, high-impact thermoplastic
   3. Material for Unfinished Spaces: Galvanized steel.
B. Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant, die-cast aluminum with weatherproof while-in-use hinged cover.
C. Lockable Cover:
   1. Hinged steel cover with cylinder lock.

2. Keyed all the same

2.6 FINISHES

A. Color:
1. Switch handles, receptacle faceplates, and device cover plates: white, except as follows:
a. Switch handles and receptacle faceplates connected to Emergency or Standby Power System: Red; labeled “Emergency.”

PART 3 - EXECUTION

3.1 COORDINATION

A. Special Purpose Receptacles: Coordinate final selections of NEMA configuration (locking, straight, blade, etc.) with configuration of plug on utilization equipment.
B. Receptacles for Owner-furnished equipment and equipment furnished under other divisions of specifications: Match plug configurations.
C. Cord and Plug Sets: Match equipment requirements.
D. Coordination with Other Trades:
1. Take steps to ensure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers guided by riding against outside of the boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the device cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.

3.2 EXAMINATION

A. Verify location of wiring devices with architectural interior elevation drawings, prior to rough-in.
B. Verify outlet boxes are installed at proper height.
C. Verify wall openings are neatly cut and completely covered by wall plates.
D. Verify branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.

3.3 PREPARATION

A. Clean debris from outlet boxes.

3.4 INSTALLATION

A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise scheduled or indicated on drawings. Indicated dimensions are to center of device.
B. Conductors:
1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. Length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Do not place bare stranded conductors directly under device screws. Use crimp on fork terminals for device terminations.
C. Device Installation:
1. Replace all devices that have been in temporary use during construction or show signs of installation prior to completion of building finishing operations.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6” in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
7. When conductors larger than #12 AWG are installed on 15A or 20A circuits, splice #12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.

9. When mounting into metal boxes, remove fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.
10. Install devices plumb, level with finished surfaces and free from blemishes.
11. Install lighting switches vertically on latch side of door within 6" of frame edge.
12. Install devices above counters, 2" to the bottom of device above countertop or backsplash. Install all devices at same height above any one counter or fixed cabinet.
13. Install special purpose receptacles and switches according to shop and rough-in drawings furnished by trade(s) producing such equipment. Verify locations prior to rough-in.
14. Install weatherproof GFCI receptacles:
    a. Within 25'-0" of roof-mounted mechanical equipment
    b. Outdoors
    c. As indicated on drawings
15. Group adjacent switches under single, multigang wall plates.
16. Connect wiring device grounding terminal to outlet box with bonding jumper and branch circuit equipment grounding conductor. Ground per requirements in Section 26 0526 – Grounding and Bonding for Electrical Systems.
17. GFCI style receptacles shall be installed so that the GFCI receptacle is the last device in line for a circuit or wired in parallel such that a trip of the GFCI device does not take out the circuit for downstream devices including additional GFCI receptacles.

D. Installation Orientations:
1. Install ground pin of vertically mounted receptacles up and on horizontally mounted receptacles to the left.
2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.
3. Install switches with handle operating vertically, with "ON" position up.
4. Unless otherwise indicated or where space problem occurs, mount devices flush, with long dimension vertical.

E. Device Cover Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

F. Wall-Box Dimmers:
1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

G. Arrangement of Devices:
1. Unless otherwise indicated or where space problem occurs, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

3.5 IDENTIFICATION

A. Comply with Section 26 0553 – Electrical Systems Identification.
1. Switches and Receptacles: Use printed clear labels with black filled lettering on face of cover plate, and durable wire markers or tags inside outlet boxes.
    a. Receptacles: Label shall indicate receptacle voltage, phase, and amperage for receptacles other than 20A, 120 V, at top of cover plate, and panel and circuit number at bottom of cover plate.
    b. Switches: Label shall indicate switch voltage, phase, and amperage at top of cover plate, and panel, circuit number and switch designation at bottom of cover plate.
2. Engrave cover plates on all Owner-furnished equipment and equipment furnished under other divisions of these specifications with panelboard, circuit number and "emergency" (where applicable) as specified in this section. This includes headwalls, gas columns and booms, patient consoles, medical rail systems, custom casework with electrical devices, etc.

3.6 FIELD QUALITY CONTROL

A. Inspect wiring devices for defects.
B. Operate wall switches with circuits energized and verify proper operation.
C. Verify receptacle device is energized.

D. Perform tests and prepare test reports:
   1. Test receptacle devices for proper polarity:
      a. Test every receptacle with receptacle circuit tester. Tester shall test for open ground, reverse polarity, open hot, open neutral, hot and ground reversed, hot or neutral and hot open. Rewire receptacles with faults and retest.
   2. Test each GFCI receptacle device for proper operation:
      a. Perform testing using an instrument specifically designed and manufactured for testing ground-fault circuit interrupters. Apply the test to the receptacle. "TEST" button operation will not be acceptable as a substitute for this test. Replace receptacles that do not shut off power with 5/1000 A within 1/40 second and retest.
   3. In healthcare facilities, prepare reports that comply with recommendations in NFPA 99.
   4. Test Instruments: Use instruments that comply with UL 1436.
   5. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

E. Tests for Convenience Receptacles:
   1. Line Voltage: Acceptable range is 105 V to 132 V.
   2. Percent Voltage Drop under 15A Load: A value of 5% or higher is not acceptable.
   3. Ground Impedance: Values of up to 2 ohms are acceptable.
   4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
   5. Using the test plug, verify that the device and its outlet box are securely mounted.
   6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

F. Operational Tests: Demonstrate the operation of each switch with the systems fully energized and operating. Each switch shall be demonstrated three times.

G. Interpret test results in writing and submit to Engineer.

3.7 ADJUSTING

A. Adjust devices and wall plates to be flush and level.

3.8 CLEANING

A. Remove excess plaster from interior of outlet boxes.

B. Clean devices and cover plates after painting is complete. Replace stained or improperly painted devices and cover plates.

END OF SECTION

SECTION 26 28 13
FUSES

PART 1 – GENERAL
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2.2 CARTRIDGE FUSES
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3.3 APPLICATION
3.4 CLEANING

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 0573 - Power System Studies
B. Section 26 2300 - Low-Voltage Switchgear
C. Section 26 2413 - Switchboards
D. Section 26 2416.16 - Distribution Panelboards
E. Section 26 2419 - Motor Control Centers
F. Section 26 2816 - Enclosed Switches and Circuit Breakers
G. Section 26 2913 - Enclosed Controllers

1.2 DESCRIPTION

A. Section includes nonrenewable cartridge fuses, rated 600V and less, for use in low-voltage power distribution system and spare fuse cabinet.

1.3 REFERENCE STANDARDS

A. NEMA FU 1 - Low Voltage Cartridge Fuses
B. UL 248-1 - Low Voltage Fuses - Part 1: General Requirements
C. UL 248-4 - Low-Voltage Fuses - Part 4: Class CC Fuses
D. UL 248-5 - Low-Voltage Fuses - Part 5: Class G Fuses
E. UL 248-8 - Low-Voltage Fuses - Part 8: Class J Fuses
F. UL 248-10 - Low-Voltage Fuses - Part 10: Class L Fuses
G. UL 248-12 - Low-Voltage Fuses - Part 12: Class R Fuses
H. UL 248-15 - Low-Voltage Fuses - Part 15: Class T Fuses
I. UL 512 - Fuseholders

1.4 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.

1.5 QUALITY ASSURANCE

A. Obtain fuses from one source and by single manufacturer.

B. Comply with NFPA 70 for components and installation.

1.6 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 1 fuse pullers for each size fuse.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Cooper Bussmann

B. Mersen

C. Littelfuse

D. Edison Fusegear

2.2 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.)
248-4	CC	600	0-30	200,000
248-5	G	600	0-20	100,000
248-5	G	480	25-60	100,000
248-8	J	600	0-600	200,000
248-10	L	600	601-6000	200,000
248-12	RK1	250 or 600	0-600	200,000
248-12	RK5	250 or 600	0-600	200,000
248-15	T	300	0-1200	200,000
248-15	T	600	0-800	200,000

2.3 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

2.4 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

2.5 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

3.1 EXAMINATION

A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

3.2 INSTALLATION

A. Verify proper fuse locations, sizes, and characteristics.
B. Install fuses in fusible devices (specified in Sections 26 2300 – Low-Voltage Switchgear, 26 2413 – Switchboards, 26 2416.13 - Lighting and Appliance Panelboards, 26 2416.16 – Distribution Panelboards, 26 2419 – Motor Control Centers, 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 in main electrical room.

3.3 APPLICATION

A. Motor Branch Circuits: Class RK5.
B. Other Branch Circuits: Class RK5.

3.4 CLEANING

A. Clean fuses and tighten connections prior to energizing of equipment.

END OF SECTION

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SECTION 26 28 16
ENCLOSED SWITCHES AND CIRCUIT BREAKERS

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3.8 CLEANING

PART 1 - GENERAL

1.1 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 0812 – Power Distribution Acceptance Tests
G. Section 26 0813 – Power Distribution Acceptance Test Tables
H. Section 26 2813 – Fuses

1.2 DESCRIPTION

A. Section includes fusible and non-fusible disconnect switches and circuit breakers in individual enclosures.

1.3 REFERENCE STANDARDS

A. ANSI//NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting
B. NEMA AB 1 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breakers Enclosures
C. 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

1.4 SUBMITTALS

A. Product Data:
   1. Submit catalog cut sheet indicating voltage, amperage, HP ratings, enclosure type, and dimension, fuse clip features, terminal lugs and all accessories including interlock devices, short circuit current ampere rating and factory settings of individual protective devices.

B. Manufacturer's Installation Instructions:
   1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

C. Test Reports:
   1. Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.

D. Closeout Submittals:
   1. Project Record Documents:
      a. Record actual locations of disconnect switches and ratings of installed fuses.
      b. Record actual locations and continuous current ratings of enclosed circuit breakers.
   2. Operation and Maintenance Data:
      a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
      b. Include spare parts data listing, source, and current prices of replacement parts and supplies.
      c. Include Manufacturer's Seismic Qualification Certification and Installation Seismic Qualification Certification.

1.5 QUALITY ASSURANCE

A. Obtain disconnect switches and enclosed circuit breakers from one source and by single manufacturer.

B. Regulatory Requirements:
   1. Comply with NFPA 70 for components and installation.
   2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.6 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.

1.7 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Square D

2.2 DISCONNECT SWITCHES

A. NEMA KS 1, UL 98

B. Load interrupter enclosed knife switch, heavy-duty type.

C. Fusible or non-fusible type as indicated.

D. Switch Interiors:
   1. Switch blades that are visible in "OFF" position when switch door is open.
   2. Plated current carrying parts.
   3. Removable arc suppressors to permit easy access to line side lugs.

E. Switch Mechanism:
   1. Quick-make, quick-break, with visible blades and externally operable handle.
   2. Lockable only in "OFF" position and accept three industrial type, heavy-duty padlocks.
   3. Dual cover interlock to prevent unauthorized opening of switch door when handle is in "ON" position, and to prevent closing of switch mechanism with door open.
   4. Defeater mechanism to bypass interlock.
   5. Operating handle integral part of enclosure.
   6. Handle to physically indicate "ON" and "OFF" position.

F. Ratings:
   1. Ampacity as indicated on drawings.
   2. Horsepower rated.
G. Fusible Switches:
   1. Rejection clips for Class R fuses specified.
   2. Provisions for Class J or Class L fuses, as applicable.
   3. Fuses: Per requirements in Section 26 2813 – Fuses.
H. Provide 6-pole switches for multi-speed motors.

2.3 ENCLOSED CIRCUIT BREAKERS

A. NEMA AB 1, UL 489.
B. Enclosed molded-case circuit breakers:
   1. Tripped indication clearly shown on breaker handle taking position between “ON” and “OFF”.
   2. 200A frame size and below: thermal-magnetic trip.
   3. 225A 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.
C. Breaker Mechanism:
   1. Quick-make, quick-break.
D. Ratings:
   1. Ampacity as indicated on drawings.
   2. Listed as Type HACR for air conditioning equipment circuits.
   3. Listed as Type SWD for lighting circuits.

2.4 LUGS

A. Front removable lugs.
B. Labeled for 75°C copper and aluminum conductors.
C. Multiple lugs to match number of conductors per phase.
D. Termination of field installed conductors: Pressure wire connectors, except wire-binding screws for #10 AWG or smaller conductors.

2.5 ACCESSORIES:

A. Solid neutral assembly, where required.
B. Equipment ground kit.
C. One set of normally open (NO) auxiliary contacts, where disconnect switch is installed at a remote motor served by variable frequency drive (VFD).

2.6 ENCLOSURES

A. NEMA KS 1, NEMA AB 1, UL 98, UL 489, as applicable.
B. NEMA Type 1, Type 3R (outdoor locations) enclosure.
C. Code-gauge galvanized steel.
D. Manufacturer’s standard gray enamel finish over prime coat.
E. Surface-mounted.

2.7 SERVICE ENTRANCE

A. UL 869A
B. Switches and circuit breakers identified for use as service entrance equipment are to be labeled for this application, provided with solid neutral assembly and equipment ground bar, and must include connection for bonding and grounding of neutral conductor.

2.8 SHORT CIRCUIT CURRENT RATING

A. Each circuit breaker shall have minimum short circuit current rating as indicated on drawings.

PART 3 - EXECUTION

3.1 COORDINATION WITH MANUFACTURER

A. Instruct manufacturer about the location of incoming lugs, i.e., top or bottom feed based on incoming feeder entrance location.

B. Verify that “touch-up” paint kit is available for repainting.

3.2 EXAMINATION

A. Examine areas and surface to receive disconnect switches and enclosed circuit breakers for compliance with requirements, installation tolerances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Verify that space indicated for disconnect switches and enclosed circuit breakers mounting meets code-required working clearances.

C. Notify Architect/Engineer of any discrepancies prior to submittal of product data and shop drawings.

3.3 INSTALLATION

A. Install disconnect switches and/or enclosed circuit breakers in accordance with ANSI/NECA 1.

B. Install disconnect switches and/or enclosed circuit breakers level and plumb, in accordance with manufacturer’s written instruction.

C. Disconnect switches and enclosed circuit breakers mounting and seismic restraints:

1. Fasten disconnect switches and enclosed circuit breakers firmly to walls and structural surfaces, ensuring they are permanently and mechanically anchored.
2. Anchor and fasten disconnect switches and enclosed circuit breakers and their supports to building structural elements (wood, concrete, masonry, hollow walls and nonstructural building surfaces) by the methods described in Section 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.

3.4 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.

3.5 FIELD QUALITY CONTROL

A. Inspect for physical damage, proper alignment connections, anchorage, and grounding.

B. Correct malfunctioning units on-site and retest to demonstrate compliance. Remove and replace with new units and retest.

C. Test disconnect switches and/or enclosed circuit breakers per requirements in Sections 26 0812 – Power Distribution Acceptance Tests and 26 0813 – Power Distribution Acceptance Test Tables.

D. Interpret test results in writing and submit to Engineer.

3.6 REPAINTING

A. Remove paint splatters and other marks from surface of equipment.

B. Touch-up chips, scratches, or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Owner.

3.7 ADJUSTING

A. Circuit Breakers: Set field-adjustable trip settings or change the trip settings recommended by the overcurrent protective device coordination study per Section 26 0573 – Power System Studies.

3.8 CLEANING

A. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.

END OF SECTION

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SECTION 26 29 13
ENCLOSED CONTROLLERS

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PART 1 - GENERAL

1.1 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 0548 – Vibration and Seismic Controls for Electrical Systems
F. Section 26 0553 – Electrical Systems Identification
G. Section 26 0812 – Power Distribution Acceptance Tests
H. Section 26 0813 – Power Distribution Acceptance Test Tables
I. Section 26 2813 – Fuses

1.2 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. Typically 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.

1.3 REFERENCE STANDARDS

A. ANSI/NECA 1 – Standard Practices for Good Workmanship in Electrical Contracting
B. NEMA AB 1 – Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breakers Enclosures
C. 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

1.4 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.
c. Include Manufacturer Seismic Qualification Certification and Installation Seismic Qualification Certification.

1.5 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.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, water, construction debris, and traffic.

1.7 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.
B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

1.8 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

2.1 MANUFACTURERS

A. Square D
B. General Electric
C. Cutler-Hammer
D. Siemens

2.2 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, red pilot light, (NO) (NC) auxiliary contact, and toggle operator.

2.3 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, (red) (green) pilot light, and toggle operator.

2.4 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[(red) (green) pilot light, and toggle operator.

2.5 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.
   4. Features:
      a. Auxiliary Contacts: NEMA ICS 2, 2 each normally open and normally closed contacts in addition to seal-in contact.
      b. Pilot Lights NEMA ICS 5: push-to-test LED type.
      c. Hand-Off-Auto (H-O-A) Selector Switches: Rotary type.
      d. 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.
      e. Terminals: NEMA ICS 4.
      f. Other accessories detailed or required by drawings.

2.6 COMBINATION CONTROLLERS

A. Factory-assembled motor controllers with externally operable disconnect, fusible switch type, in common enclosure; means for locking disconnect handle and means for defeating cover interlock.
   1. Fusible Switch: NEMA KS 1 and UL 98; enclosed knife switch, heavy-duty type, external operable handle, clips or pads to accommodate specified fuses:
      a. Rejection clips for Class R fuses.
      b. Provisions for Class J or Class L fuses, as applicable.
      c. Fuses: Per requirements in Section 26 2813 – Fuses.

2.7 FULL VOLTAGE NON-REVERSING MULTI-SPEED MAGNETIC MOTOR CONTROLLERS

A. Description: Same as full voltage non-reversing single-speed magnetic motor controllers with addition of the following:
   1. Speed selector switch
   2. Auto-Off-Low-High selector switch

2.8 REDUCED VOLTAGE MOTOR CONTROLLERS

A. Motor controllers for NEMA rated 200V motors 25 hp and above.
B. Motor controllers for NEMA rated 460 V motors 60 hp and above.

2.9 AUTOTRANSFORMER REDUCED-VOLTAGE CONTROLLERS

A. Description: NEMA ICS 2, closed transition.

2.10 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.

2.11 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.

2.12 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

3.1 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.

3.2 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.

3.3 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 and seismic restraints:

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:

F. Indicate motor served, nameplate horsepower, full load amperes, code letter, service factor, voltage/phase rating, and fuse size and type, when applicable.

G. 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.

H. Check for proper rotation and phase relationship of each motor.

I. Install fuses in fusible switch at job site per requirements in Section 26 2813 – Fuses.

J. 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.

3.4 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.

3.5 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.

3.6 FIELD QUALITY CONTROL

A. Inspect motor controllers and contactors for physical damage, proper alignment, connections, anchorage, seismic restraints and grounding.

B. Correct malfunctioning motor controllers and contactors on-site and retest to demonstrate compliance. Remove and replace with new units and retest.

C. Test continuity of each circuit.

D. Test motor controllers per requirements in Sections 26 0812 – Power Distribution Acceptance Tests and 26 0813 – Power Distribution Acceptance Test Tables.

E. Interpret test results in writing and submit to Engineer.

3.7 REPAINTING

A. Remove paint splatters and other marks from surface of equipment.

B. Touch-up chips, scratches or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Owner.

3.8 ADJUSTING

A. Set field-adjustable circuit breakers trip settings or change the trip settings as indicated on drawings.

B. Adjust motor circuit protectors.

3.9 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 26 32 13
ENGINE GENERATORS

PART 1 – GENERAL
1.1 RELATED WORK
1.2 DESCRIPTION OF SYSTEM
1.3 REFERENCE STANDARDS
1.4 SUBMITTALS
1.5 DELIVERY, STORAGE, AND HANDLING
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PART 2 – PRODUCTS
2.1 MATERIALS
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PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 0700 – Mechanical Systems Insulation
B. Section 23 1214 – Liquid Fuel Systems
C. Section 23 2118 – Pipe and Pipe Fittings
D. Section 23 3114 – Ductwork
E. Section 23 3314 – Ductwork Specialties
F. Section 26 0000 – General Electrical Requirements
G. Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables
H. Section 26 0526 – Grounding and Bonding for Electrical Systems
I. Section 26 0548 – Vibration and Seismic Controls for Electrical Systems
J. Section 26 0812 – Power Distribution Acceptance Tests
K. Section 26 0813 – Power Distribution Acceptance Test Tables
L. Section 26 2313 – Paralleling Low-Voltage Switchgear
M. Section 26 3623 – Automatic Transfer Switches

1.2 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 sound attenuated enclosure
B. Package generator set rated for emergency standby duty
C. Engine fuel system:
   1. Day Tank provided under specification section 231214 Liquid Fuel Systems

1.3 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
G. UL 142 – Steel Aboveground Tanks for Flammable and Combustible Liquids
H. UL 2085 – Protected Aboveground Tanks for Flammable and Combustible Liquids

1.4 SUBMITTALS

A. Shop Drawings
   1. Provide in writing at the beginning of the shop drawings any deviations or exceptions taken to any portion of this specification. If the shop drawings lack this information they will be rejected.
      a. For each deviation, provide a numbered footnote with reasons for the proposed deviation.
      b. For each exception, provide a numbered footnote with reasons why the equipment does not comply with the specification.
   2. 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
   3. 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%
   4. 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 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.

1.5 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.

1.6 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

2.1 MATERIALS

A. Acceptable Manufacturers:

1. Engine Generator Set - Caterpillar, Cummins, MTU Onsite Energy
2. Exhaust Silencer – Maxim, Nelson, or approved equal
3. Isolation equipment
4. Battery charger – Sens, La Marche, Charles Industries

2.2 RATINGS AND PERFORMANCE

A. Engine Generator Set

1. Generator kW Output: As shown on drawings
2. Altitude 500 ft above sea level in ambient temperature of 90°F
3. Stable frequency regulation

B. Alternator

1. As shown on drawings, .8 Power Factor
2. 480 V, 3 Ph, 60 Hz, 4 Wire Y
3. Stable voltage regulation 0-full load less than or equal to ± .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. 15% Voltage dip
   b. 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.
   c. Telephone influence factor < 40

d. Telephone harmonic factor < 3

D. Factory Prototype Test Certified
1. Harmonic Distortion Levels
   a. Demonstrate
2. Airflow Restriction tests
   a. Demonstrate controlled shutdown after overheating
3. Unit tested with enclosure
   a. UL 2200 listed
4. 30 Degree Water Spray Unit Rain Test
   a. Demonstrate no water leakage into electrical boxes
5. Overload Test
   a. Demonstrate 10% overload with no damage to engine
6. Air Filter Test
   a. Demonstrate engine contains engine backfire explosion

E. Factory Production Test Certified
1. Alternator Impedance to Ground
2. Dielectric Testing
   a. At 1000 V and 2 times rated voltage
3. Maximum kW Rating
4. Engine Response Time
5. Alternator Construction Testing
   a. Impedance Balance Tested
6. Alternator Insulation Testing
   a. Surge Tested

2.3 FABRICATION AND MANUFACTURER

A. Engine:
1. Type: Inline or vee
2. Four-stroke cycle diesel compression ignition at 1800 RPM consistent with engine durability.
3. Aspiration: Turbo Charged
4. Horsepower
   a. Brake Horsepower Rule of thumb = 1.6 x kW
5. air cooled
6. Fuel Type: No. 2 domestic diesel fuel oil.
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. Arrange liquid-cooled prime movers for NFPA level 1 applications for closed-loop cooling.
3. 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

4. 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.
5. Fill engine cooling system with solution of 50/50 mix ethylene glycol at initial fill.
6. Ductwork with flexible connection between radiator and exhaust dampers to be provided by others. Refer to Section 23 3113 – Facility Fuel Oil Piping.

C. Exhaust System:
1. Furnish critical type exhaust silencer:
   a. Sized according to manufacturer's recommendations
   b. Mount so weight is not supported by engine
   c. Flexible exhaust fitting
   d. Installation indoors by Mechanical Contractor
   e. Refer to Section 23 2113 – Hydronic Piping
2. Condensate Traps
   a. Drain plug at low point of muffler
3. Thermal Expansion
   a. Stainless steel exhaust flex to accommodate thermal growth and vibration isolation
4. Acceptable Back Pressure
   a. Coordinate silencer exhaust pipe size with mechanical contractor so exhaust back pressure does not exceed maximum limitations specified by generator set manufacturer.
5. Exhaust clearing area

D. Starting System
1. Provide DC electric starting system with positive engagement drive. Provide DC voltage recommended by manufacturer.
2. Provide fully automatic start-stop controls.
3. Provide cycle cranking to open and lock out start circuit after 3 attempts to start failed engine start.
4. Batteries
   a. Provide sealed lead-acid storage battery set:
      1) Heavy duty diesel starting type
      2) Voltage compatible with starting system voltage
      3) Capacity to provide for 1-1/2 minutes total cranking time at 0°F without recharging. In accordance with NFPA Level 1.
   b. Provide vinyl coated steel battery rack.
   c. Provide starting battery heater:
      1) Heater plate under battery
      2) Heater type blanket around battery case
      3) Thermal switch - heater control relay
      4) 120 VAC input
   d. Battery cables and clamps
5. Battery Charger
   a. Four Rate Battery Charger
      1) Constant current, constant voltage, high rate taper, and float equalized.
   b. Dual Rate Battery Charger
      1) Constant current, and float equalized
   c. Charger Accessories:
      1) Overload protection
      2) ±0.5% 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: 208 V
7. When installed on the engine generator set, mount on vibration isolators.

E. Speed Control
1. Electronic: Isochronous

F. Alternator:
1. Maximum temperature rise 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.
b. Self-excited system to be brushless and consist of a 3 Ph armature and a 3 Ph full wave bridge rectifier mounted on the rotor shaft. Include surge suppressors to protect the diodes from voltage spikes.
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) Double
12. Stator
a. 3 Ph winding
b. Laminations
c. Cooling air passages and fan
1) Provide space heater to keep alternator free of moisture. Space heater to be 1500 W, 120 VAC, 1 Ph.
d. Welded laminations to prevent cutting of wires
e. Skewed stack to minimize slot ripple on output voltage and produce smooth voltage waveform.
f. Pitch – Skewed design to optimize efficiency and minimize total harmonic distortion.
g. Varnish process
1) 2 dips and bakes using Class A impregnating varnish

13. Alternator Components
    a. 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) (3) 100% circuit breakers – LSI type, 1000A and greater to be LSIA
            a) Breakers shall be selected to selectively coordinate with downstream circuit breakers per specification section 26 0573 Power System Studies. Breakers which do not selectively coordinate shall be replaced with new at contractor's expense.
        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 (Load bank breaker shall be shunt trip type)
        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 1 enclosure. There shall be no exposed components with door open operating 750 V.
        f. Protective relays to open main circuit breaker and shut down and lockout engine on abnormal conditions including:
            1) Overspeed
            2) Operation of Remote Stop
            3) Overcrank (alarm only when fire pump is operating)
            4) Low lube oil pressure (alarm only when fire pump is operating)
            5) High Engine Temp (alarm only when fire pump is operating)
            6) Low coolant level (alarm only when fire pump is operating)

7) Fail to crank (alarm only when fire pump is operating)
8) Dead battery (alarm only when fire pump is operating)

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) Overcrank lockout shall occur after 4 cranking attempts.
11) 1 NO and 1 NC contact wired to BAS control panel in the generator room to signal control panel when generator is called to start.

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) Overcurrent (circuit breaker trap and lockout)
6) 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.
4. Connections to engine-generator set: Flexible or isolation type connections. Include electrical, fuel, exhaust, and ventilation connections.

J. Equipment Bases:
1. Mount complete unit on a structural steel sub-base, rectangular in shape, with sufficient rigidity to maintain alignment of generator set. Provide perimeter beams with minimum depth equal to 1/10 of longest dimension of base, except beam depth need not exceed 14” provided that deflection and misalignment are kept within acceptable limits as determined by manufacturer. Engine-generator set to be statically and dynamically balanced at factory. Peak-to-peak amplitude of vibration velocity in horizontal, vertical, and axial direction shall not exceed 0.65” per second at main structural components.
2. Engine-generator set weight distribution is to be considered to provide uniform deflections.
3. Bases shall provide equipment alignment and assure uniform weight distribution. Provide side brackets on bases to contain isolating mounts and reduce total installed heights of equipment.

K. Vibration Isolators:
1. Required between the structural steel sub-base and concrete housekeeping pad.
2. 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. Fuel System
1. Day Tank provided under specification section 231214 Liquid Fuel Systems

M. Load bank tap box:
1. Manufacturer: Powertron or engineer approved equal
2. UL listed
3. Wall mount, NEMA 3R
4. Front lockable access door
5. Mechanical set screw lugs
6. Integral GFCI receptacle
7. Remote start/stop terminals
8. Cam-Lock male receptacles
9. Power distribution block
10. 480V, 800A

2.4 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 automation system (BAS) via BACnet 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 6	Control switch not in automatic position	
LDI 7	High battery voltage	
LDI 8	Low coolant level	

TYPE	CONDITION/DESCRIPTION	RANGE/UNITS
LDI 9	Low cranking voltage	
LDI 10	Low voltage in battery	
LDI 11	EPS supplying loads	
LDI 12	Generator circuit breaker ground fault	
LDI 13	Low lube oil pressure	
LDI 14	High engine temperature	
LDI 15	Overcrank	
LDI 16	Overspeed	
LDI 17	Remote emergency manual stop switch	
LDI 18	Overcurrent (circuit breaker trip and lockout)	
LDI 19	Reverse power relay trip	
LDI 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 29	Battery charger failure	
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

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.

LAN – Local Area Network

3. Provide all additional information as required for a complete and operable system.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install engine-generator set and associated equipment as indicated. Coordinate final location of equipment with General Contractor. Final location of equipment to be reviewed with Engineer prior to installation.

B. Install equipment in accordance with manufacturer's recommendations. Provide equipment protection during and subsequent to installation.

3.2 ACCEPTANCE TESTS

A. Testing by Electrical Contractor

B. Perform Acceptance Testing in accordance with Section 26 0812 - Power Distribution Acceptance Tests and Section 26 0813 – Power Distribution Acceptance Test Tables.

3.3 LOAD TEST

A. Conduct load testing of engine-generator set, under direct supervision of factory-authorized representatives of manufacturers of engine-generator set and auto-transfer switch.

B. Tests to include minimum of 10 starts of engine-generator set, minimum of 10 operations of auto-transfer switch, 8 h maintained operation under conditions of randomly applied loads at 10 to 100% of rated capacity.
   1. Loading shall be by use of load banks.

C. Provide certified results of testing, including frequency and voltage regulation at 25, 50, 75, and 100% of rated load, fuel consumption 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.

D. 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.

E. 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.

F. Provide fuel for load testing of engine-generator set.

END OF SECTION

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SECTION 26 36 23
AUTOMATIC TRANSFER SWITCHES

PART 1 – GENERAL
1.1 RELATED WORK
1.2 DESCRIPTION OF SYSTEM
1.3 REFERENCE STANDARDS
1.4 SUBMITTALS
1.5 QUALITY ASSURANCE
1.6 DELIVERY, STORAGE, AND HANDLING
1.7 WARRANTY
PART 2 – PRODUCTS
2.1 MATERIALS
2.2 AUTO-TRANSFER SWITCH
2.3 ELEVATOR CONTROL INTERFACE
2.4 ATS REMOTE CONTROL PANEL
PART 3 – EXECUTION
3.1 INSTALLATION
3.2 OPERATION
3.3 ACCEPTANCE TESTING

PART 1 - GENERAL

1.1 RELATED WORK
A. Section 26 0000 – General Electrical Requirements
B. Section 26 0529 – Hangers and Supports for Electrical Systems
C. Section 26 0548 – Vibration and Seismic Controls for Electrical Systems
D. Section 26 3213 – Engine Generators

1.2 DESCRIPTION OF SYSTEM
A. Provide automatic transfer switch, 3 phase, 60 Hz, 4 pole, with overlapping neutral for voltage and current as indicated on drawings.

1.3 REFERENCE STANDARDS
A. ICS 10 Industrial Control and Systems Part 1: Electromechanical AC Transfer Switch Equipment
B. UL1008 Automatic Transfer Switches

1.4 SUBMITTALS
A. Submit shop Drawings for equipment provided under this Section.
1. Provide in writing at the beginning of the shop drawings any deviations or exceptions taken to any portion of this specification. If the shop drawings lack this information they will be rejected.
a. For each deviation, provide a numbered footnote with reasons for the proposed deviation.
b. For each exception, provide a numbered footnote with reasons why the equipment does not comply with the specification.

1.5 QUALITY ASSURANCE
A. Obtain automatic transfer switches from one source and by single manufacturer.
B. Regulatory Requirements:
1. Comply with NFPA 70 for components and installation.
2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
C. Factory Test
1. Test system in accordance at the factory in accordance with Section 26 0812 - Power Distribution Acceptance Tests and Demonstration of Transfer Functions.
2. Provide factory test report

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, fumes, water, corrosive substances, construction debris, and traffic. Provide temporary heaters in switchgear as required to prevent condensation.

B. Deliver in 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.

1.7 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable Manufacturers: Asco, Onan, Russelectric, or Zenith

2.2 AUTO-TRANSFER SWITCH

A. Auto-transfer switch:
   1. Mechanically held, electrically operated type
   2. Interlocked to ensure only 2 possible positions, normal and emergency.
   3. Rated for continuous duty in unventilated sheet metal enclosure
   4. Suitable for all classes of loads at maximum rated voltages
   5. Withstand rating that meets or exceeds withstand rating of transfer switch feeder breakers.
   6. Shall be open transition type

B. Provide main contacts with silver alloy wiping action type protected by arcing contacts.

C. Enclosure shall be front access only and shall not require side or rear access. 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 10 cycle short circuit rating to guarantee contact opening and no damage when transfer switch is served by power circuit breakers.

F. 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. Pilot light to indicate normal position.
   7. Pilot light to indicate emergency position.
   8. Auxiliary contact to close when normal power fails.
   9. Auxiliary contact to open when normal power fails.
   10. Auxiliary contact on same shaft as main contacts (closed on normal).
   11. Auxiliary contact on same shaft as main contacts (closed on emergency).
   12. Four position selector switch to provide "Test," "Auto," "OFF", and "Engine Start."
   13. Contacts to start engine-generator when normal power fails.
   14. Time delay engine start, adjustable from 0 to 5 seconds.
   15. 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.
   16. Relay to prevent transfer to emergency until voltage and frequency of generating plant have reached 90% of rated value.

17. Provide bi-direction in-phase monitor or dual motor operator with programmed neutral to allow voltage decay in motor and transformer circuits.

2.3 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.

2.4 ATS REMOTE CONTROL PANEL

A. Provide remote annunciator and control panel to indicate each switch position.
B. Panel shall allow switch position to be changed remotely from panel location.
C. Panel shall be located in Parking Structure Office.
D. Provide sign indicating “ATS L1LAHB1 SERVES ELEVATORS”.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment in accordance with manufacturer's recommendations.
B. Provide equipment protection during and subsequent to installation.
C. Provide wiring between transfer switch and elevator controller. Final connections at elevator controller by Elevator Contractor.
D. Connect transfer switches that are part of fire pump controllers.

3.2 OPERATION

A. Parallel "start engine-generator" contacts of automatic transfer switches, such that failure of normal source at any switch shall start engine.
B. Transfer of one switch from normal to emergency shall not preclude any other switch from transferring.
C. Engine generator cool down cycle shall not start until all transfer switches have timed out back to normal source.

3.3 ACCEPTANCE TESTING

A. Testing by Testing Agency
B. Perform acceptance testing in accordance with Section 26 0812 – Power Distribution Acceptance Tests.
C. 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 26 43 00
SURGE PROTECTIVE DEVICES

PART 1 – GENERAL
1.1 RELATED WORK
1.2 DESCRIPTION
1.3 REFERENCE STANDARDS
1.4 SUBMITTALS
PART 2 – PRODUCTS
2.1 MATERIAL
2.2 PERFORMANCE CHARACTERISTICS
2.3 OPERATING CONDITIONS
2.4 FABRICATION
PART 3 – EXECUTION
3.1 APPLICATION OF SPD
3.2 INSTALLATION
3.3 QUALITY ASSURANCE
3.4 FIELD QUALITY CONTROL
3.5 WARRANTY

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 0000 - General Electrical Requirements
B. Section 26 0526 - Grounding and Bonding for Electrical Systems
C. Section 26 2413 - Switchboards
D. Section 26 2416.13 - Lighting and Appliance Panelboards
E. Section 26 2416.16 - Distribution Panelboards
F. Section 26 2726 - Wiring Devices

1.2 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.

1.3 REFERENCE STANDARDS

A. ANSI/UL 1449 Surge Protective Devices Third Edition or Newer
B. IEEE 587
C. FIPS PUB 94
D. IEEE C62.11 – Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (> 1 kV)
E. IEEE C62.41.1 Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
F. IEEE C62.41.2 Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits
G. IEEE C62.45 IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and less) AC Power Circuits
H. 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
I. National Electrical Code – Article 285
J. NEMA LA 1 – Surge Arresters
K. National Fire Protection Association – NFPA 20, 70, 75, and 780
L. UL 96A Installation Requirements for Lightning Protection Systems

1.4 SUBMITTALS

A. Submit Shop Drawings for equipment provided under this Section.

B. Submit shop drawings and product information for approval and final documentation in quantities listed according to Conditions of the Contract. Identify customer name, customer location, and customer order number.
C. Submit ANSI/UL 1449 Listing documentation to indicate the following:
   1. Short Circuit Current Rating (SCCR)
   2. Voltage Protection Ratings (VPRs) for all modes
   3. Maximum Continuous Operating Voltage rating (MCOV)
   4. Nominal Discharge Current rating (I-n)
   5. Type 1 device
   6. VPR, MCOV, I-n, and Type 1 information is posted at www.UL.com under Certifications; search using UL Category Code: VZCA. SCCRs are posted in manufacturer's published documentation.
   7. UL data and visual inspection takes precedence over manufacturer's published documentation.
D. Provide shop drawings including manufacturer installation instruction manual and line drawings detailing dimensions and weight of enclosure, internal wiring diagram illustrating all modes of protection in each type of SPD required, wiring diagram showing field connections, and manufacturer's recommended wire and breaker sizes (if required).
E. Upon request, modules using encapsulation shall be presented without encapsulation for visual inspection, proprietary technology included. MOV type and quantity shall reflect kA ratings on cutsheets, verification of diagnostic monitoring, thermal and overcurrent protection, etc.

PART 2 - PRODUCTS

2.1 MATERIAL

A. Acceptable manufacturers:
   1. Advanced Protection Technologies, Inc. (APT)
   2. Thomas & Betts; Current Technology
   3. LEA International
   4. Emerson; Liebert Corporation
   5. Mersen
   6. Erico

2.2 PERFORMANCE CHARACTERISTICS

A. SPD shall bear the UL Mark and shall be Listed to Third Edition of ANSI/UL 1449. "Manufactured in accordance with" is not equivalent to UL Listing and does not meet intent of specification.
B. Post SPD and performance parameters at www.UL.com under Category Code: VZCA. Products or parameter without posting at UL.com are not approved.
C. Minimum surge current capacity for Service Entrance units based on 8 x 20 microsecond current waveform:
   1. 200,000 A between each phase for line-to-line mode
   2. 200,000 A each phase for line-to-ground mode
   3. 200,000 A each phase for line-to-neutral mode
   4. 200,000 A for neutral-to-ground mode
D. Minimum surge current capacity for panelboard units based on 8 x 20 microsecond current waveform:
   1. 80,000 A between each phase for line-to-line mode
   2. 80,000 A each phase for line-to-ground mode
   3. 80,000 A each phase for line-to-neutral mode
   4. 80,000 A for neutral-to-ground mode
E. Sequential Surge Current Survivability:
   1. 1,000 sequential category surges without failure.
F. Current Rating:
   1. Rated for continuous current and AIC rating of equipment protected.
   2. Mark SPD Short-Circuit Current Rating on the SPD label.

2.3 OPERATING CONDITIONS

A. Temperature range: -40°F to 122°F
B. Relative humidity range: 0 to 95%, non-condensing
C. Audible noise level: > 40 dBA at 5 ft
D. SPD Surface Temperature: less than131°F

2.4 FABRICATION

A. SPD Modules:

1. UL Labeled as Type 1 (verifiable at www.UL.com), intended for use without need for external or supplemental overcurrent controls. Protect suppression component of every mode, including N-G, by internal overcurrent and thermal overtemperature controls. SPDs relying on external or supplementary installed safety disconnects do not meet intent of specification.
2. UL Labeled with 20kA I-nominal (I-n) (verifiable at UL.com) for compliance to UL 96A Lightning Protection Master label and NFPA 780
3. Suppression components: Heavy-duty MOVs, selenium cells, or combination of both.
4. Provide surge current diversion paths for all modes of protection: L-N, L-G, N-G in WYE systems, and L-L, L-G in DELTA systems.
5. Provide service entrance SPD audible diagnostic monitoring by way of audible alarm.
6. Provide service entrance SPD with 1 set of NO/NC dry contacts for alarm conditions.
7. Provide visual LED diagnostics including a minimum of 1 green LED indicator per phase, and 1 red service LED. Include an audible alarm with on/off silence function and diagnostic test function (excluding branch).
8. If a dedicated breaker for the SPD is not provided in the switchgear, switchboard, or panelboard include an integral UL Recognized disconnect switch. Dedicated breaker to serve as a means of disconnect for distribution SPDs.
9. Meet or exceed the following criteria:
   a. ANSI/UL 1449 Listed Voltage Protection Ratings (VPRs) for 6kV 3000A testing as follows:

VOLTAGE	**L-N** **L-G** **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. 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 - <u>EXECUTION</u>

3.1 APPLICATION OF SPD

A. Provide UL approved disconnect switch at Service Entrance or Transfer Switch as a means of service disconnect if a breaker sized per manufacturer's recommendations is not available.

B. Provide independent means of servicing disconnect at Distribution, MCC, and Branch such that the protected panel remains energized. A 30A breaker (or larger based on manufacturer's recommendations) may serve this function.
C. Provide SPD for equipment as shown on drawings.

3.2 INSTALLATION

A. Install per manufacturer's recommended practices.
B. Provide short and straight conductors not exceeding 3 ft in length. Manufacturer-approved cables may be used that allow conductor length to extend beyond 3 ft in length without affecting capability of unit.
C. Input conductors twisted together to reduce inductance.
D. Avoid 90-degree bends in cable.

3.3 QUALITY ASSURANCE

A. Factory test system before shipment. Include quality control check, "Hi-Pot" tests at 2 times rated voltage plus 1,000 V, ground leakage tests, and calibration.
B. Manufacturer Qualifications: Engage a firm with at least 5 yrs experience in manufacturing surge protective devices.
C. Manufacturer of equipment shall have produced similar electrical equipment for a minimum period of 5 yrs. When requested by Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with requirement.
D. Provide SPD compliant with the Restriction of Hazardous Substances (RoHS) Directive 2002/95/EC.

3.4 FIELD QUALITY CONTROL

A. Inspections before SPD startup:
    1. Visual Inspection:
        a. Verify installation per drawings.
        b. Verify phase, neutral, and ground conductors are properly sized and configured.
    2. Mechanical Inspection:
        a. Check connections for tightness.
        b. Check terminal screws, nuts and/or connectors for tightness.
    3. Electrical Inspection:
        a. Confirm input voltage.
        b. Confirm phase, neutral and ground connections are proper.

3.5 WARRANTY

A. Provide 10 yr manufacturer warranty.

END OF SECTION

SECTION 26 50 00
LIGHTING

PART 1 – GENERAL
1.1 RELATED WORK
1.2 DESCRIPTION OF WORK
1.3 REFERENCE STANDARDS
1.4 QUALITY ASSURANCE
1.5 WARRANTY
1.6 SUBMITTALS
1.7 SAMPLES
1.8 LUMINAIRE MOCK-UPS
PART 2 – PRODUCTS
2.1 ACCEPTABLE MANUFACTURERS
2.2 FABRICATION AND MANUFACTURER
2.3 DRIVERS
PART 3 – EXECUTION
3.1 INSTALLATION
3.2 SUBSTANTIAL COMPLETION

PART 1 - GENERAL

1.1 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

1.2 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. Provide lamps for luminaires as recommended by luminaire manufacturer.
E. Specifications and drawings convey the features and functions of luminaires only and do not show every item or detail necessary for the work.
F. Work includes final aiming and focusing of luminaires under direction of the Architect/Engineer.

1.3 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 924 - Emergency Lighting and Power Equipment
F. UL 1598 – Luminaires
G. UL 8750 – LED Light Sources for use in Lighting Products
H. ANSI C78.377 – Chromaticity
I. IESNA LM-79 – Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products
J. IESNA LM-80 - Approved Method: Testing Lumen Maintenance of LED Light Sources
K. IESNA TM21-11 - Projecting Long Term Lumen Maintenance of LED Light Sources including Addendum A

1.4 QUALITY ASSURANCE

A. Luminaire and accessory components shall be constructed of materials appropriate for their use.
B. Luminaires, drivers, LED modules and other components shall meet the requirements of all applicable State and Municipal codes and energy codes.
C. Provide luminaires listed and labeled by UL or other testing lab acceptable to local jurisdiction for their indicated use and installation conditions.

D. Contractor shall coordinate installation of lighting systems with all trades.
   1. Manufacturers listed in the luminaire schedule shall be assumed capable of supplying listed luminaires. Any such exceptions shall immediately be brought to the attention of Architect, Engineer.
   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.
      b. Specifier has secured accurate pricing for all single name products prior to bidding and has shared this information with Architect/Owner's Representative. Contractor shall supply contractor net unit pricing for all single name products specified. Unit price shall be for equipment only and not include installation or miscellaneous electrical costs.
   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.

E. Substitution requests:
   1. Will be evaluated prior to Bid.
   2. Shall follow procedures set forth in this Section under paragraph 1.7 and in Section 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 CD, USB or via email for use in a recognized computer lighting program.
   5. 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.
   6. 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.
   7. 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.

1.5 WARRANTY

A. Exit Signs Utilizing LED lamp 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

1.6 SUBMITTALS

A. After 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.

B. 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. Luminaire schedule indicating manufacturer, type, and catalog number for each luminaire
9. Lamp cut sheet for each lamp used, referencing luminaire type(s)
10. Documentation LED and driver compatibility
11. 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.

C. 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. For 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 LED 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. For LED luminaires, 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.
8. 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.
9. 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 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 lamps if light output is asymmetric.
    d. Zonal lumens stated numerically in 10° increments (5°, 15°, etc.) as above.
10. 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.

D. Provide luminaires with factory or field finish as directed by Architect/Engineer. Verify final finish requirements before releasing luminaires for fabrication.

E. 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.

1.7 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.

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 will not be returned, nor included in quantities listed for project.

D. Sample must be actual working unit.

1.8 LUMINAIRE MOCK-UPS

A. Upon return of submittals, and prior to release for manufacturing, Contractor shall provide mock-up on site (or at another agreed upon location) in actual architectural conditions for review by Architect/Engineer and Owner.

B. Provide type and quantity of luminaires as requested by Architect/Engineer.

C. Mock-up shall include working luminaires and fastening devices.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Luminaires:
   1. As shown on Luminaire Schedule

B. LED Drivers:
   1. Shall be manufacturer recommended compatible driver.
   2. All LED drivers shall be dimming type standard unless otherwise noted. Refer to construction documents for control per application.
   3. Manufacturers must be compatible with lighting control system(s) provided and control luminaires from 100% to 1% light output or 100% to 10% light output per Luminaire Schedule and controls intent documents.

C. Emergency LED Drivers:
   1. Bodine, Dual-Lite, Iota or as specified in the Luminaire Schedule

D. LED Modules:
   1. Philips Lumileds, Xicato, Cree, GE, Nichia, Osram Sylvania, Bridgelux, Citizen or as specified in the Luminaire Schedule

2.2 FABRICATION AND MANUFACTURER

A. Luminaires:
   1. Construction
      a. Luminaires shall bear label indicating circuit voltage. Labels shall not be visible from normal viewing angles.
      b. Luminaires shall be constructed with joints made by means of welded, brazed, screwed, or bolted construction methods.
      c. Housings shall be so constructed that all electrical components are accessible and replaceable without removing luminaires from their mountings.
      d. Surface temperatures of luminaires with integral drivers shall not exceed 90°C in 30°C ambient.
      e. Luminaires recessed in ceilings utilized as air handling plenums shall be certified as suitable for the purpose and conform to NEC Article 300.
      f. Miter cuts shall be accurate, joints shall be flush and without burrs.
      g. LED troffers with doors shall have spring-loaded door cam latches.
      h. Luminaires shall be free of light leaks and designed to provide sufficient ventilation of LED modules to provide the photometric performance documented. Drivers shall be vented per manufacturer's specifications.
      i. Provide inscription for exit and stairway signs to conform to applicable codes.

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 suitably rust proofed 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 UL listed or equivalent. 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-79-08 testing using absolute photometry criteria.
   c. Be rated at > or = to 70% lumen maintenance at 50,000 hours of operation.
   d. Be rapid cycle stress tested.
   e. Have lamp modules that are capable of being easily replaced upon failure with a manufacturer provided replacement module without voiding the UL listing of the luminaire.
   f. Have driver housings easily accessible for ease of maintenance.
   g. Have a maximum operating temperature at LED junction to not exceed 90°C over the expected operating range of the luminaire.
   h. Be RoHS compliant, lead and mercury free.
   i. Have an LED operating frequency of + or – 120 Hz.
   j. 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)
   k. Be Class A Sound rated.
   l. Be supplied with power supply that complies with IEEE C. 62.41-1991.
   m. Operate at 120 or 277 volts, ±10%.
   n. 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 LED 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. LED 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.

4. 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.

5. Wiring
   a. Luminaires shall be completely wired at the factory and as required by code.
   b. Internal wiring shall contain no splices.
   c. Luminaires shall be provided with flexible conduit, pigtails, and equipment for external connections.
   d. Recessed luminaires installed in inaccessible ceilings shall be UL listed for through wiring with the junction box accessible from the luminaire opening.
   e. Cords shall be fitted with proper strain reliefs and watertight entries where required by application.

6. 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.

7. Outdoor Lighting Systems:
   a. Provide luminaires, mounting arms, brackets, poles, hand-hole covers, base components, and all other accessories for a complete assembly. Manufacturers shall be responsible for proper fitting of elements and structural integrity of unit
   b. Provide poles as shown on luminaire schedule.
      1) Poles shall have hand-holes.
      2) Fusing for each luminaire head shall be located in hand-hole near base of pole.
      3) Pole base anchor bolts shall be galvanized.
   c. Exterior Luminaires:
      1) Shall operate at a minimum ambient temperature of 0°F.
      2) Shall be fully gasketed, with UL wet location label.
      3) Shall have approved wire mesh screens for ventilation openings.
      4) Anodized aluminum reflectors shall have minimum of 0.00079" anodizing thickness.
   d. Pole/Luminaire combination shall have EPA rating that will withstand site wind conditions.
   e. All castings and extrusions shall be given minimum one coat of baked-on clear lacquer, unless painted finish is specified.
   f. Aluminum surfaces shall receive a duronodic or polyester powder paint finish.
   g. Cast-in Luminaire housings installed directly in concrete shall be fabricated of hot dip galvanized steel or cast aluminum or composite.
   h. Where cast aluminum housings are used, give two coats of asphaltum paint prior to installation.
   i. Provide 1/8" thick x 2" diameter solid neoprene grommets at each point light luminaire surfaces are mounted to concrete structure.

2.3 DRIVERS

A. 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
   13. Be DMX compatible in Color changing LED luminaires.

B. Emergency LED Drivers shall:
   1. Be UL 924 listed.
   2. Operate LED luminaire at 10W minimum output for 90 minutes.
   3. Have high temperature nickel-cadmium battery.
   4. Be installed inside luminaires.
   5. Have solid state charging.
   6. Battery to be recharged within 24 h.

C. White LED sources shall be:
   1. Minimum CRI of 85 unless noted otherwise on Luminaire Schedule
   2. Within 0.004 on the CIE 1976 diagram for color spatial uniformity
   3. Within 0.007 on the CIE 1976 diagram for color maintenance over the rated lifetime of the source
   4. Binned within a 3-step MacAdam ellipse minimum, or as indicated in Luminaire Schedule
   5. Color temperature as noted on Luminaire Schedule
   6. 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
   7. L70 rated life shall be a minimum of 50,000 hours.

8. LED modules, unless noted otherwise, shall be provided by light fixtures manufacturer and integral to luminaire.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Marking:
1. Voltage identification: Luminaires designed for voltages other than 110-125 volt circuits shall be clearly marked with rated voltage.

B. Installation of Luminaires:
1. LED modules, 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. Where noted on the drawings, the exact location of luminaires shall be confirmed (in the field) with the Architect/Engineer prior to installation.
   c. Mount all luminaires so as to maintain full range of motion.
   d. Install luminaires plumb, square, and level with ceilings and walls.
   e. Coordinate stem, rod, chain, or aircraft cable hanger lengths with job conditions.
   f. 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. Provide luminaires and/or luminaire outlet boxes with hangers to support luminaire weight.
   c. LED troffers shall be held in place by support clips.
   d. Provide plaster frames for recessed luminaires in plaster ceilings.
   e. Rigid metallic pipe stems shall be utilized for the support of pendant mounted luminaires, unless otherwise noted.
   f. 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.
   g. Wherever a luminaire or its hanger canopy is attached to a surface mounted outlet box, a finishing ring shall conceal the outlet box.
   h. 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.
   i. Recessed luminaires shall be supported with 12 ga wire hangers, 2 per luminaire, at diagonally opposite corners.
   j. Recessed LED 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.
   k. Surface luminaires installed in grid ceilings shall be supported by independent support clips and 12 ga wire.
   l. Exit signs installed in grid ceilings shall be supported by electrical box hanger and additional 12 ga wire installed from box to structure.
   m. Support surface mounted luminaires greater than 2 ft in length at a minimum of each additional 2 ft, or as recommended by manufacturer.
   n. Brace suspended luminaires installed near ducts or other constructions with solid pendants or threaded rods.

o. Rigidly align continuous rows of luminaires.

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 lamp sockets 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. Lamps:
1. Provide new lamps delivered in original manufacturer’s cartons.
2. LED and metal halide lamps shall be energized continuously for not less than 100 hours for proper seasoning.

F. Grounding:
1. Ground luminaires and metal poles according to Division 26 Section "Grounding and Bonding for Electrical Systems".
2. Poles:
   a. Install 10 ft driven ground rod at each pole.
3. Nonmetallic Poles:
   a. Ground metallic components of lighting unit and foundations. Connect luminaires to grounding system with #10 AWG conductor.

3.2 SUBSTANTIAL COMPLETION

A. Quality Control:
1. At Date of Substantial Completion, replace LED modules/LED luminaires which are not operating properly.
2. Protection wrapping on lensed or louvered luminaires shall be removed before installation of furniture, but after finish work is complete.
3. Deliver spare equipment to Owner's representative.

B. Tests:
1. Give advance notice of dates and times for field tests.
2. Provide instruments to make and record test results.
3. Verify normal operation of each luminaire after luminaires have been installed and circuits have been energized.
4. Verify operation of luminaires with lighting control system and daylight harvesting systems. Any dimmed fixtures shall exhibit no signs of flickering.
5. Replace or repair malfunctioning luminaires and components, then retest. Repeat procedure until all units operate properly.
6. Report results of tests.

C. Adjusting and Cleaning:
   1. Clean luminaires of handling marks, dust and dirt.
   2. Cleaning and touch-up work shall be performed in accordance with luminaire manufacturer's recommendations.
   3. Damaged luminaires or components shall be replaced with new.
   4. Keep luminaires clean and protected for remainder of construction period.
   5. Verify orientation of directional luminaires prior to installation.
      a. This includes wall washers, cove lighting, floodlights, exterior area lights and adjustable accent luminaires. Contractor shall provide electrician's services to aim, adjust, and focus luminaires, as required, at direction of Architect/Engineer. These electricians shall be available at times designated by Architect/Engineer and shall be provided at no extra charge to Owner over base bid. Contractor shall provide equipment for 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 3 complete copies 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.
            a) Luminaires
            b) Control gear/drivers
         3) LEDs Manufacturer's complete installation instructions for all equipment installed keyed by type to as built drawings.
            a) Luminaires
            b) Control gear/drivers
         4) LEDs Equipment maintenance requirements and schedules.
            a) Luminaires
            b) Control gear/drivers
            c) LEDs
         5) Equipment manufacturer contacts.
            a) Luminaires
            b) Control gear/drivers
            c) LED modules
         6) Equipment manufacturer warranties.
            a) Luminaires
            b) Control gear/drivers
            c) LED modules
   2. Contractor shall provide qualified personnel onsite to provide a minimum of three days 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

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SECTION 27 21 33
WIRELESS ACCESS POINTS (WAP)

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PART 1 – GENERAL

1.1. SCOPE

A. The work under this section is for the installation of OWNER PROVIDED, CONTRACTOR INSTALLED Wireless Access Points (WAP).

B. The WAPs shall be installed by the contractor providing and installing the Communications Cable and Equipment. All contractor qualifications and certifications for that section shall apply to this section.

1.2. RELATED SPECIFICATIONS

A. The Contractor shall be responsible for reviewing all other specifications for requirements associated with the complete installation of WAP's. This includes but is not limited to the following:

1. 01 31 23 Project Management Web Site
2. 01 33 23 Submittals
3. 27 00 05 Communications Cable and Equipment

1.3. SUBMITTALS

A. Contractor licenses and qualifications are required as part of the complete Division 27 submittal package as indicated under Specification 27 00 05.

B. No submittals are required for the owner provided WAP.

C. Submittals are required for installation/hanger equipment, connectors, and any other required equipment/material required for a complete WAP installation.

PART 2 - PRODUCTS

2.1. WIRELESS ACCESS POINT (WAP) DEVICES

A. The City of Madison Information Technology Department (CoM-IT) will be providing the WAP devices for this project.

B. The WAP device being used will be as manufactured by the Cisco, Model 3700E and shall be used for all types of ceiling mounted installations (suspended, gyp board, open truss, etc).

PART 3 - EXECUTION

3.1. OWNER RESPONSIBILITIES

A. The CoM-IT shall be responsible for ordering, making payment (including shipping fees), and configuring all WAP devices in a timely manner to comply with the Contractors schedule.

B. The CoM-IT shall configure and test each WAP to CoM-IT specifications prior to providing them to the contractor for installation.

C. The CoM-IT shall number each WAP and provide the contractor with a location map indicating where each WAP will be installed.

C. The CoM-IT shall test all WAP's after installation to verify configuration and signaling is correct prior to accepting the final installation of the WAP system.

3.2. CONTRACTORS RESPONSIBILITIES

A. The Contractor shall be solely responsible for coordinating with CoM-IT the scheduling and receipt of all WAP devices with his/her installation schedule.

B. The Contractor shall inspect all WAP devices upon receipt for damage. CoM-IT shall be notified immediately of any damage.

C. The Contractor shall provide all mounting hardware, blocking, and other items required for a complete installation to the manufacturers installation requirements.

D. The Contractor shall install all WAP devices per plans and specifications including cable connections.

E. The Contractor shall be responsible to pick up WAP devices from City IT and delivery to the jobsite.

3.3. FINAL TESTING

A. Contractor shall provide final testing of all WAP devices after installation is complete.

B. In the event any WAP device is not operating properly the contractor shall trouble shoot the installation and work with the CoM-IT to determine if re-configuration of the device will be required.

C. The CoM-IT shall be responsible for reconfiguring WAP's as needed after installation is complete. The contractor shall be responsible for verifying connections, cabling and connectivity of the installation is correct.

3.4. WARRANTY

A. The CoM-IT will be responsible for registering any warranty information associated with the purchase and ownership of all WAP devices.

B. The Contractor shall warrant the installation of the WAP device for one (1) year per the terms of this contract.

END OF SECTION

SECTION 27 32 43
RADIO COMMUNICATIONS EQUIPMENT

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PART 1 – GENERAL

1.1. SUMMARY

A. This specification describes the materials, equipment and installation requirements required for a complete Radio Communication Equipment installation to be utilized by the City of Madison Fire Department (Owner).

B. The Contractor shall be solely responsible for all of the following:
   1. Ensuring the completed installation meets all applicable codes and regulatory requirements.
   2. Providing all miscellaneous equipment and materials required to complete the installation of equipment and materials described in this specification.
   3. Providing all tools, equipment, and testing devices required to complete the installation.

C. The Contractor shall attend all pre-installation meetings and coordinate with other trades prior to installing materials and equipment. The Contractor shall be solely responsible for any completed work by others that needs to be redone because pre-installation coordination was not completed.

D. Radio receivers and transmitters are not a part of this contract and shall be installed by the City Radio Shop after final acceptance and testing. The Contractor shall be responsible for verifying all final connections with Owner provided equipment prior to completing the installation.

1.2. RELATED SPECIFICATIONS

A. The Contractor shall be responsible for reviewing all other specifications for requirements associated with the complete installation of all Radio Communication Equipment. This includes but is not limited to the following:
   1. 01 31 23 Project Management Web Site
   2. 01 33 23 Submittals
   3. 26 xx xx Division 26 specifications as needed

1.3. CONTRACTORS QUALIFICATIONS

A. The Contractor shall be licensed and/or certified for this installation as required by any regulatory requirements.

1.4. SUBMITTALS

A. Submittals are required for all equipment and materials specified within this specification. This shall include but not be limited to antennas, cables, connectors, PolyPhaser, and other components required for a complete radio communication installation.

B. Submittals are required for all mounting hardware required to install equipment specified in this section. Mounting hardware shall include but not be limited to antenna mounts, weatherproof cable boxes and other similar equipment/hardware.

C. Submittal shall include copies of all currently licensed installers

D. In the event a single source product is obsolete or the manufacturer's specifications have significantly changed the Communications Contractor shall submit an RFI through the General Contractor for direction from the Owner. The contractor shall not proceed with submittals until all RFI issues have been resolved.

1.5. WARRANTY

A. The Contractor shall warrant for one year the complete installation of equipment and components associated with this contract and installation. Contractors warranty shall be in the form of a written letter on company letterhead referring to the contract information, dates of installation and acceptance, signed by an authorized representative of the Contractors Company.

1. The Contractors warranty shall include but not be limited to following:
   a. Transportation to and from the location as often as needed during the warranty period.
   b. All labor and materials necessary to properly and thoroughly trouble shoot the system.
   c. All fees associated with the shipping of any component that needs to be returned or supplied by the manufacturer for repair or replacement.
   d. All labor and materials required to remove, repair, replace, or re-install any component.

B. The Contractor shall also provide all manufacturers warranties/guarantees associated with installed components of the completed installation.

1.6. PRODUCT SUBSTITUTIONS

A. The Contractor shall thoroughly review all product specifications associated with this specification.

B. Substitutions for sole sourced products will not be permitted.

C. Substitutions for items to be considered as equals shall be submitted for review at the time of bidding in accordance with the bidding instructions. Approved substitutions will be identified by a written addendum to the bidding documents prior to the end of bidding. Only items in the approved addendum will be allowed as substitutions.

PART 2 - PRODUCTS

2.1. NEW EQUIPMENT AND COMPONENTS

A. The Contractor guarantees that all equipment and components shall be furnished new, undamaged, free of defects, and conform to the drawings and specifications of this contract. The contractor is solely responsible for replacing any damaged or defective item.

2.2. ANTENNAS

A. The Contractor shall provide and install the antennas as specified in the table below, alternates shall not be considered. Antennas shall be provided and installed in the quantities and locations indicated in the plans, details, and specifications.

1. Future antenna information is provided for informational purposes only, to assist in locating antenna cables, mounting devices, and installation spacing of antennas.

Manufacturer	**Laird Technologies**	**Laird Technologies**	**Panorama Antennas Ltd.**	**Amphenol**
Model	**Y4503**	**S8060B**	**BS-IN1766**	**BCD-7504-EDIN-0**
Band Type	UHF		VHF	
Alpha Frequency	450-470 MHz	800-900 MHz	139-168 MHz	800 MHz
Horizontal Beam Width			360°	360°
Max Power Input	300W		100W	500W
Polarization				Vertical
Lightning Protection				DC Ground
Vertical Tilt				0°
Gain	7.1	0 dBD	0 dB	5.6dBi

Manufacturer	Laird Technologies	Laird Technologies	Panorama Antennas Ltd.	Amphenol
Model	**Y4503**	**S8060B**	**BS-IN1766**	**BCD-7504-EDIN-0**
Frequency (bandwidth)		62 MHz		
VSWR		1.5:1		≤1.5:1
Connector	N (Female)	N (Female)	N (Female)	
Wind Survival w/o Ice		125 mph		125 mph
Vertical Beam Width			100º	28º
Diameter				3.5 in.
Length		17.5 in.	2.2 ft.	35.2 in.
Weight		0.56 lbs	1.54 lbs	10 lbs
Color		n/a	n/a	n/a
Pigtail		17 cm		
Element Material		Plated Copper Laminate		
Enclosure Material		Fiberglass		
Mounting Style		Tube End		
Mfr Warranty			1 year	
Antenna No.s	1	2-4 & 9-11	5-8	Future 12-14
Cable type	See 1/2 Heliax below	See 1/2 Heliax below	See LMR below	See 7/8 Cellflex below

2.3. ANTENNA CABLE

A. The Contractor shall provide and install the antenna cables as specified in the table below including the antenna cable for the future antennas noted in the table above. Alternates shall not be considered. Antennas shall be provided and installed in the quantities and locations indicated in the plans, details, and specifications.

Manufacturer	CommScope	CommScope	Times Microwave	CommScope
Model	**LDF4-50A**	**LDF4-50A**	**LMR-400**	**AVA5-50FX**
Size/Type	1/2” Foam Heliax Cable	1/2” Foam Heliax Cable	3/8” LMR Coaxial Cable	7/8” Heliax-Coaxial Cable
	50 Ohm Coaxial	50 Ohm Coaxial	50 Ohm Coaxial	50 Ohm Coaxial
Outer Conductor	Annular Corrugated Copper	Annular Corrugated Copper	Stranded	Corrugated Copper
Inner Conductor	Copper Clad Aluminum	Copper Clad Aluminum	Bare Copper	Copper
Max. Frequency Capacity	8.8 GHz	8.8 GHz		
Min. Bending Radius	5 in.	5 in.	1 in.	
Antenna No.s	1	2-4 & 9-11	5-8	Future 12-14

2.4. RADIO EQUIPMENT

A. Radio equipment (transmitters and receivers) will be provided and installed by the CoM Radio Shop after the Radio Communication installation has been completed, tested, and accepted per this specification.

B. Test radios shall be provided by CoM Radio Shop for the final testing of the completed installation, see item 3.6. below.

2.5. POLYPHASER

A. Provide and install one (1) PolyPhaser for each roof mounted antenna.

B. PolyPhaser shall be flange mount 125-1000MHz, maximum surge of 50,000 amp, 600 VDC turn-on, with type N female connector on equipment side and type N male connector on the antenna port.

1. Tessco model IS-50NX-C2-MA

C. Each PolyPhaser shall be installed on the antenna cables within the first 24” of cable as it exits the conduit coming from the roof into the Radio Room (235).

D. Each PolyPhaser shall be grounded to the grounding bar in the Radio Room.

2.6. WALL MOUNTED RACK

A. The Contractor shall provide and install a wall mounted data rack in A/V Equipment Room (266) for the distribution of antenna cabling to various seating arrangements within Parkinson Hall (254).

B. Rack shall be sized to accommodate a minimum of six (6) RF Rack Panels as described below.

2.7. RF RACK PANELS

A. Provide RF Rack Panels as per the antenna riser diagram in the wall mounted rack described above for the distribution of antenna cabling within Parkinson Hall (254).

B. All connections shall be type "N" female connections; panel shall fit standard 19" rack mounting specifications; provide cut sheets with submittal package. Finish shall be black powder coat with white text. Verify quantity, location, and cabling requirements with plans and details for Parkinson Hall.

2.8. MISCELLANEOUS EQUIPMENT

A. The Contractor shall provide and install in quantities as required for a complete installation the following miscellaneous equipment:

1. Any miscellaneous equipment or device required to provide a complete and fully operational installation that meets the requirements of the plans and specifications.
2. Connectors; all connectors shall be high quality type "N" connectors; provide cut sheets with submittal package.

PART 3 - EXECUTION

3.1. COOPERATION OF THE CONTRACTOR

A. The Contractor shall be required to coordinate with all trades for a complete and timely installation. This includes attending all pre-installation meetings where equipment and conduit locations will be installed or may be in conflict with the installation of other trades. The Contractor shall be solely responsible for any additional cost required for removing/replacing/modifying any completed work by other trades because the installation was not properly coordinated.

B. The Contractor shall coordinate with the Owners Representative from the City Radio Shop for all information necessary to complete the installation and integration with the Owners existing hardware and software.

C. The Contractor shall verify with the Owners Representative from the City Radio Shop for mounting heights of all hardware and equipment prior to installation. This shall be completed at a pre-installation walk through prior to rough-in.

D. The contractor shall coordinate with the Architect and Building Owner for access to non-contract spaces and for coordinating the mounting of any conduit, hangers, etc. in non-contract spaces.

3.2. EQUIPMENT INSTALLATION - GENERAL

A. All antennas and equipment shall be properly grounded as per the plans, details, manufacturer's installation requirements, and code requirements.

B. All mounting hardware (u-bolts, cable clamps, etc) in exterior type environments shall be hot dip galvanized.

3.3. ANTENNA INSTALLATION

A. The Contractor shall review the enlarged plans and details provided in the drawing set indicating antenna locations on the roof and other installation details.

B. All antennas shall be installed per the numbers on the plan which are cross-referenced to the antenna numbers provided in Section 2.2 above.

C. Antennas shall be bolted to the 2" antenna mast pipes with one or two antenna clamps as per the antenna manufacturer's written instructions.

D. The Contractor shall be responsible for all mounting hardware and equipment required for a complete installation except when noted as provided by others in plans and details.

3.4. ANTENNA CABLE INSTALLATION

A. The Contractor shall properly install all antenna cables in conduits and other cable management devices as indicated in the plans and details. This shall include but not be limited to any grounding, fasteners, pull boxes, or other required materials necessary for a complete installation.

B. The following antenna cable installation requirements shall apply to the installation of all antenna cables:

1. All exterior antenna cables shall be clamped to the existing cable clamp channel located on the roof as per details. The Contractor shall provide cable clamps of the appropriate size and spacing as needed for a neat and secure installation of all antenna cables.
2. Strain relief devices shall be used at a minimum spacing of 200 feet during antenna cable installation. Strain relief devices shall remain in place to support the cables after installation. A support cable shall be used between the grips to prevent damage to the cable caused by lifting from only one point.

3. All exterior cables shall have a slight upward incline prior to entering the building to minimize moisture from entering the building.
4. All cables shall enter/leave conduits through the use of entry port boots of appropriate sizes and configurations. This applies to all interior and exterior locations.
5. Cables from the roof down to the Radio Room shall be located in existing vertical conduits. The Contractor shall be solely responsible for ensuring the conduit capacities are not exceeded.
6. All exterior antenna cables shall be continuous (no splices) from the roof antenna to the PolyPhaser connection in the Radio Room (235). Provide sufficient cable as needed for bends and drip loops.
7. Provide/install the PolyPhaser in the Radio Room for lightning protection on each antenna cable installed. Each PolyPhaser shall be properly attached to the antenna cable and the grounding bar located in the Radio Room.
8. All interior antenna cables shall be continuous (no splices) from the PolyPhaser to its final end point except were designated in the plans or details to be broken for installing specific pieces of equipment. Provide sufficient cable as needed for bends and connections.
9. Provide five (5) feet of additional cable fastened to the structure as necessary at the base of the antenna. Provide sufficient cable as needed for bends, and drip loops.
10. The contractor shall use Velcro straps when bundling antenna cables on the interior of the building. The use of zip ties or other plastic fasteners shall not be allowed.

C. Antenna cables shall be run as follows:
1. Antenna 1
   a. Connect 1/2" Heliax cable to Antenna 1 on the roof
   b. Route cable to the Radio Room, install PolyPhaser, route cable to Telecom Room M111.
   c. Provide and install appropriate connectors and make final connection as the primary radio system to be installed with the Station Alerting equipment.
2. Antenna 2
   a. Connect 1/2" Heliax cable to Antenna 2 on the roof
   b. Route cable to the Radio Room, install PolyPhaser, route cable to Telecom Room M111.
   c. Provide and install appropriate connectors and make final connection as the backup radio system to be installed with the Station Alerting equipment.
3. Antennas 3 and 4
   a. Connect 1/2" Heliax cable to each antenna (3 & 4) on the roof
   b. Route cable to the Radio Room, install PolyPhaser, route cable to A/V Equipment Room (266).
   c. Provide and install appropriate connectors and make final connection to the RF Rack Panel.
4. Antennas 5 through 8
   a. Connect LMR-400 cable to each antenna (5 – 8) on the roof
   b. Route cable to the Radio Room, install PolyPhaser, route cable to A/V Equipment Room (266).
   c. Provide and install appropriate connectors and make final connection to the RF Rack Panel.
5. Antennas 9 through 11
   a. Connect 1/2" Heliax cable to each antenna (9 – 11) on the roof
   b. Route cable to the Radio Room, install PolyPhaser, route cable to A/V Equipment Room (266).
   c. Provide and install appropriate connectors and make final connection to the RF Rack Panel.
6. Antennas 12 through 14 (future antennas)
   a. Provide sufficient 7/8" Heliax cable to each future antenna (12-14) location on the roof including the required additional five (5) feet and as needed for bends and drip loops. Fasten all cable to the structure as required. No additional connections at the roof are required.
   b. Route cable to the Radio Room, provide five (5) feet of cable after exiting the conduit from the roof. Antenna cables shall be neatly bundled and fastened to the wall, no additional terminations, PolyPhasers or other connections shall be required.
7. A/V Equipment Room (266)
   a. Provide nine (9) – three foot (3') jumpers of 1/2" Heliax cable/LMR-400 cable
   b. Provide and install the appropriate connectors to each end of each jumper
   c. Connect one end of each jumper to the RF Rack Panel terminating antennas 3-11
   d. Do not permanently connect the other end of the jumper to other RF Rack Panels except to perform testing procedures.
8. Parkinson Hall (Room 254)
   a. Provide twenty three (23) – thirty foot (30') leads of 1/2" Heliax cable/LMR-400 cable
   b. Provide and install the appropriate connectors to each end of each lead
   c. Connect one end of each lead to the RF Rack Panel

d. Route each lead to the appropriate desk location in Parkinson Hall.

3.5. EQUIPMENT IDENTIFICATION AND LABELING

A. The Contractor shall provide and install all equipment identification and labeling to the following specifications.
   1. Tags and labels shall be permanent rigid plastic or metal tags with engraved or machine stamped lettering. Hand written self stick or metal hand stamped tags will not be accepted.
   2. The Contractor shall work out the labeling scheme for all equipment with the City Radio Shop prior to ordering any labels or tags.

B. Antennas shall be labeled with their assigned antenna number, antenna type, and use.

C. Antenna cable conduits shall be labeled as follows:
   1. Vertical conduits from the roof shall be labeled with the antennas served at the roof level and in the radio room.
   2. Horizontal conduits shall be labeled with the antennas served at both ends.

D. Antenna cables not in conduit shall be labeled as follows:
   1. Individual antenna cables shall be labeled with antenna served when leaving the conduit and at end connector.

E. The RF Rack Panels in A/V Equipment Room (266) shall be labeled as follows:
   1. Each connector on the two (2) panels receiving original antenna cables shall be labeled with the antenna number and antenna type
   2. Each connector on the four (4) panels connecting leads to desk locations in Parkinson Hall shall be numbered with "D-#" where # shall be 1-18, or 32-36.
   3. The jumpers do not need to be labeled

3.6. INSTALLATION TESTING AND ACCEPTANCE

A. The Contractor shall be responsible for pre-testing and troubleshooting the completed radio communication installation for connectivity and grounding requirements. The contractor shall correct all deficiencies prior to scheduling final testing with the City Radio Shop.

B. The City Radio Shop shall perform final testing with the Contractor using appropriate testing equipment and radios as follows:
   1. Visually inspect the entire radio equipment installation against plans and specifications
   2. Visually inspect and test connections for connectivity and grounding.
   3. Connect radios in Parkinson Hall and test for proper signal input/output at each location.
   4. Connect radio to Station Alerting equipment to verify primary and backup radio input/output is working.
   5. Using a hand held radio provide the following tests and reports of the Bi-Directional Amplifier System provided by the Building Owner:
      a. The interior 2nd Floor Admin area for input/output.
      b. The interior Parking Garage BDA loop for input/output.
      c. The interior Command Vehicle Garage BDA loop for input/output.
      d. Provide the City Project Manager and Project Architect a list of all locations having insufficient input/output.
         i. Building Owner shall have additional amplifier antennas installed as needed.
         ii. Retest item 5 as necessary until all areas have acceptable input/output levels.

   Special Note: Item 5 is not a condition of installation acceptance.

C. A completed and accepted installation shall pass all of the above tests (except Item 3.6.B.5 above) for the entire completed installation.

D. The warranty period for the completed and accepted installation shall not begin until the date of the accepted general contract. The Contractor shall coordinate this date with the General Contractor.

3.7. PRODUCT AND INSTALLATION LICENSING

A. The Contractor shall provide any licensing applications associated with this installation directly to the City Radio Shop. The City Radio Shop will be responsible for all regulatory licensing applications and processing.

END OF SECTION

SECTION 28 10 00

ACCESS CONTROL SYSTEM

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
B. Division 26 sections.
C. Section 282000 “Video Surveillance System.”

1.2 SUMMARY

A. The product of the work included under this Section shall be an expansion of the existing facility Access Control System (ACS).
B. The expansion of the facility ACS will provide access control for locations shown on the drawings.
C. System shall be a fully distributed processing system so that information, including time, date, valid codes, access levels, and similar data, is downloaded to Access Control Panels (ACPs) so that each ACP makes access-control decisions for that Location.

1. When communications to Central Station is lost, all ACPs shall automatically buffer event transactions until communications are restored, at which time buffered events shall be uploaded to the Central Station.
2. ACPs, Central Station shall be connected via an Ethernet LAN.

D. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of control panels, card readers, and sensors.

E. The system shall incorporate the necessary hardware, software, and firmware to collect, transmit, and process alarm, tamper and trouble conditions, access requests, and advisories in accordance with the security procedures of the facility.

F. The Access Control System described herein shall control all existing and new doors indicated on the drawings.

1.3 GENERAL CONDITIONS

A. Documentation to be submitted by Contractor upon completion of system installation.
1. Upon completion of installation, the Contractor shall prepare Record (or "as-built") drawings of the system. Drawings" shall be AutoCAD (2010 or more recent). Drawings shall include:
   a. Floor and Site plan(s) indicating exact device locations, panel terminations, cable routes, and wire numbers as tagged and color-coded on the cable tag.
   b. Point-to-point wiring diagrams of each type of device
2. Documentation of software configuration, changes or additions.
3. Operation and maintenance manuals: Two (2) sets.
   a. All approved Submittals
   b. Manufacturers Operation and maintenance documents for each component

1.4 DEFINITIONS

A. ACP: Access Control Panel.
B. ACS: Access Control System.
C. IDC: Intelligent Door Controller.
D. LAN: Local Area Network.
E. PC: Personal Computer.
F. VSS: Video Surveillance System.
G. WAN: Wide Area Network.
H. Furnish: To purchase, procure, acquire, and deliver complete with related accessories.
I. Install: To set in place, join, unite, fasten, link, attach, set up or otherwise connect together and test, before turning over to the Owner, all parts, items, or equipment supplied by the Contractor.
J. Provide: To furnish, transport, install, erect, connect, test and turn over to the Owner complete and ready for regular operation.

1.5 SUBMITTALS

A. Proposal Delta: It is the duty of the contractor to provide a working system. Any omissions or errors or differences between this document and the contractor's submitted proposal shall be clearly outlined in a separate document labeled "[COMPANY NAME] Proposal Deltas".

B. Qualification Statements
1. Manufacturer:
   a. Submit confirmation and details of manufacturer's warranty, extended warranty, and replacement policies.
   b. Submit proceeding 3 years' financial statements for the equipment manufacturer.
   c. Submit list of available manufacturer provided, fee based professional services available to the contractor or the owner including but not limited to: training, installation, commissioning, remote diagnostics and integration with 3rd party software and hardware systems.
2. Contractor:
   a. General:
      1) This scope of work must be followed by the winning bidder, sub-contractor and Lessor.
      2) All requirements must be adhered to, including notification of project award, discussion of the project prior to start and providing a project schedule.
   b. Documentation:

1) Submit confirmation that contractor is licensed to install access control and security equipment as required by the authority having jurisdiction.
2) Submit history of contractor certification(s) for items in this section.
3) Submit references with contact information where contractor has installed items in this section.
4) Submit confirmation that installer who will install this equipment or who will supervise installation of this equipment has received manufacturer training and is certified by the manufacturer on this equipment and that the training the installer received is current.

C. Product Data: Submit manufacturer technical specifications, typical installation drawings, system overview drawings and sample images of items included in this section.

D. Shop Drawings: For access control system and accessories. Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Include scaled drawings for master station that detail built-in equipment.
   3. Wiring Diagrams: For power, signal, and control wiring.
      a. Identify terminals to facilitate installation, operation, and maintenance.
      b. Single-line diagram showing interconnection of components.
      c. Cabling diagram showing cable routing.

E. Equipment List: Complete bill-of-materials indicating all products being furnished and installed under the project.

F. Field quality-control reports.

G. Configuration and testing plan.

H. Operation and maintenance data.

I. Warranty: Sample of project warranty and service agreement.

1.6 QUALITY ASSURANCE

A. All equipment, systems, and materials furnished and installed under this section shall be installed in accordance with the applicable standards of:
   1. National codes: NEC and NFPA
   2. Approvals and Listings: UL
   3. EIA/TIA Telecommunications wiring standards
   4. Local Authorities Having Jurisdiction

B. Contractor Certification:
   1. The Contractor shall be a factory-authorized and trained dealer/integrator of the system and shall be factory-trained and certified to maintain/repair the system after system acceptance.
      a. This certification must be in place at time of Bidding and remain so throughout project.
   2. Contractor performing access control system installation shall have on the project team at a minimum one (1) Certified Installer trained by the manufacturer(s) of the system installed under this project.

C. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
   1. Interior, Controlled Environment: System components, except central-station control unit, installed in air-conditioned interior environments shall be rated for continuous operation in ambient temperatures of 36 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing. Use NEMA 250, Type 1 enclosures.
   2. Interior, Uncontrolled Environment: System components installed in non-air-conditioned interior environments shall be rated for continuous operation in ambient temperatures of 0 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing. Use NEMA 250, Type 3R enclosures.
   3. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambient temperatures of minus 30 to plus 122 deg F dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to 85 mph and snow cover up to 24 inches thick. Use NEMA 250, Type 3R enclosures.
   4. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers shall be rated, listed, and installed according to NFPA 70.
   5. Corrosive Environment: System components subject to corrosive fumes, vapors, and wind-driven salt spray in coastal zones. Use NEMA 250, Type 4X enclosures.

6. Security Environment: Camera housing for use in high-risk areas where surveillance equipment may be subject to physical violence.

1.7 GUARANTEE OF WORK

A. All components, parts, and assemblies supplied by the Manufacturers and installed by the Contractor shall be warranted against defects in material and workmanship for a period of at least three years (parts and labor), commencing upon date of acceptance by Owner.
   1. Warranty service shall be provided by a factory-trained service representative.
   2. Warranty shall include all parts, labor and necessary travel.

B. At the end of the warranty period, Contractor shall provide detailed documentation of corrective maintenance performed from date of acceptance. Documentation shall include:
   1. Description of symptoms, diagnoses and subsequent actions taken.
   2. Recommended changes in routine preventive maintenance procedures shall also be included.

C. Contractor shall provide a preventive maintenance outline for all equipment included in this project.

D. The Contractor shall provide, at no additional cost, all software and/or firmware revisions and updates during the warranty period. The Contractor shall verify proper operation of the access control system after incorporation of each update. Software updates shall be fully documented.

E. The Contractor will provide a cost budget for up to five (5) years for the maintenance and upgrades to the system. The budget must clearly define all contractor and manufacturer costs expected.

F. Warranty of Proximity Card Readers and Keypads shall be lifetime against defects in materials and workmanship.

1.8 SERVICE / MAINTENANCE

A. During the warranty period the Contractor shall be responsible for maintenance and repair of the system at no charge to the owner.
   1. Includes:
      a. Labor to troubleshoot and diagnose system problems,
      b. Labor to replace workmanship defects failed devices and/or software problems.
      c. Materials
      d. Travel time and expenses.
   2. Provide 24-hours daily, 7-days per week including holidays.
   3. Repair service shall be provided within 4 hours of notification.

B. The Contractor will provide a cost budget for up to five (5) years for the maintenance and upgrades to the system. The budget must clearly define all contractor and manufacturer costs expected. The agreement shall be renewable monthly, quarterly, or yearly.

C. All repairs shall be made by a qualified service representative (fully trained in the servicing of the access control systems).

D. All test adjustments or replacements shall be made in the presence of Owner's technician, or other person designated by the owner.

E. Upon completion of each call a report will be provided to clearly indicate any replacements or adjustments and any evidence of tampering.

1.9 EXTRA MATERIALS

A. Extra materials shall be housed in an environment and condition recommended by the manufacturer and shall be clearly labeled with "SPARE: DO NOT REMOVE", manufacturer part number, and date of delivery to the owner.

B. All packaging for spares must be kept in good condition and used as appropriate for any Returns to Manufacturer (RMA).

C. Deliver to the owner in its original packaging:
   1. Card Reader: Quantity (1) of each type installed.

PART 2 - PRODUCTS

2.1 ACCESS CONTROL SYSTEM

A. The Access Control System shall be an extension of the exiting Access It! Universal version from RS2 Technologies, and all components shall be fully compatible with RS2 Panels.

B. The access control system shall be a fully distributed processing system so that information, including time, date, valid codes, access levels, and similar data, is downloaded to ACPs so that each ACP makes access-control decisions for that Location. If communications to the server is lost, all ACPs shall automatically buffer event transactions until communications are restored, at which time buffered events shall be uploaded to the server.

2.2 SYSTEM REQUIREMENTS

A. Per manufacturer's recommendations for all field device wiring and cabling.

B. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor's entry connection to components.

1. Minimum Protection for Power Connections 120VAC and More: Auxiliary panel suppressors complying with requirements in Division 26 Sections.
2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Connections: Comply with requirements in Division 26 Sections as recommended by manufacturer for type of line being protected.

C. Transient Voltage Surge Suppression (TVSS): The Contractor shall install Transient Voltage Surge Suppressors (TVSS) to protect al ACPs in the facility.

D. Tamper Protection: Tamper switches on enclosures, control units, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled. Control-station/control-unit alarm display shall identify tamper alarms and indicate locations.

E. Horizontal Cabling

1. Performance Requirements
   a. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
      1) Flame-Spread Index: 25 or less.
      2) Smoke-Developed Index: 50 or less.
   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.
2. Cabling
   a. Description:
      1) Cabling shall be Plenum rated.
      2) Card Reader Cabling
         a) 18/6 Stranded Shielded.
      3) Access Control RS-485 DATA Cable
         a) 18/4 Stranded Shielded.
      4) Lock Power Cable
         a) 16/4 STRANDED
      5) Position Switch, Request to Exit Cable
         a) 22/4 STRANDED
      6) Security Network Communications Cable
         a) Category 6. Refer to Specification Section 28 20 00
   b. Plenum-Rated Cable: NFPA 70, Type CMP.
      1) Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
      2) Fluorinated ethylene propylene insulation.
      3) Fluorinated ethylene propylene jacket.
      4) Flame Resistance: NFPA 262, Flame Test.

2.3 SIGNAL TRANSMISSION COMPONENTS

A. System shall be connected to Owner's existing security network. Connection to network requires coordination with Owner for IP addressing scheme, port configuration as necessary and physical connection location(s).

B. Signal transmission components (network switches and power injectors) are to be shared between access control and video surveillance systems

2.4 ACCESS CONTROL PANELS

A. General:
   1. Intelligent peripheral control unit, complying with UL 294, that stores time, date, valid codes, access levels, and similar data downloaded from the Central Station or workstation for controlling its operation.
   2. Controller and related equipment shall be secured in a metal enclosure.
      a. Enclosure shall house the ACP, Power Supply, Battery Back-up and Electrical Receptacles.
   3. Compatible with iNet Panels.
   4. Configuration:
      a. Unit shall support connectivity to the number of doors/gates identified on the project drawings.
      b. Memory / Capacity: 64 MB
         1) Upgradeable to 128 MB using field-installable, industry-standard 64 MB SDRAM module

B. Manufacturer / Model: iNet panels to match existing.

2.5 ACCESS CONTROL PANEL POWER SUPPLIES

A. In-building ACPs shall be supplied by independent power supplies. The power supply shall only provide power to the field devices associated to its coupled ACP.
B. Each power supply shall incorporate the following features, as a minimum:
C. Construction:
D. Power and Environmental:
   1. Standby-by battery power for a total of 4-hours of operation of door locks after AC power failure to the power supply.
      a. Battery Type and configuration shall be per ACP manufacturer's specification.
   2. Individual fused and MOV protected output circuits. (One circuit per device powered).
   3. Battery charger
   4. Class 2 rated power limited outputs
      1) Fused 120VAC input power
      2) Short circuit and thermal overload protection
      3) Zero voltage drop upon transfer to battery operation
      4) AC fail supervision relay contact
      5) Low battery and battery presence supervision relay.
      6) Tamper switch on enclosure door.
   5. Battery backup for four hours of normal operation.
   6. Support for up to four reader inputs.
   7. 16 AWG metal wall mounted lockable cabinet
   8. NEMA 1 enclosure
   9. Tamper switch on door
   10. Input: 115VAC 50/60 Hz.
   11. Output: 12VDC at 6.5A maximum
   12. Operating temperature: -4 to 104 degrees F
   13. Operating humidity: 5% to 95% relative humidity non-condensing

E. Manufacturer / Model: Altronix AL600ULX series or approved equal.

2.6 CARD READER

A. Cabling:
   1. Manufacturer/Model Cable type: per manufacturer's recommendations
   2. Termination: miniature screw terminal block
B. Manufacturer/Model: HID ProxPro

2.7 CREDENTIALS

A. Not applicable to this project.

2.8 INTRUSION PANEL

A. System shall integrate with our client software which is Access It! Universal from RS2 Technologies.

B. Tyco Security shall be programmed as the monitoring service:
   1. Tyco Receiver# 877-482-4943
   2. Backup# 855-261-4672
C. Alarm panel communication (timer test) test should be configured for 4:00 AM.
D. Zone Reporting Designations:
   1. Silent Hold-up
   2. Hold-up Reset
   3. Door Opening
   4. Window Opening
E. Manufacturer/Model: Bosch D7412GV3
F. Duress Button:
   1. ND 100 GLT Panic Button
G. Motion Sensor:
   1. DS9360 Panoramic TriTech Detector
H. Alarm Keypad:
   1. D1260 Keypads

2.9 DOOR HARDWARE

A. Electric Locksets with request to exit mirco switch: Provided by others, Specified in Division 08.
B. Electric Power Transfer: Provided by others, Specified in Division 08.
C. Door Status Sensor (Concealed): Magnasphere MSS Series

PART 3 - EXECUTION

3.1 GENERAL

A. Maintain the integrity and operational status of existing access control system, including head-end equipment, panels, card readers and field devices.
B. Coordinate all system outages (partial or otherwise) with owner a minimum of two working days prior to outage.
C. Furnish, install and configure all necessary components to expand the existing access control system as indicated on the drawings and as defined in this specification.
D. In meetings with Engineer, Owner and tenant, present planning documents and review, adjust, and prepare final setup documents. Use final documents to configure and program system software.

3.2 PROTECTION

A. Maintain strict security during the installation of equipment and software.
B. Keep confidential all details of the installation, configuration and programming of the access control system. Comply with all local and federal regulations regarding the distribution of sensitive security information.
C. Room housing the control station that has been powered up shall be locked and secured. Coordinate with owner during construction.

3.3 EXAMINATION

A. Examine pathway elements intended for cables. Check raceways and other elements for compliance with space allocations, installation tolerance, hazards to camera installation, and other conditions affecting installation.
B. Examine roughing-in for LAN and IP network before device installation.
C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.4 INSTALLATION`

A. Install all equipment and materials in accordance with the current recommendations of the manufacturer.
B. The work shall also be in accordance with:
   1. Installation criteria defined in these specifications and in the construction documents.
   2. Approved submittals.
   3. Applicable requirements of the referenced standards.
C. Door Controller:

1. Mount in enclosure at locations indicated on project drawings.
2. Make connections to Card Reader, Power, Alarms and Door Latch.

D. Card Reader:
1. Mount as shown on project drawings. Use security screws where screws are accessible.

3.5 CABLING AND WIRING

A. All wiring shall be in conduit or otherwise concealed and protected against harm.
B. Comply with EIA/TIA-569.
C. Comply with NECA 1, "Good Workmanship in Electrical Contracting."
D. Install cables and wiring according to identified requirements and as noted in Division 26.
E. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.
F. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
G. Install cables using techniques, practices, and methods that are consistent with rating of components and that ensure manufacturer recommended performance of completed and linked signal paths, end to end.
H. Install cables without damaging conductors, shield, or jacket.
I. Where installed indoors, boxes and enclosures containing security system components or cabling, and which are easily accessible to employees or to the public, shall be provided with a lock. Boxes above ceiling level in occupied areas of the building shall not be considered to be accessible. Junction boxes and small device enclosures below ceiling level and easily accessible to employees or the public shall be covered with a suitable cover plate and secured with tamperproof screws.
J. Install end-of-line resistors at the field device location and not at the panel location.
K. Cable application requirements are minimum requirements and shall be exceeded if recommended or required by manufacturer of system hardware.
L. Card Readers and Keypads:
1. Install cable type(s) (construction, number of conductors, wire gauge, etc.) recommended by manufacturer for the functions specified.
2. Unless manufacturer recommends larger conductors, install No. 22 AWG wire if maximum distance from Controller to the reader is 250 feet, and install No. 20 AWG wire if maximum distance is 500 feet.
3. For greater distances, install "extender" or "repeater" modules recommended by manufacturer of the Controller.
4. Install minimum No. 18 AWG shielded cable to readers and keypads that draw 50 mA or more.

M. Cable gauge and distance shall be per manufacturers recommendations or the following, whichever is more stringent:
1. Minimum No. 16 AWG cable from Controller to electrically powered locks. Do not exceed 250 feet.
2. Minimum No. 18 AWG ac power wire from transformer to Controller, with a maximum distance of 25 feet.

3.6 SYSTEM HARDWARE INSTALLATION

A. Coordinate configuration at each door location with owner.
B. Provide access control panels, card readers, request-to-exit devices, wiring and related hardware per project drawings.
1. Mount access control panels and related hardware at exterior location(s) in weather-tight NEMA Enclosure with other low voltage equipment at these locations.

C. Provide tamper switches inside all cabinets, magnetic locks, keypad locations, and shunt-trip key locations (as applicable) to detect unauthorized opening or tampering. Wire to Gate Controllers. Tamper switches shall be installed and baffled to prevent defeat by deforming or opening the cover and to initiate a signal whenever the cover is displaced more than 1/4 of an inch from the closed position.
D. Provide Transient Voltage Surge Suppressors (TVSS) to protect all Access Control Panels.

3.7 GROUNDING

A. Comply with Division 26.
B. Comply with IEEE 1100, "Power and Grounding Sensitive Electronic Equipment."
C. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
D. Bond shields and drain conductors to ground at only one point in each circuit.

E. Signal Ground:
   1. Terminal: Locate in each equipment room and wiring closet; isolate from power system and equipment grounding.
   2. Bus: Mount on wall of main equipment room with standoff insulators.
   3. Backbone Cable: Extend from signal ground bus to signal ground terminal in each equipment room and wiring closet.

3.8 IDENTIFICATION

A. Label all hardware and cable.
B. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
   1. All wiring conductors connected to terminal strips shall be individually numbered, and each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with the name and number of the particular device as shown.
   2. Each wire connected to building-mounted devices is not required to be numbered at the device if the color of the wire is consistent with the associated wire connected and numbered within the panel or cabinet.

3.9 CONFIGURATION

A. Update existing RS2 Enterprise software and partition the existing database for the complete and proper operation of new system with multiple tenants.
B. Configure each field device (card readers, door position switches, electric strikes and request-to-exit devices) and panel tamper switches in the server. Coordinate device, door and panel naming with the Owner and with tenant (CBP).
C. Assign any new software licenses to owner.

3.10 PROGRAMMING

A. Owner and tenant will provide direction as to users and access schedule for the new building.
B. Programming of the system shall include the following tasks:
   1. Programming operational parameters such as unlocking/locking times, events, door shunt times, and communication failure/restore times.

3.11 TESTING

A. Operational Testing: The contractor shall perform thorough operational testing and verify that all system components are fully operational.
B. Hard-copy System Printout: The contractor shall submit a hard-copy system printout of all components tested and certify 100 percent operation indicating all devices/panels/units have passed the test criteria set forth by the manufacturer.
C. Acceptance Test Plan Form: An acceptance test plan form shall be prepared/provided by the contractor prior to the acceptance walk through.
D. This form shall include separate sections for each device/panel/unit as well as a column indicating the manufacturer’s performance allowance/margin, a column indicating the result of the testing performed by the contractor (pass/fail), and an empty column for recording finding during the walk-through.

3.12 COMMISSIONING

A. The Contractor shall certify completion in writing and schedule the commissioning walk-through. The contractor shall provide all the tools and personal needed to conduct an efficient commissioning process.

3.13 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.
   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.
B. Tests and Inspections:

1. Inspection: Verify that units and controls are properly installed, connected, and labeled, and that interconnecting wires and terminals are identified.
2. Pretesting: Align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements. Conduct tests at day and night as applicable. At a minimum, prepare access control system equipment for acceptance and operational testing as follows:
   a. Prepare equipment list described in "Submittals" Article.
   b. Verify operation of card readers; access granted and access denied, logging of all credentials provided at card readers.
   c. Verify operation of door position switches vis-à-vis door forced and door-held alarms.
   d. Connect and verify responses to alarms.
   e. Verify proper operation of electric strikes and other locking mechanisms.
   f. Verify proper operation of request-to-exit devices.
   g. Verify operation of control-station equipment.
   h. Verify interaction with video surveillance systems as specified in sections 282000 and 282100.
3. Test Schedule: Schedule tests after pretesting has been successfully completed and system has been in normal functional operation for at least 14 days. Provide a minimum of 10 days' notice of test schedule.
4. Operational Tests: Perform operational system tests to verify that system complies with Specifications. Include all modes of system operation. Test equipment for proper operation in all functional modes.

C. Access control system will be considered defective if it does not pass tests and inspections.
D. Prepare test and inspection reports.
E. Perform the following field tests and inspections and prepare test reports:
1. Test each circuit and component of each system. Tests shall include, but are not limited to, measurements of power supply output under maximum load, signal loop resistance, and leakage to ground where applicable. System components with battery backup shall be operated on battery power for a period of not less than 10 percent of the calculated battery operating time. Provide special equipment and software if testing requires special or dedicated equipment.
2. LAN cable procedures: Install in accordance with manufacturer recommendations and standard practices.
3. Operational Test: After installation of cables and connectors, demonstrate product capability and compliance with requirements. Test each signal path for end-to-end performance from each end of all pairs installed. Remove temporary connections when tests have been satisfactorily completed.

3.14 TRAINING

A. Conduct group and/or individual training sessions, as required by the owner, for the proper operation and maintenance of all systems installed.
1. The purpose of the training is to fully prepare the administrative and maintenance staff for complete operational responsibility of the newly installed equipment.
B. All training shall be conducted by a manufacturer authorized trainer with expertise in each listed component.
C. At minimum, the Training shall cover:
1. System Overview including Overall System Design, Features and Capabilities
2. System Operation and Maintenance
3. Component Labeling
4. Test Documentation (methods & interpretation of results)
5. Facility Tour (locations that demonstrate typical configurations)
D. Training shall:
1. Include a total of at least four (4) hours of instruction.
2. Be performed at the site
3. Be presented at time(s) arranged with the owner.
4. Include training materials for up to (6) students.
E. The Session(s) may be videotaped (by the Owner and the tenant) for use as future refresher materials for Owner and tenant technical staff.

3.15 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions.

B. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Tasks shall include, but are not limited to, the following:
   1. Check cable connections.
   2. Check proper operation of Gate/Door operation.
   3. Provide a written report of adjustments and recommendations.

3.16 CLEANING

A. Clean installed items using methods and materials recommended in writing by manufacturer.

B. Clean video-surveillance-system components, including camera-housing windows, lenses, and monitor screens.

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SECTION 28 20 00

VIDEO SURVEILLANCE SYSTEM

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
B. Division 26 sections.
C. Section 281000 “Access Control System.”

1.2 SUMMARY

A. The work included under this Section shall be an expansion of the existing Video Management System (VMS).
B. Video surveillance system shall remain integrated with the existing Access Control System (ACS) system specified in Division 28.

1.3 GENERAL CONDITIONS

A. Documentation to be submitted by Contractor upon completion of system installation.
1. Upon completion of installation, the Contractor shall prepare Record (or “as-built”) drawings of the system. Drawings” shall be AutoCAD (2010 or more recent). Drawings shall include:

a. Floor and Site plan(s) indicating exact device locations, panel terminations, cable routes, and wire numbers as tagged and color-coded on the cable tag.
b. Point-to-point wiring diagrams of each type of device.

2. Documentation of software configuration, changes or additions.
3. Operation and maintenance manuals: Two (2) sets.
   a. All approved Submittals.
   b. Manufacturers Operation and maintenance documents for each component.

1.4 DEFINITIONS

A. IP: Internet protocol.
B. LAN: Local area network.
C. PC: Personal computer.
D. PTZ: Pan-tilt-zoom.
E. RAID: Redundant array of independent disks.
F. TCP: Transmission control protocol - connects hosts on the Internet.
G. UPS: Uninterruptible power supply.
H. VMS: Video Management System
I. VSS: Video Surveillance System
J. WAN: Wide area network.
K. Furnish: To purchase, procure, acquire, and deliver complete with related accessories.
L. Install: To set in place, join, unite, fasten, link, attach, set up or otherwise connect together and test, before turning over to the Owner, all parts, items, or equipment supplied by the Contractor.
M. Provide: To furnish, transport, install, erect, connect, test and turn over to the Owner complete and ready for regular operation.

1.5 SUBMITTALS

A. Proposal Delta: It is the duty of the contractor to provide a working system. Any omissions or errors or differences between this document and the contractor's submitted proposal shall be clearly outlined in a separate document labeled "[COMPANY NAME] Proposal Deltas".
B. Qualification Statements:
   1. Manufacturer:
      a. Submit confirmation and details of manufacturer's warranty, extended warranty, and replacement policies.
      b. Submit proceeding 3 years' financial statements for the equipment manufacturer.
      c. Submit list of available manufacturer provided, fee based professional services available to the contractor or the owner including but not limited to: training, installation, commissioning, remote diagnostics and integration with 3rd party software and hardware systems.
   2. Contractor:
      a. General:
         1) This scope of work must be followed by the winning bidder, sub-contractor and Lessor.
         2) All requirements must be adhered to, including notification of project award, discussion of the project prior to start and providing a project schedule.
      b. Documentation:
         1) Submit confirmation that contractor is licensed to install video surveillance and security equipment as required by the authority having jurisdiction.
         2) Submit history of contractor certification(s) for items in this section.
         3) Submit references with contact information where contractor has installed items in this section.
         4) Submit confirmation that installer who will install this equipment or who will supervise installation of this equipment has received manufacturer training and is certified by the manufacturer on this equipment and that the training the installer received is current.
C. Product Data: Submit manufacturer technical specifications, typical installation drawings, system overview drawings and sample images of items included in this section.
D. Shop Drawings: For video surveillance system and accessories. Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, required clearances, method of field assembly, components, and location and size of each field connection.

2. Include scaled drawings for master station that detail built-in equipment.
3. Wiring Diagrams: For power, signal, and control wiring.
    a. Identify terminals to facilitate installation, operation, and maintenance.
    b. Single-line diagram showing interconnection of components.
    c. Cabling diagram showing cable routing.

E. Equipment List: Complete bill-of-materials indicating all products being furnished and installed under the project.

F. Field quality-control reports.

G. Configuration and testing plan.

H. Operation and maintenance data.

I. Warranty: Sample of project warranty and service agreement.

1.6 QUALITY ASSURANCE

A. All equipment, systems, and materials furnished and installed under this section shall be installed in accordance with the applicable standards of:
1. National codes: NEC and NFPA
2. Approvals and Listings: UL
3. EIA/TIA Telecommunications wiring standards
4. Local Authorities Having Jurisdiction

B. Contractor Certification:
1. The Contractor shall be a factory-authorized and trained dealer/integrator of the system and shall be factory-trained and certified to maintain/repair the system after system acceptance.
    a. This certification must be in place at time of Bidding and remain so throughout project.
2. Contractor performing video surveillance system installation shall have on the project team at a minimum one (1) Certified Installer trained by the manufacturer(s) of the system installed under this project.

C. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
1. Interior, Controlled Environment: System components, except central-station control unit, installed in air-conditioned interior environments shall be rated for continuous operation in ambient temperatures of 36 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing. Use NEMA 250, Type 1 enclosures.
2. Interior, Uncontrolled Environment: System components installed in non-air-conditioned interior environments shall be rated for continuous operation in ambient temperatures of 0 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing. Use NEMA 250, Type 3R enclosures.
3. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambient temperatures of minus 30 to plus 122 deg F dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to 85 mph and snow cover up to 24 inches thick. Use NEMA 250, Type 3R enclosures.
4. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers shall be rated, listed, and installed according to NFPA 70.
5. Corrosive Environment: System components subject to corrosive fumes, vapors, and wind-driven salt spray in coastal zones. Use NEMA 250, Type 4X enclosures.
6. Security Environment: Camera housing for use in high-risk areas where surveillance equipment may be subject to physical violence.

1.7 GUARANTY OF WORK

A. All components, parts, and assemblies supplied by the Manufacturers and installed by the Contractor shall be warranted against defects in material and workmanship for a period of at least two (2) years (parts and labor), commencing upon date of acceptance by Owner.
1. Warranty service shall be provided by a factory-trained service representative.
2. Warranty shall include all parts, labor and necessary travel.

B. At the end of the warranty period, Contractor shall provide detailed documentation of corrective maintenance performed from date of acceptance. Documentation shall include:
1. Description of symptoms, diagnoses and subsequent actions taken.
2. Recommended changes in routine preventive maintenance procedures shall also be included.

C. Contractor shall provide a preventive maintenance outline for all equipment included in this project.

D. The Contractor shall provide, at no additional cost, all software and/or firmware revisions and updates during the warranty period. The Contractor shall verify proper operation of the video surveillance system after incorporation of each update. Software updates shall be fully documented.

1.8 SERVICE / MAINTENANCE

A. During the warranty period the Contractor shall be responsible for maintenance and repair of the system at no charge to the owner.
   1. Includes:
      a. Labor to troubleshoot and diagnose system problems,
      b. Labor to replace workmanship defects failed devices and/or software problems.
      c. Materials
      d. Travel time and expenses.
   2. Provide 24-hours daily, 7-days per week including holidays.
   3. Repair service shall be provided within 4 hours of notification.

B. The Contractor will provide a cost budget for up to five (5) years for the maintenance and upgrades to the system. The budget must clearly define all contractor and manufacturer costs expected. The agreement shall be renewable monthly, quarterly, or yearly.

C. All repairs shall be made by a qualified service representative (fully trained in the servicing of the video surveillance systems).

D. All test adjustments or replacements shall be made in the presence of owners technician, or other person designated by the owner.

E. Upon completion of each call a report will be provided to clearly indicate any replacements or adjustments and any evidence of tampering.

1.9 EXTRA MATERIALS

A. Extra materials shall be housed in an environment and condition recommended by the manufacturer and shall be clearly labeled with “SPARE: DO NOT REMOVE”, manufacturer part number, and date of delivery to the owner.

B. All packaging for spares must be kept in good condition and used as appropriate for any Returns to Manufacturer (RMA).

C. Deliver to the owner in its original packaging:
   1. Camera: Quantity (1) of each type installed.

PART 2 - <u>PRODUCTS</u>

2.1 VIDEO SURVEILLANCE SYSTEM

A. The Video Surveillance System shall be an expansion of the existing video management system in place and new video surveillance cameras within the scope of the project.

2.2 SYSTEM REQUIREMENTS

A. Per manufacturer’s recommendations for all field device wiring and cabling.

B. General:
   1. Comply with NECA 1.
   2. Wiring Methods:
      a. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, in attics, and in gypsum board partitions where specified unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.
         1) Install plenum cable in environmental air spaces, including plenum ceilings.
         2) Comply with requirements for raceways and boxes specified in Division 26.
      b. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
      c. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3. General Requirements for Cabling:
   a. Comply with TIA/EIA-568.
   b. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
   c. Install 110-style IDC termination hardware unless otherwise indicated.
   d. Terminate conductors; no cable shall contain un-terminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
   e. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used for heating.
   f. Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions if cable is not pulled by hand.

C. Backbone Cabling:
   1. General:
      a. Backbone cabling system shall provide interconnections between communications equipment rooms and entrance facilities in the telecommunications cabling system structure.
      b. Backbone cabling system consists of backbone cables, cross-connects and patch cords or jumpers used for backbone-to-backbone or backbone-to-horizontal cross-connection.
      c. Backbone cable shall be splice-free unless noted otherwise.
      d. Bridged taps shall not be used as part of backbone cabling.
      e. Backbone cabling system shall comply with ANSI/TIA-568 and standards referenced therein for the cable type(s) specified when tested according to test procedures of these standards.
   2. Innerduct:
      a. General:
         1) Where required by the project design, install fiber optic cable in protective innerduct.
         2) Innerduct shall be plenum rated as required by the installation environment.
   3. Construction;
      a. Material: Innerduct shall be fabricated of flame-retardant and smoke-inhibiting materials suitable for installation in a plenum environment.
         1) Innerduct shall meet or exceed requirements for flame propagation and emissions as specified by test method UL-910.
         2) Innerduct shall be listed for optical fiber raceways.
      b. Type: Corrugated
      c. Color: White
      d. Size: As indicated on the drawings
      e. Pull Line: 1250# polyester in all vacant innerducts
   4. Fiber Optic Cabling:
      a. Fiber Count: Per drawings.
      b. Inter-Building Cable (Outside Plant):
         1) Type: Indoor/Outdoor rated, Loose Tube.
         2) Construction: All dielectric (no conductive material) with integral dry-type water blocking material or swellable yarn and UV-resistant polyethylene (PE) jacket.
         3) Cable Rating: Plenum rated, nonconductive: Type OFNP, complying with NFPA 262 or permitted substitutes.
         4) Jacket: As required for cable rating.
            a) Jacket Color: Black
         5) Cable jacket, fiber, unit, and group color per TIA/EIA-598.
         6) Imprinted with manufacture name, cable identification (fiber type and strand count), year of manufacture and aggregate length at regular intervals not to exceed 40 inches.
         7) Cable must comply with ICEA S-83-596 for mechanical properties, ICEA S-104-696 (indoor and outdoor cables) and ICEA S-87-640 (outdoor cables).
         8) Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70.
      c. Intra-Building Cable (Inside Plant):
         1) Type: Tight Buffer
         2) Cable Rating: Plenum rated, nonconductive: Type OFNP, complying with NFPA 262 or permitted substitutes
         3) Jacket: As required for cable rating.
            a) Jacket Color:
            b) Containing Multimode fiber: Aqua.
            c) Containing Single-mode fiber: Yellow.
            d) Cable jacket, fiber, unit, and group color per TIA/EIA-598.
         4) Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.

5) Cable must comply with ICEA S-83-596 for mechanical properties, ICEA S-104-696 (indoor and outdoor cables) and ICEA S-87-640 (outdoor cables).
6) Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70.

d. Optical Fiber:
1) Singlemode Fiber Type: OS2.
a) Construction: doped silica core surrounded by a concentric glass cladding.
b) Cable must comply with TIA/EIA-492AAAB.
c) Maximum Attenuation: 1.0 dB/km at 1310 nm; 1.0 dB/km at 1550 nm.

D. Backbone Termination Hardware:
1. Copper Termination Hardware:
a. Termination Blocks:
1) Construction:
a) Type at all cross-connect locations: 110-type.
b) On 110-type blocks, 5-pair Connecting Blocks (a.k.a. “Clips”) shall be used for Backbone cabling.
c) Connecting Blocks shall identify pair position by color designation (1-Blue, 2-Orange, 3-Green, 4-Brown, 5-Slate).
d) Block base shall incorporate legs and be suitable for wall mounting.
2) Performance: Backbone Cabling – ANSI/TIA Category 3
3) Installed Block Capacity: 25-pairs for each 25-pair conductor group of indicated cables, plus 20 percent spare positions.
b. Horizontal Jumper Management:
1) Designed for use with the termination block.
2) Construction: Split plastic rings;
3) Configurations shall be available with- and without-legs and include:
a) Plastic troughs available with and without legs, and in a rack-mountable configuration.
b) Metal panel 6.5 H x 10.7 W inches with two plastic distribution rings.
c. Vertical Jumper Management:
1) For wall-mounted installations shall be in the form of split rings. Rings shall be plastic or metal. Dimensions (minimum) shall be 3.5 inches (90 mm) square.
2. Fiber Optic Termination Hardware
a. General: Enclosed assembly that protects incoming cables, terminated fibers, couplers and connecting cords.
b. Construction:
1) Enclosure: Steel
2) Metal or polycarbonate front cover
3) Metal rear cover
c. Features:
1) Incorporates a hinged or retractable front cover designed to protect the connector couplings and fiber optic jumpers.
2) Provides strain relief of incoming cables and shall incorporate radius control mechanisms to limit bending of the fiber to the manufacturer’s recommended minimums or 1.2 inches, whichever is larger.
3) Provides access to the patching area during installation from the front and rear without any disassembly of the enclosure.
4) Requires front access only when patching.
5) Provides a physical barrier between the patching side of the panel and incoming cables.
d. Cable Connecting Hardware:
1) Must comply with TIA/EIA 604 Fiber Optic Connector Intermateability Standards (FOCIS) and applicable addenda for connector type(s) specified.
2) Must comply with TIA/EIA-568 and standards referenced therein.
e. Female/Female Couplers shall be mounted on a panel that, in turn, snaps into the enclosure. The enclosure shall be designed to accommodate a variety of connector types.
f. Connector – General Requirements:
1) Epoxy-polish or pre-polish design incorporating locking mechanism (e.g. cam) that retain optical fiber in connector body.
2) Ceramic Ferrule.
g. Connector – Singlemode:
1) Type: LC duplex.

2) Polish: Ultra-Physical Contact (UPC).
3) Body Color: BLACK.

h. Coupler – Singlemode:
1) Type: LC duplex.
2) Alignment Sleeve: Ceramic.
3) Coupler color: BLACK.

E. Horizontal Cabling:

1. General:

a. Cabling and connectivity components proposed shall be by the same manufacturer or from manufacturers between which exist a documented partnership supporting an extended warranty and performance guarantees. Partnership shall have been in effect for minimum 1-year prior to bidding.

b. Bridged taps and splices shall not be installed in the horizontal cabling.

2. Unshielded Twisted Pair (UTP) Cabling:

a. Horizontal cable and its connecting hardware provide the means of transporting signals between the telecommunications outlet/connector (TO) and the horizontal cross-connect (HC) located in the communications equipment room serving that outlet location. This cabling and its connecting hardware are called the "permanent link," a term that is used in the testing protocols.

b. The maximum allowable horizontal cable length for the permanent link is 295 feet. This maximum allowable length does not include an allowance for the length of connecting cord to the workstation equipment nor does it include an allowance for the length of connecting cord in the horizontal cross-connect.

c. General Performance: Horizontal cabling system shall comply with transmission standards in ANSI/TIA-568 and standards referenced therein for the cable type(s) specified, when tested according to test procedures of these standards.

d. UTP Cabling shall:
1) Be listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70.
2) Meet NFPA 70 Listing Requirements for Communications Plenum Rated cable type CMP.

e. Description (Inside Plant): 100-Ohm, 4-pair UTP, covered with a thermoplastic jacket.
1) Performance: ANSI/TIA Category 6.
2) Conductor Wire Gauge: 24 AWG.
3) Jacket Color: Per C.o.S. standards.
4) Comply with ICEA S-90-661 for mechanical properties.

F. Horizontal Termination Hardware:

1. Patch Panels:

a. Modular Patch Panels:
1) Connector Type: Modular Jack; 8P8C (“RJ-45”); non-keyed.
2) Cable Interface: IDC-type connectors shared by multiple jacks for permanent termination of installed cables.
a) IDC shall be 110-type or similar.
b) On rack-mounted panels, this interface shall be on the rear of the panel.
3) Panels which incorporate individual jacks inserted into the panel shall be provided in increments of no less than 12-jacks.
4) All remaining empty slots on the panel must be filled with blank inserts.

b. Pre-Installed Connector Patch Panel:
1) Panels that include all connectors pre-installed in the panel shall group the connectors in blocks of four to eight.

c. Horizontal Cabling Patch Panel: Used for all horizontal cabling within the facility.
1) Category 6 rated
2) Flat
3) 48-port

G. Racks, Cabinets and Enclosures:

1. Equipment Enclosures: Wall-Mounted.

a. General: Wall-mounted, modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.

b. Industrial Control Panel Enclosures, NEMA Type 12, IP 55

c. Dimensions:
1) Mounting width compatible with EIA 310 standard, 19-inch panel mounting.
2) Height: 19.1-inches; 9 RU usable

3) Width: 27.6-inches (nominal)
4) Depth: 24-inches (nominal)
5) Capacity: up to 200 lbs., open or closed

d. Construction:
1) Steel Frame, base and mounting rails.
2) Solid top, bottom, door and sides.
3) Door Front: 180° swing perforated doors with field-reversible hinges and a lockable swing handle.
4) Grounding studs and bonding conductors for each door.
5) Mounting Rails (vertical):
6) Drilled and tapped to accommodate 12-24 screws.
7) Supply of screws (minimum of 48 each per cabinet).
8) EIA-standard hole pattern: 5/8-5/8-1/2 inch.
9) Finish: Manufacturer's standard, baked-polyester powder coat.
10) Supply of spare screws (minimum of 48).

H. Rack, Cabinet and Enclosure Accessories
1. Grounding Components:
a. General: Products must comply with UL 467.
2. Horizontal Grounding Bar:
a. 3/16" x 3/4" x 19” copper ground bar.
b. Attachment screws (to match equipment rack, cabinet and/or enclosure).
c. 6-32 threaded holes with matching green screws.
d. Ground lug or provision for a bonding jumper.
3. Vertical Grounding Strip:
a. 1/2" x 2/3" copper ground strip (length to match height of rack and/or cabinet).
b. Attachment screws (to match equipment rack and/or cabinet).
c. 12-24 holes with matching green thread-forming screws.
d. Ground lug or provision for a bonding jumper.

I. Connecting Cords and Cables
1. General:
a. For purposes of this section, “Patch Cords” refer to those cords used at both the telecommunications room (TR) and at the station end or work area (WA) and are used to connect between the horizontal cabling and the network equipment in the TR and between the horizontal cabling and the user devices at the WA.
b. Patch cords shall be labeled with (1) manufacturer part number and (2) length (if not included in par number). At least one end of the cord shall be labeled.
2. Copper Cross-Connect Wire:
a. Cross-Connect wire shall be:
1) 24 AWG, copper twisted pair
2) Unjacketed
b. Insulation color:
1) Single-pair: white-blue/blue
2) 2-pair: white-blue/blue & white-green/green
3) 4-pair: white-blue/blue, white-green/green, white-orange/orange & white-brown/brown
3. Copper Patch Cords:
a. Patch / work area cord assembly shall meet performance requirements of TIA-568-C.2 Category 6.
b. Construction:
1) 4-Pair; 24 AWG stranded copper twisted pairs.
2) Unshielded (UTP).
3) 8-Position, 8-Conductor (8P8C) Modular Plug at both ends; Straight-through pair orientation.
c. Modular Plugs shall:
1) Be pinned TIA T-568A/B and be a snag-less design.
2) Incorporate boot/strain-relief at each modular plug.
d. Size of the modular plug and boot / strain-relief shall allow for patch cords to be positioned in adjacent ports of modular patch panel.
e. Cable jacket material shall be PVC and be marked with manufacturer’s name and cable type. Jacket color(s) shall be as indicated in on the drawings.
f. Patch cord assembly shall meet performance requirements of IEEE 802.3af and 802.3at for Power-over Ethernet applications.
4. Fiber Optic Cords:

a. For purposes of this section, “Patch Cords” refer to those cords used at both ends of either backbone or horizontal fiber optic cable and are used to connect between backbone or horizontal cabling and network equipment.
b. Construction:
    1) Cable jacket material shall be PVC. Jacket shall be factory marked indicating manufacturer and cable type. Optical connectors shall comply with TIA-604 “Fiber Optic Connector Intermateability Standards (FOCIS) and applicable addenda for connector type(s) specified.
    2) Tight-buffer.
    3) Simplex (1 fiber) and/or Duplex (2 fibers) as indicated on drawings.
    4) Incorporate optical fiber type(s) meeting specifications of backbone cabling in article above.
    5) Incorporate connector type(s) as indicated on drawings.
    6) Incorporate strain relief at rear of each connector body.
c. Duplex patch cords shall have fibers of equal length. Fibers shall be identified by strain-relief boot color or other means.
    1) Duplex Cords fitted with duplex connectors (e.g. SC, LC) shall be configured so fiber position A connects to B and B connects to A per TIA-568-C.3.
d. Singlemode Patch Cords
    1) Optical Connector:
        a) Ferrule material - Ceramic or glass-in-ceramic
        b) Ferrule Polish - Ultra-Physical Contact (UPC). End-face geometry shall be in compliance with Telcordia GR-326-CORE, Issue 3.
        c) Insertion Loss (mated pair) shall be 0.30 dB or better.
    2) Cable jacket color shall be YELLOW to indicate fiber type.
    3) Connector body color shall indicate fiber type and polish as follows:
        a) UPC polish - BLUE
        b) APC polish - GREEN

2.3 SIGNAL TRANSMISSION COMPONENTS

A. System shall be connected to Owner’s existing security network. Connection to network requires coordination with Owner for IP addressing scheme, port configuration as necessary and physical connection location(s).
B. Signal transmission components (network switches and power injectors) are to be shared between access control and video surveillance systems.

2.4 VIDEO MANAGEMENT SYSTEM

A. Existing system is Exacq Vision 6.

2.5 IP CAMERAS

A. Fixed Camera: Camera shall be P3367-VE.
B. 180 degree camera: Camera shall be Q3708-PVE
C. 360 degree camera: Camera shall be P3707-PE

2.6 INDUSTRIAL MANAGED GIGABIT EHTERNET POE SWITCH

A. Cisco Model IE-1000-8P2S-LM
B. Power Supply:
    1. PWR-IE170W-PC-AC
C. SFP Transceivers
    1. GLC-BX-D

2.7 POWER SUPPLIES

A. Not Applicable; all camera power is derived via PoE (Power over Ethernet) provided by Ethernet switch as described above.

PART 3 - EXECUTION

3.1 GENERAL

A. Maintain the integrity and operational status of existing video surveillance system, including head-end (server) equipment, storage devices and cameras.
B. Coordinate all system outages (partial or otherwise) with owner a minimum of two working days prior to outage.
C. In meetings with Engineer and Owner, present planning documents and review, adjust, and prepare final setup documents. Use final documents to configure and program system software.

3.2 PROTECTION

A. Maintain strict security during the installation of equipment and software.
B. Keep confidential all details of the installation, configuration and programming of the video surveillance system. Comply with all local and federal regulations regarding the distribution of sensitive security information.
C. Room housing the VMS server and storage that has been powered up shall be locked and secured. Coordinate with owner during construction.

3.3 EXAMINATION

A. Examine pathway elements intended for cables. Check raceways and other elements for compliance with space allocations, installation tolerance, hazards to camera installation, and other conditions affecting installation.
B. Examine roughing-in for LAN and IP network before device installation.
C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.4 INSTALLATION

A. Install all equipment and materials in accordance with the current recommendations of the manufacturer.
B. The work shall also be in accordance with:
    1. Installation criteria defined in these specifications and in the construction documents.
    2. Approved submittals.
    3. Applicable requirements of the referenced standards.

3.5 CABLING AND WIRING

A. All wiring shall be in conduit or otherwise concealed and protected against harm.
B. Comply with EIA/TIA-569C, "Commercial Building Standard for Telecommunications Pathways and Spaces."
C. Comply with NECA 1, "Good Workmanship in Electrical Contracting."
D. Install cables and wiring according to identified requirements and as noted in Division 26.
E. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.
F. Install cables using techniques, practices, and methods that are consistent with rating of components and that ensure manufacturer recommended performance of completed and linked signal paths, end to end.
G. Install cables without damaging conductors, shield, or jacket.
H. Where installed indoors, boxes and enclosures containing security system components or cabling, and which are easily accessible to employees or to the public, shall be provided with a lock. Boxes above ceiling level in occupied areas of the building shall not be considered to be accessible. Junction boxes and small device enclosures below ceiling level and easily accessible to employees or the public shall be covered with a suitable cover plate and secured with tamperproof screws.
I. Cable application requirements are minimum requirements and shall be exceeded if recommended or required by manufacturer of system hardware.

3.6 SYSTEM HARDWARE INSTALLATION

A. Install cameras level and plumb.
B. Install cameras with 84-inch-minimum clear space below cameras and their mountings. Change type of mounting to achieve required clearance.

C. Set final camera position and to obtain the field of view required for camera. Connect all controls and alarms, and adjust.

3.7 GROUNDING

A. Comply with Division 26 Section "Grounding and Bonding for Electrical Systems."
B. Comply with IEEE 1100, "Power and Grounding Sensitive Electronic Equipment."
C. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
D. Bond shields and drain conductors to ground at only one point in each circuit.
E. Signal Ground:
    1. Terminal: Locate in each equipment room and wiring closet; isolate from power system and equipment grounding.
    2. Bus: Mount on wall of main equipment room with standoff insulators.
    3. Backbone Cable: Extend from signal ground bus to signal ground terminal in each equipment room and wiring closet.

3.8 IDENTIFICATION

A. Label all hardware and cable.
B. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
    1. All wiring conductors connected to terminal strips shall be individually numbered, and each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with the name and number of the particular device as shown.
    2. Each wire connected to building-mounted devices is not required to be numbered at the device if the color of the wire is consistent with the associated wire connected and numbered within the panel or cabinet.

3.9 CONFIGURATION

A. Configure each new camera in the server. Coordinate camera naming with the Owner.
B. Assign any new software licenses to owner.
C. Setup and focus cameras as noted in the camera schedule to achieve the following view types:
    1. Identification:
        a. A minimum of 70 pixels per foot at a radius of ten (10) feet from the camera.
    2. Monitoring:
        a. A minimum of 5 pixels per foot at a radius of fifty (50) feet from the camera.

3.10 PROGRAMMING

A. Owner will provide direction as to users and access schedule for the building.

3.11 TESTING

A. Operational Testing: The contractor shall perform thorough operational testing and verify that all system components are fully operational.
B. Acceptance Test Plan Form: An acceptance test plan form shall be prepared/provided by the contractor prior to the acceptance walk through.
C. This form shall include separate sections for each device/panel/unit as well as a column indicating the manufacturer’s performance allowance/margin, a column indicating the result of the testing performed by the contractor (pass/fail), and an empty column for recording finding during the walk-through.

3.12 COMMISSIONING

A. The Contractor shall certify completion in writing and schedule the commissioning walk-through. The contractor shall provide all the tools and personal needed to conduct an efficient commissioning process.

3.13 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.
   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.
B. Tests and Inspections:
   1. Inspection: Verify that units and controls are properly installed, connected, and labeled, and that interconnecting wires and terminals are identified.
   2. Pretesting: Align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements. Conduct tests at varying lighting levels, including day and night scenes as applicable. At a minimum prepare video surveillance system equipment for acceptance and operational testing as follows:
      a. Prepare equipment list described in "Submittals" Article.
      b. Verify operation of auto-iris lenses.
      c. Set back-focus of fixed focal length lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Adjust until image is in focus with and without the filter.
      d. Set back-focus of zoom lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Additionally, set zoom to full wide angle and aim camera at an object 50 to 75 feet away. Adjust until image is in focus from full wide angle to full telephoto, with the filter in place.
      e. Set and name all preset positions; consult Owner's personnel.
      f. Set sensitivity of motion detection.
      g. Connect and verify responses to alarms.
      h. Verify operation of control-station equipment.
      i. Verify interaction with access control system as specified in section 281000.
   3. Test Schedule: Schedule tests after pretesting has been successfully completed and system has been in normal functional operation for at least 14 days. Provide a minimum of 10 days' notice of test schedule.
   4. Operational Tests: Perform operational system tests to verify that system complies with Specifications. Include all modes of system operation. Test equipment for proper operation in all functional modes.
C. Video surveillance system will be considered defective if it does not pass tests and inspections.
D. Prepare test and inspection reports.

3.14 TRAINING

A. Conduct group and/or individual training sessions, as required by the owner, for the proper operation and maintenance of all systems installed.
   1. The purpose of the training is to fully prepare the administrative and maintenance staff for complete operational responsibility of the newly installed equipment.
B. All training shall be conducted by a manufacturer authorized trainer with expertise in each listed component.
C. At minimum, the Training shall cover:
   1. System Overview including Overall System Design, Features and Capabilities
   2. System Operation and Maintenance
   3. Component Labeling
   4. Test Documentation (methods & interpretation of results)
   5. Facility Tour (locations that demonstrate typical configurations)
D. Training shall:
   1. Include a total of at least four (4) hours of instruction.
   2. Be performed at the site
   3. Be presented at time(s) arranged with the owner.
   4. Include training materials for up to (6) students.
E. The Session(s) may be videotaped (by the Owner and the tenant) for use as future refresher materials for Owner and tenant technical staff.

3.15 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Tasks shall include, but are not limited to, the following:
   1. Check cable connections.

2. Check proper operation of cameras and lenses. Verify operation of auto-iris lenses and adjust back-focus as needed.
3. Adjust all preset positions; consult Owner's personnel.
4. Recommend changes to cameras, lenses, and associated equipment to improve Owner's use of video surveillance system.
5. Provide a written report of adjustments and recommendations.

3.16 CLEANING

A. Clean installed items using methods and materials recommended in writing by manufacturer.

B. Clean video-surveillance-system components, including camera-housing windows, lenses, and monitor screens.

END OF SECTION

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SECTION 28 31 16

MULTI-PLEXED FIRE DETECTION AND ALARM SYSTEM

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PART 1 - GENERAL

1.1 RELATED WORK

A. Section 14 2100 - Electric Traction Elevators
B. Section 14 2400 - Hydraulic Elevators
C. Section 21 1314 - Automatic Fire Sprinkler System
D. Section 21 1318 - Fire Protection Systems
E. Section 23 0993 - Control Sequences
F. Section 26 0000 - General Electrical Requirements
G. Section 26 0519 - Low-Voltage Electrical Power Conductors and Cables
H. Section 26 0526 - Grounding and Bonding for Electrical Systems
I. Section 26 0533 - Raceway and Boxes for Electrical Systems

J. Section 26 0553 - Electrical Systems Identification

1.2 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. Manual Stations
      c. Heat Detectors
      d. Smoke Detectors
      e. Alarm Indicating Devices
      f. Terminations
      g. 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.

1.3 REFERENCE STANDARDS

A. IBC - 2000 - International Building Code
B. IFC - 2000 - International Fire 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

1.4 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.

1.5 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.

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.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Simplex
B. Siemens
C. Notifier by Honeywell
D. Gamewell-FCI by Honeywell

2.2 SYSTEM OPERATIONS

A. Alarm Initiation
   1. System alarm operation after activation of any manual station, automatic detection device, or sprinkler flow switch shall be:
      a. Appropriate initiating device circuit red LED shall flash on Control Panel until the alarm has been acknowledged at Control Panel.
      b. Once acknowledged, this same LED shall latch on.
      c. Subsequent alarm received after acknowledging shall flash subsequent zone alarm LED on Control Panel.
      d. Acknowledgment of alarm shall not reset activated device.
      e. Pulsing alarm tone shall occur within Control Panel 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.
      g. Visual alarm indicating devices shall operate in continuous flashing pattern until system is reset.
      h. Call out to TYPCO security via dedicated phone line to FACP
      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.
   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. Auxiliary manual controls. "Off normal" position of any switch shall cause an "off normal" system trouble
      d. Auxiliary circuits for addressable relays. Blown fuse or open in circuit shall be visibly and audibly annunciated.
      e. Incoming power. Power failure shall be audibly and visually indicated at Control Panel Green "power on" LED shall be displayed continuously while incoming power is present.
      f. System Modules for module placement. Should modules become disconnected, system trouble indicator shall illuminate and audible trouble signal shall sound.

g. System batteries. Low battery condition or disconnection of battery shall be audibly and visually indicated at Control Panel.

2. Device activation shall be annunciated at Control Panel
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 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.
3. New Fire Alarm Control Panel shall provide AHU fan shutdown functions identical to existing. Reconnect existing fan shutdown wiring to new panel.

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.
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. Control relay functions shall be bypassed, such as elevator capture, fan shut down, etc.
   b. Audio and visual circuits shall be bypassed.
   c. Control Panel shall show trouble condition.
   d. Alarm activation of initiation device shall cause audible signals to sound for 2 seconds.
   e. Control Panel shall automatically reset itself after signaling is complete.
   f. Momentary opening of initiating or indicating appliance circuit wiring shall cause audible signals to sound for 2 seconds indicating trouble condition.
   g. If system becomes inactive for period of longer than 5minutes, Control Panel shall default to normal fire alarm functions.
   h. Activation of any initiation device shall be silently logged as an alarm condition in historical data file.
2. Panel shall have capability of dividing system into distinctive walk test groups, minimum of 8 groups.

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 has been operated.
   b. Audio alarm operations of speaker circuit selection and alarm tone timing variations shall be activated by system software so that required future changes to evacuation sequence or re-arrangements of audio circuits can be facilitated by authorized personnel without additional components or rewiring.
   c. System shall be configured to allow for "All Call" and selective voice paging from the main Control Panel. A/E to select next paragraph if selective paging is required and show designated FAAP.
2. Selective Paging:
   a. Upon activation of any speaker manual control switch(es), 2 seconds of tone shall sound over selected speakers. At end of this tone, operator shall be able to make announcements via push-to-talk paging microphone over pre-selected speakers.
   b. Strobes shall flash only in selected area(s) or floor(s).
   c. Each floor, stairwell and elevator car shall be separate selectable zones.
3. All Call:
   a. Upon activation of "All Call" switch, 2 seconds of tone shall sound over all speakers in system. At end of this tone, the operator shall be able to make announcements via push-to-talk paging microphone overall 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.

R. Two-Way Voice Communications
1. Two-Way Fire Fighter Communications
   a. Plugging handset into emergency phone jack or removal of any phone from its normal hook position shall cause phone location LED to flash and distinctive audible device to sound at Control Panel.
   b. Picking up of master phone and acknowledgment of phone circuit shall silence pulsing tone and cause phone location LED to stop flashing and remain on. This action shall couple remote phone to master phone to provide direct and private communications.
   c. Attempting to use another phone on same circuit shall not cause pulsing tone to activate if any two-way communications are already established.
   d. Any new circuits activated shall cause their discrete phone circuit LEDs to flash until acknowledged.
   e. Two-Way Communications System shall provide capacity to handle simultaneous use of multiple remote phones.
   f. Unplugging all handsets in use and replacement of all remote phones to their normal hook position and returning all related circuit acknowledgment switches to normal position shall cause restoration of normal supervisory functions.
   g. If any remote phone is not hung up or unplugged, then appropriate phone zone indicator LED shall flash and pulsing tone shall resume at control panel.

h. When combined with one-way voice communications system, it shall permit remote paging from any fire fighters remote phone location via system speakers as manually selected at main controls.
i. Master Telephones shall be capable of communicating to one another or to any remote fire fighters phone jack or phone station.

2.3 ENCLOSURE

A. Provide cabinets of sufficient size to accommodate equipment.
B. Cabinet shall be equipped with door, with lock and transparent door panel, providing tamper proof enclosure and allowing full view of various lights and controls.
C. Install panel flush in wall.

2.4 CONTROL PANEL

A. Control Panel shall be modular, expandable with solid state, microprocessor based electronics.
B. Control Panel shall provide the following features:
1. Support intelligent (analog) detection devices.
2. Number of initiating device loops required for specified quantity of initiating devices plus 1 spare loop for each 5active loops. Each active loop shall include 5% spare capacity.
3. Number of indicating device (horn/speaker) circuits required for quantity of horns/speakers alarm, plus 1 spare circuit for each 10 active circuits. Each active circuit shall include 25% spare capacity.
4. Number of indicating device (strobe) circuits required for specified quantity of strobes plus one (1) spare circuit for each 10 active circuits. Each active circuit shall include 25% spare capacity.
5. 80-character liquid crystal display
6. Printer interface
7. History log file with minimum of 600 events
8. Field programmable
9. Drift compensation
10. Sensitivity display in %
11. Sensitivity adjustment
12. Day/night sensitivity adjustment
13. Auto detector test
14. Alarm verification with tally counter
15. Silent walk test
16. Maintenance alerts
C. System shall provide ability to recall alarms and trouble conditions in chronological order.
D. Under normal condition viewing window shall display "System is Normal" message and current time and date.
E. When an abnormal condition occurs appropriate LED (Alarm, Supervisory or Trouble) shall flash.
F. Audible signal shall pulse for alarm conditions and sound steady for trouble and supervisory conditions.
G. Panel shall display the following information relative to abnormal condition of a point in system prior to acknowledgement:
1. 40 characters for:
a. Point address and loop number
b. Type of device (i.e. smoke, pull station, water-flow)
c. Point status (i.e. alarm, trouble)
2. 40 characters for:
a. Custom location label (i.e. 4th Floor - Room 444)
H. Keyboards or keypads shall not be required to operate the system during fire alarm conditions.
I. Following software functions shall be provided:
1. Setting of time and date
2. LED testing
3. Alarm, trouble, and abnormal condition listing
4. Enabling and disabling of each monitor point separately
5. Activation and deactivation of each control point separately
6. Changing operator access levels
7. Walk Test enable
8. Running diagnostic functions
9. Displaying historical logs
10. Point listing
J. Following hardware functions shall be provided:
1. Acknowledge alarm or trouble

2. Silence alarm or trouble
3. Reset system after alarm
4. Provide manual evacuation (drill)
5. Bypass elevator recall and shunt trip operation
6. Bypass door holders
7. Allow computer interface

2.5 STATUS INDICATORS AND DISPLAYS

A. Audible device shall sound during Alarm, Trouble or Supervisory conditions.
B. Audible device shall sound during each key-press.
C. Visual display shall distinguish between alarm, trouble and supervisory conditions.
D. Indicators and displays to be visible:
   1. One red system alarm LED
   2. One yellow supervisory service LED
   3. One yellow trouble LED
   4. Green "power on" LED
   5. Eighty-character LCD
E. 2-line by 40-character LCD shall be backlit.
F. Cursor shall be visible on LCD when entering information.
G. Scrolling through menu options shall be in self-directing manner in which prompting messages shall direct user.
H. Controls shall be located behind an access door.
I. Status data to be available on display:
   1. Initiating device circuits
   2. Indicating device circuits
   3. Auxiliary relays
   4. Primary State of point
   5. Zone information
   6. Class "A" Status
   7. Current priority of outputs
   8. Disable/Enable status
   9. Automatic/Manual Control Status of output points
   10. Acknowledge status

2.6 CONTROLS

A. Controls (one switch per function per system) visible through front viewing window:
   1. Alarm Acknowledge key
   2. Trouble Acknowledge key
   3. Alarm Silence key
   4. System Reset key
B. Controls accessible with front door open:
   1. Manual evacuation (drill)
   2. Key pad for data input and microprocessor control

2.7 LED SUPERVISION

A. Slave module LEDs shall be supervised. When problem occurs, LCD shall display module and LED location.

2.8 ACKNOWLEDGMENT

A. Two methods of acknowledgment for each abnormal condition shall be provided:
   1. Acknowledge one event at a time from an unacknowledged list of events.
   2. Pressing acknowledge button shall display first unacknowledged condition in list (either alarm, supervisory or trouble), and require another acknowledge button. Press to acknowledge only displayed point.
B. After all points have been acknowledged, LEDs shall glow steadily and alarm will be silenced. Total number of alarms, supervisory and trouble conditions shall be displayed.
C. Pressing appropriate acknowledge button shall acknowledge all points
D. Acknowledge functions shall be behind locked door or pass-code protected.

2.9 SILENCING

A. If an alarm condition exists and "Alarm Silence" button is pressed, all alarm signals shall cease operation. Strobes shall remain active until system is reset.

B. If trouble conditions exist in system and "Trouble Silence" button has been pressed, audible trouble signal shall cease, but shall resound at timed intervals to act as reminder that fire alarm system is not in normal operating mode.

2.10 RESET

A. SYSTEM RESET button shall be used to return system to normal state after alarm condition has been remedied.

B. Should an alarm condition continue to exist, system shall provide indications that resetting cannot be completed and shall remain in an abnormal state.

C. Sonalert and Alarm LED shall remain activated.

D. Display shall indicate total number of alarms and troubles present in system along with prompt to use ACK keys to review points.

E. Points shall not require acknowledgment if they were previously acknowledged.

F. Should Alarm Silence Inhibit function be active, system shall ignore all key presses. An indication of enabling and disabling inhibit state shall be provided as feedback to operator.

2.11 ACCESS LEVELS

A. Provide 4 access levels with level 4 being highest level. Level 1 actions shall not require pass-code.

B. Pass-codes shall consist of up to 5 digits.

C. Pass-code digits entered shall be displayed as an X to indicate that digit has been accepted.

D. Key presses shall be acknowledged by local audible sound.

E. When correct pass-code is entered, system shall indicate to operator "Access Granted."

F. Access level shall be in effect until operator manually logs out or keypad has been inactive for 5 minutes.

G. Operator entering invalid code shall be notified with message "Incorrect Pass- Code" and shall be allowed three chances to enter valid code. After three unsuccessful tries, the message "Access Denied" shall be displayed.

H. Following keys/switches shall have associated access levels:

1. Alarm Silence
2. System Reset
3. Set Time/Date
4. Manual Control
5. On/Off/Auto Control
6. Disable/Enable
7. Programming functions
8. Clear Historical Alarm Log
9. Clear Historical Trouble Log
10. Walk Test

I. Acknowledge keys shall require pass code access to acknowledge points. If operator presses an (ACK) key with insufficient access, an error message shall be displayed.

2.12 POINT LISTING

A. Point list menu includes:

1. All points list by address
2. Monitor point list
3. Signal/speaker list
4. Auxiliary control list
5. Feedback point list

2.13 HISTORY LOGGING

A. System shall be capable of logging and storing the last 400 events (alarm and trouble) in history log. These events shall be stored in battery protected random access memory.

B. Following historical alarm log events shall be stored:

1. Alarms
2. Alarm Acknowledgment
3. Alarm Silence
4. System Reset
5. Alarm Historical log cleared

C. Following historical trouble log events shall be stored:
   1. Trouble conditions
   2. Supervisory alarms
   3. Trouble acknowledgment
   4. Supervisory acknowledgment
   5. Walk Test results
   6. Trouble Historical log cleared

2.14 COMPUTER INTERFACE

A. Control Panel shall operate as proprietary local system with capability of sending status data to and receiving control data from Central Processing Unit (CPU).
B. CPU shall monitor all alarms and troubles and control selected functions of Control Panel.
C. CPU shall supervise all data communication wiring between CPU and Control Panel for opens, shorts and grounds.

2.15 FIELD PROGRAMMING

A. System shall be fully programmable, configurable, and expandable in field and shall not require replacement of memory IC's.
B. Programming may be accomplished through Control Panel keyboard or keyboard at printer, or use of PC.
C. Programs shall be stored in non-volatile memory.
D. Programming or reprogramming shall be done by supplier at no charge until system is accepted by Owner.

2.16 TERMINAL/PRINTER INTERFACE

A. Control Panel shall be capable of operating remote monitors and/or printers.
B. Output shall be ASCII from RS-232-C connection with an adjustable baud rate.
C. Each RS-232-C port shall be capable of supporting and supervising up to 4 remote CRTs and Printers.
D. Data amplifiers shall be used to increase CRT or printer line distance.

2.17 INTELLIGENT NETWORK

A. System shall provide communications with intelligent initiating and control devices individually.
B. Devices shall be individually annunciated at control panel.
C. Annunciation shall include the following conditions for each point:
   1. Alarm
   2. Trouble
   3. Open
   4. Short
   5. Device missing/failed
D. Devices shall have capability of being disabled or enabled individually.
E. There shall be no limit to number of detectors, stations, or addressable modules, which may be activated or "in alarm" simultaneously.
F. Multiple intelligent devices shall be connected to a single pair of wires.
G. Communication format must be completely digital poll/response protocol to allow t-tapping of circuit wiring.

2.18 ONE-WAY VOICE COMMUNICATION SYSTEM

A. Provide central audio control module for:
   1. Alarm message/tone generation
   2. Main and remote microphone connections
   3. Mixer/pre-amplifier circuits
   4. Continuous supervision shall be provided for all circuits, amplifiers and modules.
B. Hand-held, push-to-talk microphone:
   1. Recessed in panel-mounted enclosure
   2. Dynamic communication type with frequency range of 200 Hz to 4000 Hz
   3. Equipped with self-winding 5’ coiled cable
   4. LED indicator shall be provided to indicate microphone push-to-talk button has been pressed and speaker circuits are ready for transmission.
   5. Supervised for disconnection
C. Audio control switch module:
   1. Provide manual access to audio operations personnel.
   2. Include "All circuits" switch, "Aux Tone" switch and tone generator stop switch
   3. Switches and LED indicators shall be supervised for disarrangement on failure.

D. Automatic message player:
   1. Provide a pre-recorded digitized voice message to building occupants during alarm conditions
   2. Not rely on tape or other mechanical means of transmitting evacuation message
   3. Be capable of transmitting a custom message of up to 3 minutes long

E. Self-contained speaker and switching arrangement shall provide testing of message(s) without disturbing occupants of the facility.

F. Provide standard message, approved by Authority Having Jurisdiction.

G. Audio power amplifiers:
   1. Be furnished with self-contained filtered 24 VDC power supply, transformer and amplifier monitoring circuits
   2. Provide 25 or 75 VRMS output with frequency response of 100 Hz to 7000 Hz
   3. Be constantly monitored
   4. Be current limited or disconnected from circuit should a short develop on speaker circuit
   5. Individual speaker circuits shall not be loaded more than 70%of rated amplifier power output.

H. Provide amplifiers to operate system speakers at 1-watt tap simultaneously plus 50% reserve capacity.

I. Provide at least one back-up amplifier capable of automatically replacing any failed amplifier. Stand-by amplifier shall be rated at same output capacity as the largest amplifier in evacuation system.

J. Speaker and strobe circuits shall be zoned by floor or as noted on plans, with isolating module on each circuit.

K. Audio Evacuation Supervision:
   1. Each speaker zone, amplifier, preamplifier, and power supply shall be supervised for component or circuit failure.
   2. Detection of amplifier failure shall automatically cause substitution of stand-by amplifier and shall activate trouble light and audible signal at console and initiate trouble alarm on fire alarm system.
   3. Provide minimum of one circuit for each zone or area of distinct communication.

L. Manual Voice Paging Sequence
   1. System shall allow selective voice paging.
   2. An "All Call" switch shall be provided to allow for activation of all speakers.
   3. Control Panel shall provide a method for remote fire fighters telephone patch-in to one-way voice communication speakers.
   4. Manual operation shall be controlled at Fire Alarm Control Panel, or remote microphone; if provided.

M. Tones
   1. Main evacuating tone shall be temporal code-three.
   2. Optional tones shall include:
      a. Hi/Lo
         1) Free running tone with high frequency of 544 Hz and low frequency of 440 Hz
         2) "On time" (Hi) shall be 100 milliseconds while the "off time" (Lo) is 400 milliseconds.
      b. Slow whoop
         1) Slowly ascending tone from 200 to 830 Hz in 2.5 seconds
   3. One primary and one secondary tone generator shall be furnished.
      a. Automatic transfer to secondary unit should primary unit fail
      b. Trouble signals shall indicate a failure of either primary or secondary unit.

2.19 MULTIPLEXED PERIPHERAL DEVICES

A. Devices shall be supervised for trouble conditions.

B. Failure of device shall not hinder operation of other system devices.

C. Device Identification
   1. Each intelligent device shall be identified by an address code.
   2. Location of end-of-line device shall be indicated on device that containing same.
   3. System must verify that proper type device is in place and matches software configuration.

D. Intelligent Detector Bases
   1. Either base or head shall contain electronic circuits that communicate detector's status (normal, alarm, sensitivity status, trouble) to Control Panel over two wires. Same two wires shall also provide power to base and detector.
   2. Contacts between base and head shall be of bifurcated type using spring-type, self-wiping contacts.
   3. Base shall have locking capability. Locking feature must be field removable when not required.
   4. Upon removal of detector's head, trouble signal shall be transmitted to Control Panel.
   5. Detector base or head shall contain LED(s) that flash when detector is being scanned by Control Panel.

6. LED(s) shall turn on steady when detector is in alarm condition.

E. Intelligent Detector Heads - General
1. Intelligent detector heads shall be low-profile type.
2. Heads shall be plug-in units, which mount to common base.
3. Heads shall be 24 VDC type.
4. Heads may be reset by actuating Control Panel reset switch.
5. To minimize false alarms, voltage and RF transient suppression techniques shall be employed.
6. Smoke detectors:
   a. Listed for sensitivity testing from Control Panel. Sensitivity test results shall be logged and downloaded to printer.
   b. Include an insect screen.
   c. Communicate actual smoke chamber values to Control Panel.
   d. Covered with plastic bags after installation to maintain cleanliness. Bags shall be red for quick visual identification for removal at time of occupancy.
7. Install smoke detectors on circuits with alarm verification modules.

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. Double action
   b. Constructed of high impact, red Lexan with raised white lettering and smooth high gloss finish
   c. Contain circuits that communicate station's status (alarm, normal) to Control Panel over two wires
   d. Mechanically latch upon operation and remain so until manually reset. Stations that use Allen wrenches or special tools to reset shall not be accepted.
   e. Fitted with screw terminals for field wire attachment
2. Address shall be field programmable on station.

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.

2.20 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. Provide a minimum sound pressure level of 90 dBA at 10’ using the 2-watt tap.
g. Speakers located in generator room shall have 3 taps minimum with 8W being the highest.
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.

2.21 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. 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.

2.22 ISOLATED LOOP CIRCUIT PROTECTORS (ILCP)

A. Fire Alarm Control Panel shall include Isolated Loop Circuit Protector (ILCP) on circuits which extend beyond building. Circuits include, initiating device circuits, alarm notification appliance circuits, and signaling line circuits.

B. ILCP shall:
1. Be located as close as practical to point where circuits leave or enter building.
2. Have line-to-line response time of less than 1 nanosecond.
3. Have #12 AWG grounding conductor with maximum length of 25'. It shall be run in straight line and connected to building grounding electrode system.

C. Spark gap devices or devices incorporated in or installed within control panel in lieu of ILCP are not acceptable.

2.23 PRINTERS AND TERMINALS

A. Multiplex/intelligent systems shall be provided with printer and terminal (keyboard and CRT).

B. Printer
1. Desktop 80-column, impact dot matrix printer.
2. Printer shall receive English language text from Control Panel in standard ASCCII format via RS-232-C connection.
3. Printed information shall include time, date, status, point number, label, and device type identifier.
4. Printer shall have the following features:
   a. 120 VAC input power
   b. 180 characters per second printing speed
   c. 3 kilobytes buffer capacity
   d. Cartridge type ribbon
   e. Friction feed for cut forms
   f. Tractor feed for continuous 9-1/2" wide pin-to-pin fanfold paper

C. Terminal
1. Desktop terminal (monitor with detachable keyboard) with English language and display of time and date of system events.
2. Monitor shall be tilt/swivel, with 14", green phosphor, non-glare CRT.
3. Displayed information shall include time, date, status, point number, label, and device type identifier.
4. Information on screen shall not scroll off until an acknowledge key is pressed.
5. Terminal shall include composite video output to drive slave monitors.
6. Terminals shall provide and control the following:
   a. Acknowledgment of alarms, troubles and supervisory conditions
   b. Alarm silence
   c. System Reset
   d. Time and Date
   e. Alarm, Trouble and Supervisory service conditions summary screens

PART 3 - EXECUTION

3.1 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.

3.2 RACEWAYS

A. Fire Alarm Panel risers shall be in conduit system separate from other building wiring.
B. Wiring shall be in conduit system separate from other building wiring. See Section 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.

3.3 CONDUCTORS

A. Cables and wires shall be provided per manufacturer shop drawings.
B. Conductors shall be color-coded. Coding shall be consistent throughout 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.
K. Cable for RS 232-c devices (CRT, PRINTER) shall be two, shielded twisted pair.
L. Wiring of initiating device circuits, alarm horn/speaker 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/speaker and strobe circuits shall have separate conductors, and shall operate independently of each other.

3.4 DEVICE MOUNTING

A. Recommended mounting heights, and requirements are as follows:
    1. Fire Alarm Control Panels
        a. Mount control panel so visual indicators and controls at 60" above floor level.
    2. Audio-Visual Devices
        a. Install flush, semi-flush or surface mount 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.
    3. 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.

4. Heat and Smoke Detectors
    a. Location of detectors shown on plans is schematic only. Detectors must be located according to code requirements.
    b. Surface mounted detectors shall be installed using back boxes equal to base size. Standard octagon and square boxes are not acceptable.
    c. Detectors shall be located on the highest part of smooth ceiling so that edge of detector is no closer than 4” from sidewall.
    d. Ceilings with beams, joists or soffits that exceed 8” in depth require special planning and closer spacing.
    e. Mount detectors on sidewalls with top of detector no closer than 4” from ceiling and no further away than 12”.
    f. Smoke detectors shall not be installed closer than 3’ from air supply diffusers.
    g. No detectors shall be installed in direct airflow.
    h. Heat and smoke detectors should be located near center of open area, which they protect.
    i. Mark zone number and ranking of each detector on its base.
    j. For intelligent systems, mark address and loop number on each detector's base.

3.5 DEMOLITION

A. Existing equipment that is removed shall be inventoried and turned over to Owner
B. Upon inspection by Owner, Contractor shall dispose of equipment that is deemed useless to Owner.
C. Contractor shall remove abandoned devices and conduit not being reused.

3.6 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 sheath.
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.

3.7 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.

3.8 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

3.9 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 insure 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.

3.10 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.

3.11 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.

3.12 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.

3.13 SPARE PARTS

A. Contractor shall provide the following spare parts in quantities shown, with a minimum of 1/item:

Quantity	Type of Device Present
10%	Photoelectric smoke detectors
10%	Heat detectors
10%	Smoke and heat detector bases
5%	Monitor Modules
5%	Control Modules
1%	Duct detectors with housing and sample tubes
1%	Speaker/Strobe annunciation devices
1%	Manual Stations

END OF SECTION

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SECTION 31 20 00
EARTH MOVING

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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. Preparing subgrades for slabs-on-grade.
   2. Excavating and backfilling for buildings and structures.
   3. Drainage course for concrete slabs-on-grade.
   4. Subsurface drainage backfill for walls and trenches.

B. Related Sections:
   1. Section 01 32 00 "Construction Progress Documentation", Section 01 32 33 "Photographic Documentation" for recording pre-excavation and earth moving progress.
   2. Section 03 30 00 "Cast-in-Place Concrete" for granular course if placed over vapor retarder and beneath the slab-on-grade.
   3. Section 31 10 00 "Site Clearing" for site stripping, grubbing, stripping and stockpiling topsoil, and removal of above- and below-grade improvements and utilities.

4. Section 31 23 19 "Dewatering" for lowering and disposing of ground water during construction.
5. Section 31 50 00 "Excavation Support and Protection" for shoring, bracing, and sheet piling of excavations.
6. Section 33 46 00 "Subdrainage" for drainage of foundations, slabs-on-grade, walls and landscaped areas.

1.3 DEFINITIONS

A. Backfill: Soil material or controlled low-strength material used to fill an excavation.
   1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
   2. Final Backfill: Backfill placed over initial backfill to fill a trench.
B. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.
C. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.
D. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
   1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Architect. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
   2. Bulk Excavation: Excavation more than 10 feet in width and more than 30 feet in length.
   3. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Architect. Unauthorized excavation, as well as remedial work directed by Architect, shall be without additional compensation.
E. Fill: Soil materials used to raise existing grades.
F. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.
G. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.
H. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following manufactured products required:
   1. Geotextiles.
   2. Controlled low-strength material, including design mixture.
   3. Geofoam.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.
B. Material Test Reports: For each on-site and borrow soil material proposed for fill and backfill as follows:
   1. Classification according to ASTM D 2487.
   2. Laboratory compaction curve according to ASTM D 1557.
C. Pre-excavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces that might be misconstrued as damage caused by earth moving operations. Submit before earth moving begins.

1.6 QUALITY ASSURANCE

A. Geotechnical Testing Agency Qualifications: Qualified according to ASTM E 329 and ASTM D 3740 for testing indicated.
B. Pre-excavation Conference: Conduct conference at Project site.

1.7 PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth moving operations.
   1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.

2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

B. Improvements on Adjoining Property: Authority for performing earth moving indicated on property adjoining Owner's property will be obtained by Owner before award of Contract.
1. Do not proceed with work on adjoining property until directed by Architect.

C. Utility Locator Service: Notify utility locator service for area where Project is located before beginning earth moving operations.

D. Do not commence earth moving operations until temporary erosion- and sedimentation-control measures are in place.

E. The following practices are prohibited within protection zones:
1. Storage of construction materials, debris, or excavated material.
2. Parking vehicles or equipment.
3. Foot traffic.
4. Erection of sheds or structures.
5. Impoundment of water.
6. Excavation or other digging unless otherwise indicated.
7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.

F. Do not direct vehicle or equipment exhaust towards protection zones.

G. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

B. Satisfactory Soils: Soil Classification Groups GW, GP, GM, SW, SP, and SM according to ASTM D 2487, or a combination of these groups; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.

C. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D 2487, or a combination of these groups.
1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.

D. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1-1/2-inch (37.5-mm) sieve and not more than 12 percent passing a No. 200 sieve.

E. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; except with 100 percent passing a 1-inch sieve and not more than 8 percent passing a No. 200 sieve.

F. Drainage Course: Narrowly graded mixture of washed crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch sieve and 0 to 5 percent passing a No. 8 sieve.

G. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D 448; coarse-aggregate grading Size 67; with 100 percent passing a 1-inch sieve and 0 to 5 percent passing a No. 4 sieve.

H. Sand: ASTM C 33; fine aggregate.

I. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

2.2 GEOTEXTILES

A. Subsurface Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
1. Survivability: Class 2; AASHTO M 288.
2. Grab Tensile Strength: 157 lbf; ASTM D 4632.
3. Sewn Seam Strength: 142 lbf; ASTM D 4632.
4. Tear Strength: 56 lbf; ASTM D 4533.
5. Puncture Strength: 56 lbf; ASTM D 4833.
6. Apparent Opening Size: No. 60 sieve, maximum; ASTM D 4751.

7. Permittivity: 0.2 per second, minimum; ASTM D 4491.
8. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.

B. Separation Geotextile: Woven geotextile fabric, manufactured for separation applications, made from polyolefins or polyesters; with elongation less than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:

1. Survivability: Class 2; AASHTO M 288.
2. Grab Tensile Strength: 247 lbf; ASTM D 4632.
3. Sewn Seam Strength: 222 lbf; ASTM D 4632.
4. Tear Strength: 90 lbf; ASTM D 4533.
5. Puncture Strength: 90 lbf; ASTM D 4833.
6. Apparent Opening Size: No. 60 sieve, maximum; ASTM D 4751.
7. Permittivity: 0.02 per second, minimum; ASTM D 4491.
8. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.

2.3 CONTROLLED LOW-STRENGTH MATERIAL

A. Controlled Low-Strength Material: Self-compacting, low-density, flowable concrete material produced from the following:

1. Portland Cement: ASTM C 150, Type I.
2. Fly Ash: ASTM C 618, Class C or F.
3. Normal-Weight Aggregate: ASTM C 33, 3/4-inch nominal maximum aggregate size.
4. Foaming Agent: ASTM C 869.
5. Water: ASTM C 94/C 94M.

B. Produce low-density, controlled low-strength material with the following physical properties:

1. As-Cast Unit Weight: 36 to 42 lb/cu. ft. at point of placement, when tested according to ASTM C 138/C 138M.
2. Compressive Strength: 250 to 400 psi at 28-days, when tested according to ASTM C 495.

2.4 GEOFOAM

A. Extruded-Polystyrene Board Insulation: ASTM C 578, Type VI, 1.80-lb/cu. ft. density, 40-psi compressive strength.

B. Rigid Cellular Polystyrene Geofoam: ASTM D 6817, Type EPS 19, 1.15-lb/cu. ft. density, 5.8-psi compressive strength at 1 percent deformation; 16-psi compressive strength at 10 percent deformation.

C. Connectors: Geofoam manufacturer's multibarbed, galvanized-steel sheet connectors.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth moving operations.

B. Protect and maintain erosion and sedimentation controls during earth moving operations.

C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

3.2 DEWATERING

A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.

B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.

1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.

3.3 EXPLOSIVES

A. Explosives: Do not use explosives.

3.4 EXCAVATION, GENERAL

A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.
   1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.

B. Classified Excavation: Excavate to subgrade elevations. Material to be excavated will be classified as earth and rock. Do not excavate rock until it has been classified and cross sectioned by Architect. The Contract Sum will be adjusted for rock excavation according to unit prices included in the Contract Documents. Changes in the Contract Time may be authorized for rock excavation.
   1. Earth excavation includes excavating pavements and obstructions visible on surface; underground structures, utilities, and other items indicated to be removed; together with soil, boulders, and other materials not classified as rock or unauthorized excavation.
      a. Intermittent drilling; ram hammering; or ripping of material not classified as rock excavation is earth excavation.

3.5 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
   1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
   2. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 inch. Do not disturb bottom of excavations intended as bearing surfaces.

B. Excavations at Edges of Tree- and Plant-Protection Zones:
   1. Excavate by hand to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
   2. Cut and protect roots according to requirements in Section 01 56 39 "Temporary Tree and Plant Protection."

3.6 SUBGRADE INSPECTION

A. Notify Architect when excavations have reached required subgrade.

B. If Owner's Geotechnical representative determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.

C. Proof-roll subgrade below the building slabs and pavements with a pneumatic-tired loaded truck or smooth drum vibratory compactor weighing not less than 10 tons to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
   1. Completely proof-roll subgrade in one direction(2 passes minimum), repeating proof-rolling in direction perpendicular(2 passes minimum) to first direction. Limit vehicle speed to 3 mph.
   2. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.

D. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.

E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Architect, without additional compensation.

3.7 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of 2500 psi, may be used when approved by Architect.
   1. Fill unauthorized excavations under other construction, pipe, or conduit as directed by Architect.

3.8 STORAGE OF SOIL MATERIALS

A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.

1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.9 BACKFILL

A. Place and compact backfill in excavations promptly, but not before completing the following:
   1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
   2. Surveying locations of underground utilities for Record Documents.
   3. Testing and inspecting underground utilities.
   4. Removing concrete formwork.
   5. Removing trash and debris.
   6. Removing temporary shoring and bracing, and sheeting.
   7. Installing permanent or temporary horizontal bracing on horizontally supported walls.
B. Place backfill on subgrades free of mud, frost, snow, or ice.

3.10 UTILITY TRENCH BACKFILL

A. Place backfill on subgrades free of mud, frost, snow, or ice.
B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.
C. Trenches under Footings: Do not trench below footings. Where approved by Architect, backfill trenches excavated under footings and within 18 inches of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings. Concrete is specified in Section 03 30 00 "Cast-in-Place Concrete"
D. Backfill voids with satisfactory soil while removing shoring and bracing.
E. Place and compact initial backfill of satisfactory soil, free of particles larger than 1 inch in any dimension, to a height of 12 inches over the pipe or conduit.
   1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.
F. Controlled Low-Strength Material: Place initial backfill of controlled low-strength material to a height of 12 inches over the pipe or conduit. Coordinate backfilling with utilities testing.
G. Place and compact final backfill of satisfactory soil to final subgrade elevation.
H. Controlled Low-Strength Material: Place final backfill of controlled low-strength material to final subgrade elevation.

3.11 SOIL FILL

A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.
B. Place and compact fill material in layers to required elevations as follows:
   1. Under grass and planted areas, use satisfactory soil material.
   2. Under walks and pavements, use satisfactory soil material.
   3. Under steps and ramps, use engineered fill.
   4. Under building slabs, use engineered fill.
   5. Under footings and foundations, use engineered fill.
C. Place soil fill on subgrades free of mud, frost, snow, or ice.

3.12 GEOFOAM FILL

A. Place a leveling course of sand, 2 inches thick, over subgrade. Finish leveling course to a tolerance of 1/2 inch when tested with a 10-foot straightedge.
   1. Place leveling course on subgrades free of mud, frost, snow, or ice.
B. Install geofoam blocks in layers with abutting edges and ends and with the long dimension of each block at right angles to blocks in each subsequent layer. Offset joints of blocks in successive layers.
C. Install geofoam connectors at each layer of geofoam to resist horizontal displacement according to geofoam manufacturer's written instructions.
D. Cover geofoam with separation geotextile before placing overlying soil materials.

3.13 SOIL MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.
   1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
   2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.14 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Place backfill and fill soil materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.
B. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.
C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 1557:
   1. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 inches of existing subgrade and each layer of backfill or fill soil material at 95 percent.

3.15 GRADING

A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
   1. Provide a smooth transition between adjacent existing grades and new grades.
   2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.
B. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2 inch when tested with a 10-foot straightedge.

3.16 SUBSURFACE DRAINAGE

A. Subdrainage Pipe: Specified in Section 33 46 00 "Subdrainage."
B. Subsurface Drain: Place subsurface drainage geotextile around perimeter of subdrainage trench. Place a 6-inch course of filter material on subsurface drainage geotextile to support subdrainage pipe. Encase subdrainage pipe in a minimum of 12 inches of filter material, placed in compacted layers 6 inches thick, and wrap in subsurface drainage geotextile, overlapping sides and ends at least 6 inches.
   1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 698.
C. Drainage Backfill: Place and compact filter material over subsurface drain, in width indicated, to within 12 inches of final subgrade, in compacted layers 6 inches thick. Overlay drainage backfill with one layer of subsurface drainage geotextile, overlapping sides and ends at least 6 inches.
   1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 698.
   2. Place and compact impervious fill over drainage backfill in 6-inch-thick compacted layers to final subgrade.

3.17 DRAINAGE COURSE UNDER CONCRETE SLABS-ON-GRADE

A. Place drainage course on subgrades free of mud, frost, snow, or ice.
B. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs-on-grade as follows:
   1. Install subdrainage geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
   2. Place drainage course 6 inches or less in compacted thickness in a single layer.
   3. Place drainage course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
   4. Compact each layer of drainage course to required cross sections and thicknesses to not less than 95 percent of maximum dry unit weight according to ASTM D 698.
C. Refer to Geotechnical engineering report for additional underslab drainage requirements.

3.18 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.

B. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.
C. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Architect.
D. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:
   1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 2000 sq. ft. or less of paved area or building slab, but in no case fewer than three tests.
   2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every 50 feet or less of wall length, but no fewer than two tests.
   3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 150 feet or less of trench length, but no fewer than two tests.
E. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.19 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
   1. Scarify or remove and replace soil material to depth as directed by Architect; reshape and recompact.
C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
   1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.20 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION

SECTION 32 31 19

DECORATIVE METAL FENCES AND GATES

PART 1 – GENERAL
1.1 RELATED DOCUMENTS
1.2 SUMMARY
1.3 ACTION SUBMITTALS
1.4 INFORMATIONAL SUBMITTALS
1.5 QUALITY ASSURANCE
1.6 DELIVERY, STORAGE, AND HANDLING
PART 2 – PRODUCTS
2.1 ORNAMENTAL FENCE MATERIALS
2.2 POWDER COAT FINISH
PART 3 – EXECUTION
3.1 FENCE INSTALLATION
3.2 CLEANING

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. Decorative planter fence
a. This work includes: furnishing and installing ornamental steel items, preparation, cleaning and TIG powder coat finishing of all metal work; including grounding, complete as shown and specified.

B. Related Sections:
1. Division 03 Section "Cast-in-Place Concrete" for post concrete fill.
2. Division 26 Sections for electrical service and connections for electrical receptacles.
3. Division 31 Section "Earth Moving" for site excavation, fill, and backfill where decorative metal fences and gates are located.
4. Section 32 13 13 “Concrete Paving” for concrete curbs and gutters, walks, driveways, parking lots, and miscellaneous paving

1.3 ACTION SUBMITTALS

A. Complete, signed, and sealed manufacturer’s shop drawings, showing location of fencing and posts location of grounding rods, details of post installation, and expansion joints.

B. Individual piece samples and full mock-up of fence segment. Samples must include the post, fence segment.

C. Specifications and color samples on metal bars, for all coatings, epoxy sealers and grouts.
1. Manufacturers data for powder coating materials.
2. Salt Spray Test report for power coating. Test report shall be prepared following ASTM B –117 guidelines.
3. Powder coating limited warranty.
4. Powder coating applicator’s printed instructions for field repair of minor surface scratches

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.5 QUALITY ASSURANCE

A. Codes and Standards: Comply with provisions of following, except as otherwise indicated:
1. American Institute of Steel Construction (AISC) "Code of Standard Practice for Steel Buildings and Bridges."
2. AISC "Specifications for Structural Steel Buildings," including "Commentary."

3. "Specifications for Structural Joints using ASTM A 325 or A 490 Bolts" approved by the Research Council on Structural Connections.
4. American Welding Society (AWS) D1.1 "Structural Welding Code Steel."
5. ASTM A 6 "General Requirements for Delivery of Rolled Steel Plates, Shapes, Sheet Piling and Bars for Structural Use."
6. The Society for Protective Coatings (SSPC)

B. Installer Qualifications: Engage an experienced Installer who has at least three years of experience and has completed at least five fence projects with similar material and scope to that indicated for this Project with a successful construction record of in-service performance.

C. Qualifications for Welding Work: Qualify welding procedures and welding operators in accordance with AWS "Qualification" requirements.
1. Present evidence that each welder to be employed in work has satisfactorily passed AWS qualification tests.
2. If recertification of welders is required, retesting will be Contractor's responsibility.

D. Testing: Materials and fabrication procedures are subject to inspection and tests in mill, shop, and field, conducted by a qualified inspection agency. Such inspections and tests will not relieve Contractor of responsibility for providing materials and fabrication procedures in compliance with specified requirements.
1. Promptly remove and replace materials or fabricated components which do not comply.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to site at such intervals to ensure uninterrupted progress of work.

B. Deliver anchor bolts and anchorage devices, which are to be embedded in cast in place concrete or masonry, in ample time to not to delay work.

C. Store materials to permit easy access for inspection and identification. Keep steel members off ground by using pallets, platforms, or other supports. Protect steel members and packaged materials from erosion and deterioration.
1. Do not store materials on structure in a manner that might cause distortion or damage to members or supporting structures. Repair or replace damaged materials or structures as directed.

PART 2 - PRODUCTS

2.1 ORNAMENTAL FENCE MATERIALS

A. Steel Fencing Materials: Use only materials which are smooth and free of surface blemishes including pitting, seam marks, roller marks, rolled trade names and roughness.
1. Steel shall meet the requirements of ASTM Specification A-36.
2. Steel Bars shall meet the requirements of ASTM Specification A-108, cold finished, grade optional.

B. Form fencing of welded construction to forms and profiles indicated.

C. Form exposed work true to line and level with accurate angles and surfaces and straight edges. Weld corners and seams continuously, complying with AWS recommendations. Grind exposed welds smooth and flush to match and blend with adjoining surfaces.

D. Expansion Joints: Provide expansion joints at intervals not to exceed 20 feet.

E. Fabricate joints in a manner to exclude water or provide weep holes where water may accumulate.

F. miscellaneous Items: This specification is intended to include complete fence materials, and the Contractor shall furnish all necessary fittings, and connections necessary to securely and rigidly install the fence. Color shall be semi-gloss black. All materials shall be the same color.

2.2 POWDER COAT FINISH

A. All metal surfaces are to be powder coated using a tri-treatment process. The coating system must be capable of surpassing a 6,000-hour salt spray test with zero failure on the scribe mark.

B. Surface Preparation: All surfaces of the fence system shall be grit blasted to SSPC-SP5 specification; 100% white metal blast achieving 1.5 ML minimum etch.

C. Powder Coating
1. Gray epoxy powder primer shall be electrostatically applied and properly cured. Cured primer coat shall be two to three mills thickness.
2. TGIC Polyester powder finish coating shall be applied at a rate of four to six mills and properly cured per coating manufacturer specifications.

PART 3 - EXECUTION

3.1 FENCE INSTALLATION

A. Mounting Posts: Fasten two 2"x5" L shaped brackets to either side of the upright post and into concrete curb at height indicated on drawing.

B. Epoxy Grout: The epoxy grout must be a two component, epoxy-resin bonding system conforming to the requirements of ASTM C 881, Type IV, Grade 2, Class B or C. The Class supplied must be governed by the range of temperatures for which the material is to be used. The resin must contain a white pigment and the hardener must contain a black pigment in such proportions that the resulting mixture is concrete gray.

1. The two-component, epoxy-resin grout must be furnished by the manufacturer in premeasured, preassembled cartridges suitably designed for mixing and application of the grout or in containers individually marked to clearly identify each component.
2. The epoxy adhesive must be packaged in a kit with each component in a separate container. The containers of each kit must be filled with the adhesive components in exact mixing proportions and one container must be large enough to mix both of the components. The size of the kit must be the total volume of the mixed adhesive which must be 4 L (1 gal) or 20 L (5 gal) as specified. Regardless of how it is furnished, the manufacturer must supply mixing instructions.
3. Prior to approval and use of the epoxy-resin grout, the Contractor must submit a notarized certification by the formulator, stating that the epoxy-resin grout meets these requirements.

C. Install fencing plumb, level, true to line and location, and secure.

D. Fence shall conform to the alignment and finish grades as shown on the project drawings. Verify dimensions at the site.

E. Fence and posts shall have all weld splatters and rough spots ground smooth prior to powder coating.

3.2 CLEANING

A. Clean all core drilling slurry, epoxy grout and other materials from fence. Clean areas with minor scratches and abraded areas and touch-up using methods and applying materials as specified in powder coater's printed instructions.

B. Disposal: All excess excavated and unsuitable material is to be disposed of in a lawful manner off Project property.

END OF SECTION

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SECTION 32 91 13
SOIL PREPARATION

PART 1 – GENERAL
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1.5 DELIVERY, STORAGE, AND HANDLING
1.6 JOB CONDITIONS
PART 2 – PRODUCTS
2.1 MATERIALS
PART 3 – EXECUTION
3.1 PREPARATION
3.2 PERFORMANCE
3.3 FIELD QUALITY CONTROL
3.4 CLEANUP AND PROTECTION

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. Furnish and place subsoil, topsoil and planting mixes to meet finished grade elevations.
2. Soil testing of supplemental topsoil and on-site topsoil.
3. Excavation of landscape planting beds including tree pits, turf areas and planters to receive planting mixes or topsoil to the specified depths.
4. Preparation and placement of topsoil and planting mix in landscape planting beds to required finished grades including all soil amendments.
5. Finished grading of all landscape planting beds.

B. Related Sections:
1. Section 32 93 00 “Plants”

1.3 ACTION SUBMITTALS

A. Soil Testing
1. Soils report to be obtained by contractor and submitted to the Landscape Architect.
2. Soil testing and report shall be done by Dirt-N-Turf Consulting, Inc. (David Marquardt, 630-251-1511), no outside data shall be accepted. Contractor shall contact soil lab for proper sampling technique and instructions.
3. Tests shall be provided for onsite topsoil, imported topsoil, and blended soil mixes
   a. Onsite Topsoil
      1) Sample shall be raw, unblended soil.
      2) Sample quantity: Quantity to be determined by the amount of soil on site. No less than (2) samples shall be provided. Topsoil stock piles over 500 cubic yards shall require min. four (4) samples, one composite from each the north, south, east and west side of the stock pile.
      3) Sample size: Provide ¾ of a one gallon bag for each sample.
      4) Samples shall be a composite of the site or pile and not a single grab sample.
      5) Samples shall be submitted and approved six (6) weeks prior to project start date.
      6) If topsoil is hauled off during excavation, site samples shall be taken prior to grading.
   b. Imported Topsoil
      1) Sample shall be raw, unblended soil.
      2) Provide samples from (2) possible import locations. Samples shall be a composite of the import source and representative of the soil available at the time of the import.
      3) Sample quantity: Provide (2) samples.

4) Sample size: ¾ of a one gallon bag for each sample.
5) Samples shall be a composite of the site or pile and not a single grab sample.
6) Samples shall be submitted and approved six (6) weeks prior to project start date.

c. Blended Planting Mixes
1) Samples shall be blended mixes using the approved topsoil (onsite or import) according to the testing labs recommendations.
2) Sample quantity: Provide (2) samples.
3) Sample size: ¾ of a one gallon bag
4) Samples shall be a composite of the site or pile and not a single grab sample.
5) Samples shall be submitted and approved two (2) weeks prior to project start date.

4. Testing Parameters
a. The Contractor shall submit a complete soils report to the Landscape Architect prepared by Dirt-N-Turf Consulting, Inc. (David Marquardt, 630-251-1511). Soils report shall include complete physical and chemical analysis of import topsoil to be used on site, including, but not limited to, the following parameters:
1) U.S.D.A. soil classification
Percent of sand
Percent of clay
Percent of silt
2) Chemical analysis including:
Exchange Capacity
pH
Organic Matter
Major Anions
Soluble Sulfur
Extractable Phosphorus
Bray II Phosphorus
3) Major cation's amounts and percentage of base saturation
Calcium
Magnesium
Potassium
Sodium
Hydrogen
4) Extractable Minors
Boron
Iron
Manganese
Copper
Zinc
Aluminum
b. Report shall include recommendations for fertilization and soil amendment for the various types of turf and plants to be installed at the site to provide complete soils that will ensure vigorous growth for all plants specified.
c. Report shall identify presence of problem salts, minerals, and heavy metals (including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium and vanadium)

5. Other Samples
a. The following materials shall be submitted to the Architect for approval prior to delivery to the site.
1) Submit 1 quart samples of imported topsoil, sand, mulch, and soil conditioner to be used in preparation of the planting mix for review.
2) Submit manufacturer's data for fertilizers and amendments recommended by the soil testing analysis.

1.4 QUALITY ASSURANCE

A. Contractor Qualifications:
1. The contractor shall be a company specializing in landscape construction with a minimum of five (5) years of experience on comparable projects.

B. Code and Standards Compliance

1. All materials and work shall comply with applicable codes, standards and with the requirements of local agencies. The Contractor shall obtain all permits required.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Topsoil and Planting Mixtures
   1. Coordinate and deliver soil to pre-approved staging areas. Inform the Architect of all delivery schedules, twenty-four (24) hours in advance of delivery.
   2. All deliveries of topsoil which in any way fails to meet the requirements of these specifications will be rejected, and the Contractor shall immediately remove such rejected topsoil from the premises and supply suitable topsoil in its place.
   3. No deliveries will be permitted when weather conditions are unsatisfactory, or if the approved staging area is not in a satisfactory condition to receive topsoil. No frozen topsoil will be accepted. Do not deliver or handle soil in wet, muddy or frozen conditions. Protect stockpiles from winds and disturbance with landscape fabric or other material.
   4. Trucks making deliveries shall use routes as directed to avoid damage to property. The Contractor shall deliver topsoil in dump trucks having pneumatic tires and shall be unloaded from the trucks where directed. All topsoil that is deposited other than in the place designated shall be moved.

B. Other Materials
   1. Handle and store all other materials according to manufacturer's recommendations.

1.6 JOB CONDITIONS

A. General
   1. Prior to beginning work, the Contractor shall examine and verify the acceptability of the job site and notify the Architect of unsatisfactory conditions. The Contractor shall not proceed with the work until unsatisfactory conditions have been corrected or resolved.
   2. Where soil preparation occurs in close proximity to other site improvements, adequate protection shall be given to all features prior to commencing work. Any items damaged during soil preparation operations shall be promptly repaired to their original condition at no addition to the Base Contract Price.

B. Utilities
   1. Contractor shall have all underground utilities located by servicing agencies. In the vicinity of utilities, hand excavate to minimize the possibility of damage to underground utilities.

C. Excavation
   1. When conditions detrimental to plant growth are encountered such as limestone, rubble fill, adverse drainage conditions, or obstruction, notify the Architect prior to placement of any soil.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Subsoil Fill
   1. Where site conditions require a layer of fill below the specified bed depth, provide a clean, debris-free mineral material with a brown sandy clay content and granular material with no stones measuring larger than one inch in diameter. The pH should range between 5.5 to 7.3 with no limestone present. Gray clay soils shall not be accepted.

B. Planting Mixture Materials
   1. Amendments
      a. Acceptable and preferred amendments include:
         1) Pine Bark Fines – Lightly aged
         2) Coarse sand
         3) Lightweight aggregates
         4) Yard waste compost
      b. Unacceptable amendments include:
      c. Mushroom Compost
      d. Hardwood shredded or ground
   2. Topsoil

a. Topsoil shall be a mineral soil, uniform in color and texture; corresponding to native soils; containing no grass roots, sod, weeds, rocks, stiff clay, clods, or any other substance undesirable to plant growth. The soil shall be loose, friable, and of good tilth. The pH shall range between 5.5 to 7.3. Higher pH levels may be approved by Landscape Architect if appropriate for planting types and use.

b. Organic content shall not be less than 3 percent and not greater than 7 percent determined by loss of ignition.

c. Gradation: General guide to particle size as follows, may vary depending on use. Amend as needed based on soil test lab recommendations.

Sieve Designation	Percent Passing
No. 4 (4.76 mm)	100
No. 10 (2.00 mm)	95 - 100
No. 18 (1.00 mm)	90 - 100
No. 35 (500 micron)	65 - 100
No. 60 (250 micron)	0 - 50
No. 140 (105 micron)	0 - 20
No. 270 (53 micron)	0 - 10

d. Textural Grades: General guide to textural grade as follows, may vary depending on use. Amend as needed based on soil test lab recommendations.

Fine gravel, coarse sand, medium sand	25 - 40 %
Silt	25 - 60 %
Clay	5 - 25 %

Clay content shall be determined by Bouyoucous hydrometer Test.

e. Sand shall be clean, sharp, coarse sand passing 1/4" mesh screen and free of foreign and organic matter. The pH shall range between 6.5 to 7.5.

f. Blended Soil (unless otherwise specified after testing) should be the following ratios:

Approved topsoil	60%
Pine fines	20%
Sand	20%

3. Amendments
   a. pH Adjustments Soil pH adjustments will be made based on soil test lab recommendations.
      1) Limestone: Calcium carbonate (ground limestone) with 50% passing a No. 200 mesh sieve, 90% passing a N0. 100 mesh sieve and 100% passing a No.10 mesh sieve. Total carbonates shall not be less than 80%.
      2) Sulfur: Granular sulfur.

C. Planting Mix Types / Planting Conditions.
   1. All on-grade landscape shrub beds and tree pits shall be backfilled with a planting mixture described below. All soil mixtures shall be mixed with amendments and other materials by hand or mechanical methods prior to placement. All topsoil shall be tested and amended per test results. The following mix types shall be tested, prepared and installed for the planting conditions at grade.
   2. Planting Mix.
      a. Depth: 36 inches min. for trees or per the tree installation detail.
      b. Depth: 18 inches min. for shrub, groundcover, and perennial planting beds or per the shrub installation detail.
      c. Depth: 3 inches min. for perennials. Place amended soil on the top of the existing soil and till to a depth of 10-12 inches.
   3. Turf: Ornamental (low traffic).
      a. Depth: 6" min. or per the turf installation detail.
   4. Turf: High Performance (high traffic).
      a. Depth: 6" min. or per the turf installation detail.
   5. Bioswale / Rain Garden.
      a. Depth per the installation detail.
   6. Planting Mix for Freestanding Planters
      a. Depth per the installation detail.
      b. All freestanding planters and planter boxes shall be backfilled with a commercially prepared and approved planting mix which may contain topsoil, sand, pine fines, compost, or lightweight aggregates. Mycorrhizae, pH adjustments and nutrients shall be based on laboratory recommendation.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protection of Site Improvements: Protect all existing site improvements during excavation. If any existing improvements are damaged, replace or make arrangements with the proper authorities for repair.

3.2 PERFORMANCE

A. Planting Bed Preparation: Prior to installation of any plant material, ensure all tree and shrub pits to be free of debris and not in a muddy condition prior to backfill with specified planting mixture. Loosen the bottom of the pit or bed and ensure that all stones larger than 1" diameter and that all limestone have been removed from the subgrade to a depth of 24 inches.

B. Landscape Excavation and Backfill

1. Excavate new landscape areas as indicated on the drawings.

C. Excavate new landscape areas to the following depths:

1. Turf Lawn Area 6" minimum depth
2. Perennial Beds 12" minimum depth
3. Shrub Beds 18" minimum depth
4. Large Shrub and Tree Pits 2' greater than diameter of root ball on each side.

D. Compact subgrade in planting beds to 85% proctor density. Where pavement and other structures have been removed, bring planting bed to sub-grade with suitable subgrade fill.

E. After planting beds have been prepared and planting operations completed backfill turf beds and tree pits with specified planting mixtures and to grades and profiles shown on the plans. Rough grading of all areas shall be within 1/10th of grades shown on the Construction Drawings.

3.3 FIELD QUALITY CONTROL

A. The Owner will engage an independent soil testing and inspection agency to take samples of installed topsoil and planting soil mixtures and to perform tests and prepare test reports.

1. Testing agency shall conduct and interpret tests, state in each report whether test specimens comply with requirements, and specifically state any deviations therefrom.
2. Testing agency may inspect topsoil at source before shipment; however, Landscape Architect reserves right, at any time before final acceptance, to reject material not complying with specified requirements.

B. Correct deficiencies in topsoil and planting soil mixture work that inspections and laboratory test reports have indicated to be not in compliance with requirements. Perform additional tests, at Contractor's expense, as may be necessary to reconfirm any noncompliance of original work and to show compliance of corrected work

3.4 CLEANUP AND PROTECTION

A. Clean Up

1. Debris and excess material shall be removed from the site immediately.
2. When an excavation or backfill area is completed, completely clean up all soil piles and sweep all walks and drives.
3. All existing sidewalks and driveways providing access to on-site buildings shall be kept clean and free of obstructions. Other paved areas shall be cleaned when work in adjacent areas is completed

B. Protection

1. Protect all completed work from disturbance from operations of other trades and trespassers. Replace damaged work to specified conditions.

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SECTION 32 93 00

PLANTS

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3.11 WARRANTY

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. This section specifies installation, maintenance and warranty of all trees, shrubs, ground cover, perennials, annuals, and vines shown on the plans and specified herein.
   2. Tree grates.

B. Related Sections:
   1. Section 32 91 13 “Soil Preparation”

1.3 ACTION SUBMITTALS

A. Contractor Qualifications
   1. The Contractor shall submit qualifications with the bid.

B. Nursery List: Submit nursery list that complies with the above items under Section 1.3, Quality Assurance.

C. Samples and Product Data: Submit samples and/or product data for all items listed below in Section 2.1, Materials.

D. Schedule: Upon authorization to proceed with the work, a schedule indicating the dates of each of the following items will be prepared by the Contractor and submitted to the Landscape Architect:
   1. Tagging of plant material in nurseries.
   2. Staking of plant locations on the site.
   3. Digging and preparation of plant pits and beds.
   4. Delivery of plant material to the site.
   5. Planting schedule.
   6. Substantial completion of the work.

1.4 QUALITY ASSURANCE

A. Contractor Qualifications:

1. The contractor shall be a company specializing in landscape construction with a minimum of five (5) years of experience on comparable projects.

B. Code and Standards Compliance

1. All materials and work shall comply with applicable sections of the following references:
   a. American Association of Nurserymen, Inc. (MN) Standard: American Standard for Nursery Stock (ANSI Z60 .1 2004)
   b. Hortus Third, Cornell University, 1976

C. Source Quality Control

1. All landscape materials shall be from stock inspected and certified by authorized governmental agencies. The stock shall comply with governmental regulations prevailing at the supply source and the job site. The Landscape Architect reserves the right to ask for certification by authorized governmental agencies.
2. All landscape materials that have been treated with herbicides, pesticides, insecticides, fungicides, etc. should have been applied by a licensed applicator and been treated with products that comply with governmental regulations. The Landscape Architect reserves the right to ask for certification.
3. Products packaged in sealed containers shall be labeled with manufacturer's certified analysis. The composition of bulk materials shall be tested by an approved laboratory in accordance with procedures established by the Association of Official Agricultural Chemists, wherever applicable, or as specified by product specifications referenced herein.
4. Plant Material Selected by Contractor
   a. Contractor shall locate all plant material to be supplied for the project and inform the Landscape Architect and Owner in writing of plant location(s) at least thirty (30) days prior to scheduled date of plant review and selection. Both the Landscape Architect and Owner may be present for plant review and selection. Plant review and selection shall occur at least ninety (90) days prior to installation.
   b. Contractor shall select reputable nurseries for plant material. The nursery is subject to approval by the Landscape Architect. The following nurseries are pre-approved:

Beaver Creek Nursery	(815) 737-8758
Beeson's McHenry County	(815) 943-6382
Charles J. Fiore Co.	(847) 913-1414
Clavey's Nursery	(815) 943-7778
D. Hill Nursery	(815) 923-2141
GRO Horticultural Ent.	(847) 669-8658
Hinsdale Nursery	(630) 323-1411
Kaneville Tree Farms	(630) 557-2793
King Nursery	(630) 554-1171
Klehm Nursery	(847) 551-3710
Mariani Nursery	(262) 857-6529
Midwest Groundcovers	(847) 742-1790
Poplar Farms	(630) 879-7202
Possibility Place Nurseries	(708) 534-3988
P.P. & O. Nursery	(847) 836-1437
Rich's Foxwillow Pines	(815) 338-7442
St. Aubin Nurseries	(815) 522-3535
Stonegate Farm Nursery	(815) 765-2771
Wilson Nurseries, Inc.	(847) 683-3700

5. All landscape materials will be grown in the same climate zone as the site in which they will be planted. If the landscape material comes from a different, but adjacent climate zone, the contractor will supply a two (2) year warranty on that material.
6. The Landscape Architect will select all plant material required for the project, or reserves the right to select representative examples of individual plant species or varieties where the number of plants is too great to reasonably review and select all of the individual plants. No trees shall be delivered without the Landscape Architect's seal.
7. For plants located more than a one hundred fifty (150) mile radius from downtown Chicago, Contractor shall forward photographs of all species and varieties of plant material to the Landscape Architect at least thirty (30) days prior to scheduled date of plant review and selection, for advance review by Landscape Architect. Photographs shall be of at least ten (10%) percent of each species and variety of small shrubs and perennials, fifty (50%) percent of all large shrubs, and one hundred (100%) percent off all shade and ornamental trees. The photographs shall be digital so they can

electronically mailed to the Landscape Architect. They should also have a person with a surveyor's rod in the photograph so the size of the plants can be established.

8. The Contractor shall be responsible for all costs related to the review of plants located outside of the one hundred fifty (150) mile radius. This includes, but is not limited to, the cost of travel, lodging, and related expenses. All plant inspections shall take place during normal working hours. The Contractor shall be responsible for giving timely notice to the Landscape Architect
9. In the event plant material is found to be unacceptable after review by the Landscape Architect, the Contractor shall pursue other sources until acceptable plant material is found, at no additional cost to the Owner and Landscape Architect. If additional site visits are required, the Contractor shall compensate the Landscape Architect seven hundred fifty dollars ($750.00) per day.

D. Substitutions
1. If specified landscape material is not obtainable, notify the Landscape Architect, who will identify alternate sources or substitutes. If substitutions are smaller in size than the specified material, credits to the base bid contract will be made based on comparable cost differentials customary for materials and sizes involved.
2. Plants shall be supplied at the minimum sizes specified. Plants larger than the minimum size may be used upon approval of the Landscape Architect.
3. Container plants may be substituted for those designated balled and burlapped (B & B) only if approved by the Landscape Architect.

1.5 DELIVERY, STORAGE, AND HANDLING

A. General
1. Notify the Architect forty-eight hours in advance of all delivery times for plant material.
2. Store materials only in locations approved by the Landscape Architect.Topsoil and Planting Mixtures

B. Packaged Materials: Deliver packaged materials in unopened containers showing weight, analysis, and name of manufacturer. During shipment and storage on site, protect materials from breakage, moisture, heat, or other damage and according to manufacturer's recommendations.

C. Plant Materials
1. Schedule shipping to minimize on site storage of plants. Stock shall not be shipped until the planting preparations have been completed.
2. Label the size and variety of plant and securely attach to individual plants or to bundles of like variety and size.
3. During shipment, plants shall not be bent, stacked, or bound in a manner that damages bark, breaks branches, deforms root balls, or destroys natural shape.
4. Plant material shall be transported within enclosed trailers or covered by tarpaulin to protect the material from damage caused by drying winds, heat, freezing, or other exposure that may be harmful to the plants. Plant material arriving at the site in a damaged condition shall be rejected and removed from the site.
5. If delays beyond the Contractor's control occur after delivery, plants shall be kept watered and protected from sun, wind, and mechanical damage; root balls shall be covered with topsoil or mulch. Container grown stock shall not be removed from containers until planting time. Keep the roots constantly moist until planted.
6. Handle plants at all times in accordance with the best horticultural practices. Lift balled and burlapped materials from the bottom of the ball only. Balled and burlapped plants which have cracked or broken balls shall be rejected and removed from the site.

D. Deliver, store, and handle all other materials according to manufacturer recommendations.

PART 2 - PRODUCTS

2.1 PLANT MATERIAL

A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant Schedule or Plant Legend shown on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
1. Trees with damaged, crooked, or multiple leaders; tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); crossing trunks; cut-off limbs more than 3/4 inch in diameter; or with stem girdling roots will be rejected.

2. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.
3. Provide plant materials true to name and variety established by the American Joint Committee on Horticultural Nomenclature Standardized Plant Names, Second Edition, 1942, as indicated on the Drawings.
4. Specimen Quality: Plants indicated, as "specimen plants" shall be exceptionally heavy, symmetrical, and tightly knit, cultured, to be unquestionably superior in form, branching, compactness, and symmetry.
5. The minimum acceptable sizes of all plants shall be measured before pruning and with branches in normal position. Unless otherwise designated on the drawings, all plant dimensions shall conform to those listed in ANSI A60.1, American Standard for Nursery Stock.
    a. Where height is indicated within a range, the smaller dimension is the minimum acceptable; the larger dimension represents the maximum permissible except with approval of the Landscape Architect. The average dimension of all plants must at least equal the average of the height range specified.
    b. Spread shall meet the minimum dimension specified in all directions and must be considered as pivoting on the center of the plant. Where range is shown between two spread dimensions, the smaller dimension is the minimum acceptable. Spreads shall at least average on the average of the range indicated.
    c. Caliper is the trunk diameter taken at a specified distance above root collar as described in ANSI Z60.1.
    d. Branching point is the distance above ground where balanced branching occurs or where a dimension on trunk appears to form the head of the tree.
    e. Provide trees and shrubs of sizes shown or specified. Trees and shrubs of larger size may be used, if acceptable to the Landscape Architect, and if sizes of roots or root-balls are increased proportionately in accordance with ANSI Z60 standards or greater. Increased size shall result in no additional cost to the Owner.
    f. 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.

B. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which shall begin at root flare according to ANSI Z60.1. Root flare shall be visible before planting.

C. Root Treatment
1. Root treatments on all plants shall conform to the requirements of ANSI Z60.1. Plants shall be dug and prepared for shipment in a manner that will not cause damage to branches, shape, and future development after planting.
2. Balled and burlapped (B&B) plants shall have a firm, natural ball of earth of sufficient diameter and depth to encompass the fibrous and feed root systems necessary for full recovery of the plant. Ball shall be securely wrapped with burlap and bound with cord. Ball sizes shall meet the requirements of the ANSI Z60.1.
3. Plants furnished in containers shall have the roots well established in the soil mass and shall have grown in the container for at least one growing season. Containers shall be large enough to provide earth root mass of adequate size to support the plant tops being grown. Plants, other than ground covers, over established in the container, as evidenced by pot-bound root ends, will not be accepted.

D. Plant materials shall be subject to final approval by the Landscape Architect at the site. The Landscape Architect reserves the right to reject any plant material that does not meet project specifications at the time of planting.

2.2 PLANTING MIX AT GRADE

A. Planting Mix for landscape work shall be topsoil tested and amended per soils report to be obtained by contractor. Refer to Section 32 91 13 "Soil Preparation".

2.3 MULCHES

A. Hardwood Bark Mulch: Mulch shall be finely shredded and processed composted hardwood bark, free from other foreign material.

2.4 HERBICIDES AND PESTICIDES

A. Herbicide: Herbicides shall be products with rates of application that conforms to registered uses and is applied by a licensed professional applicator.

1. For woody materials ten (10') feet or further from the water's edge: Garlon 4 herbicide as manufactured by DowElanco.
2. For woody and/or herbaceous material ten (10') feet or further from the water's edge: Roundup Pro herbicide as manufactured by Monsanto.
3. For woody and herbaceous materials within ten (10') feet of the water edge: Rodeo herbicide as supplied by DowElanco.
4. Pesticides, Insecticides, Fungicides, etc.

B. Pest Control: If plant material becomes infected with any pests or insects, the most practical and environmentally benign methods should be utilized to control the problem. All products should comply with government regulations and be applied by a licensed applicator. The Landscape Architect reserves the right to ask for certification.

2.5 TREE GRATES

A. Tree Grates and Frames: City of Madison standard. 48 inch by 96 inch rectangular, model R-8815-A, with 18nch diameter expandable opening and frames, as manufactured by Neenah Foundry Company, Neenah, Wisconsin.

2.6 MISCELLANEOUS PRODUCTS

A. Tree Watering Bags: : One bag shall be installed per tree, bags shall be installed on the same day tree is installed.
1. Tree watering bags for single stem deciduous trees, Treegator, green, 20 gallon capacity as manufactured by Spectrum Products, Inc., Youngsville, North Carolina.
2. Tree watering bags for multi-stem or low branched trees and coniferous trees, Treegator Jr., brown, 14 gallon capacity as manufactured by Spectrum Products, Inc., Youngsville, North Carolina.

B. Anti-transpirant: Anti-transpirant shall be a protective film emulsion providing protective film over plant surfaces, permeable to permit transpiration, as manufactured by Wilt Pruf Products, Inc. or approved equal. Mix and apply in accordance with manufacturer's instructions.

C. Fertilizer: Fertilizer shall be an organic granular mycorrhizal such as Bio-Green Correct Plant Routine or approved equal.

D. Burlap: Burlap for wrapping root-ball and trunks shall be biodegradable jute mesh not less than seven (7) ounces per square yard. Wrapping materials made from manmade fibers are unacceptable.

E. Water: Water supply during installation shall be the sole responsibility of the Contractor.

F. Geotextile Fabric
1. Needle punched 150EX geotextile fabric as supplied by Industrial Fabrics or approved equal.
2. Local Representative: Dan Salsinger, Hanes Geo Componenets Telephone 1-888-239-4539.

G. Gravel: Gravel shall be washed gravel with no fines. The size should range from one (1") inch to two (2") inches.

H. Tree Wrapping Material: Tree wrapping material shall be ten (10 oz.) ounce, untreated burlap, not less than six (6") inches wide nor more than ten (10") inches wide.

PART 3 - <u>EXECUTION</u>

3.1 PREPARATION

A. General Job Conditions
1. Prior to beginning work, the Contractor shall examine and verify the acceptability of the job site and notify the Landscape Architect of unsatisfactory conditions. Do not proceed with the work until unsatisfactory conditions have been corrected or resolved.
2. Where planting occurs in close proximity to other site improvements, provide adequate protection for all site areas prior to commencing work. Any items damaged during planting operations shall be promptly replaced or repaired to their original condition at the Contractor's expense and no additional cost to the Owner.

B. Utilities
1. Contractor shall be solely responsible for determining location of all utilities. Contractor shall be responsible for obtaining site utility plans and contacting local utility locator service, and shall perform no work on site until utility locator service has marked site utilities.
2. Perform work in a manner that will avoid possible damage. Excavate to avoid underground utilities including hand digging as required. All damage to utilities resulting from work covered in these contract documents will be repaired at the Contractor's expense and no additional cost to the Owner. No time extension will be allowed due to delay in utility location.

C. Planting Season
1. Plant material shall be dug and planted only during the planting season appropriate for each individual plant species. Digging coniferous and deciduous trees prior to August 15th will not be approved.
2. Pre-digging of plants with proper storage may extend the planting season, however, the installation of plant material outside the normal planting season shall be done only with the approval of the Landscape Architect.
3. Installation of groundcovers, vines and perennials after September 1st shall be done only with the approval of the Landscape Architect.
4. Installation of coniferous or evergreen shrubs and trees after September 30th shall be done only with the approval of the Landscape Architect.

D. Coordination with Other Work
1. Proceed with complete landscape work as rapidly as portions of the site become available, working within the season limitations for each kind of landscape work required.

E. Layout
1. Individual plant locations shall be staked on the project site by the Contractor and approved by the Landscape Architect before any planting operations commence. Notify Landscape Architect a minimum one week prior to date of staking. The Landscape Architect reserves the right to adjust plant material locations to meet field conditions, without additions to the base contract price.
2. Accurately stake plant material according to the drawings. Where location or spacing dimensions are not clearly shown, request clarification from the Landscape Architect.
3. If obstructions are encountered that are not indicated, do not proceed with planting operations until alternate plant locations have been selected and approved in writing by the Landscape Architect.
4. If alternate locations are not possible, notify the Landscape Architect of the adverse conditions so the Landscape Architect can request a proposal from the Contractor for method of correction. The Contractor shall obtain approval for the additional work prior to continuing work in the affected area

3.2 PLANTING AREA ESTABLISHMENT

A. Rocks / underground obstructions shall be removed and proper planting depths shall be established to conform to Section 329113 “Soil Preparation”.

B. Plant Pit Excavation
1. Planting pits shall be round, with vertical sides and flat bottoms, and sized in accordance with the specification and dimensions shown on the drawings.
2. If rotating augers or other mechanical diggers are used to excavate holes, the vertical sides of the pits shall be scarified, fractured, or otherwise broken down to eliminate impervious surfaces.
3. Loosen or scarify soil in the bottom of all plant pits to a depth of four (4”) inches.

C. If existing soil is to be used, it shall meet the requirements of specification for topsoil as contained in Section 329113 “Soil Preparation. Beds shall be excavated to proper depths and amended as specified. Plant beds shall be brought to a smooth and even surface conforming to established grades.

D. Excavated material that does not meet specifications for topsoil will not be used for backfill in any planter or planting pit and shall be removed to an area designated by the Landscape Architect.

E. Test Drainage: Fill approximately two (2%) percent of the tree and large shrub pits with water. If percolation is less than one hundred (100%) percent within a period of twelve (12) hours, drill a ten (10”) inch auger hole to a depth of four (4’) feet below the bottom of the pit. Fill auger hole with drainage gravel. Retest pit. In case drainage is still unsatisfactory, notify Landscape Architect, in writing, of the condition before planting trees in the questionable areas. The Landscape Architect reserves the right to select the pits that will be tested.

F. Subsoil Removal: Dispose of subsoil removed from landscape excavations. Do not mix with planting soil. Do not use as backfill.

3.3 PLANTING OPERATIONS

A. When the ground is frozen, no planting activities shall occur.

B. Plant Balled and burlapped (B & B) trees and large shrubs in the following manner. Set the plant in the pit to the same relationship to the grade as in the original container or at the top of the burlap ball, faced to give the best appearance or relationship to one another and adjacent structures. Cut away burlap, rope, wire, or other wrapping materials one-third (1/3) of the way from the top of the ball and remove from pit. Do not remove burlap or ties from sides or bottom of ball. If plastic wrap or other non-biodegradable materials are used in lieu of burlap, completely remove them before placing of backfill. Cleanly cut off broken or frayed roots. Place approved topsoil and fertilizer around the ball and carefully compact to avoid injury to the roots and to fill the voids. Apply fertilizer at a rate recommended by the manufacturer. After backfilling planting pit approximately two thirds full, add water and allow planting mixture to settle. After

the water has been absorbed, fill the planting pit with topsoil tamp light to grade. In tree grates, set top of root ball to allow a two inch air space between the mulch layer and the bottom of the grate.

C. Plant container grown shrubs as specified above for balled and burlapped plants and as modified herein. Remove containers before planting and loosen the sides of root ball in several places, freeing the roots on the outside of the ball sufficiently to encourage rapid root extension into the surrounding soil and to prevent girdling of root mass.

D. Plant groundcover, perennials and annuals so that the top of the root mass is even with the surrounding grade. Adjust spacing as necessary to evenly fill planting bed with indicated quantity of plants. Adjust spacing so plants are within six (6") inches of edge of bed. Backfill planting with specified planting mixture and fertilizer at a rate recommended by manufacturer.

E. Planting of shrubs, groundcovers, bulbs and annuals around tree root balls shall occur beyond the perimeter of the root ball. Do not plant directly over any root balls.

3.4 MULCHING

A. Mulching shall take place within forty-eight (48) hours after planting, using approved materials.

B. Mulch shrub beds to a uniform depth of three (3") inches. Mulch ground cover and perennial areas to a uniform depth of three (3") inches.

C. Mulch shall be kept out of the crowns of shrubs and trees and off buildings, sidewalks, light standards, and other site improvements.

D. Form mulch rings around trees and large shrubs that are within turf areas.

3.5 PRUNING

A. General

1. After planting, prune the branches of deciduous stock to balance the loss of roots in such manner as to retain the natural form of the plant type. Workmen experienced in this type of work shall do pruning. The Landscape Architect shall approve pruning techniques and appearance before proceeding with all pruning.
2. Trimmings shall be removed from the site and legally disposed.

B. Trees

1. Prune trees by removing all dead wood, badly formed, interfering limbs, and sufficient other growth to ensure healthy and symmetrical growth of new wood. Up to one third (1/3) of the branches may be removed. The proportion is, in all cases, subject to the approval of the Landscape Architect. The central leader shall not be removed.
2. In the case of multiple leaders, preserve the one which will best promote the symmetry of the tree, and remove or cut back the remainder so that they will not compete with the selected leader. Cut back surrounding top branches to conform to the leader.

C. Shrubs: Prune shrubs by removing all dead wood and broken branches, thinning out canes and cutting back or removing asymmetrical branches. Pruning shall result in a loose outline conforming to the natural shape of the shrub type. Shearing to unnatural shapes will not be accepted.

3.6 TREE GRATE INSTALLATION

A. Tree Grates: Set grate segments flush with adjoining surfaces as shown on Drawings. Shim from supporting substrate with soil-resistant plastic. Maintain a 3-inch minimum growth radius around base of tree; break away units of casting, if necessary, according to manufacturer's written instructions.

3.7 OTHER PROCEDURES

A. Apply anti-transpirant to all broadleaf evergreen shrubs in all planting beds.

B. Stake or guy deciduous trees only if directed by the Landscape Architect. Landscape Architect shall approve tree bracing method.

C. Install tree watering bags the same day that trees are planted and fill with water. Contractor shall be responsible for keeping bags filled with water until substantial completion unless noted otherwise.

3.8 CLEANUP AND PROTECTION

A. Clean Up

1. Excess and waste material shall be removed daily. Keep pavement clean and work area in an orderly condition.
2. When planting in an area has been completed, the area shall be cleared of all debris, soil piles, containers and all paved areas swept.

3. At least one paved pedestrian access route and one paved vehicular access route to each building shall be kept clean at all times. Other paving shall be cleaned when work in adjacent areas is completed.

B. Repairs: Any damage to existing landscape, paving, or other such features as a result of work related to this contract shall be repaired by the responsible Contractor to its original condition. Treat, repair, or replace damaged work at the Contractor's expense and at no additional cost to the Owner.

C. Protection: Protect landscape work and materials from damage due to landscape operations, operations by other contractors and trades, and trespassers. Maintain protection during installation and maintenance periods.

D. Insurance: Insurance on plant material and other materials stored or installed is the responsibility of the Contractor. Such insurance shall cover fire, theft, vandalism, and any other damage that may occur to the plant material. Should the Contractor elect not to provide such insurance, the Contractor will in no way hold the Owner responsible for any losses incurred during the project. The Contractor is responsible for all costs incurred in replacing materials prior to date of substantial completion.

3.9 MAINTENANCE

A. Maintenance: The Contractor shall be responsible for maintenance until the certificate of substantial completion. After the certificate of substantial completion, the Owner shall be responsible for all aspects of the maintenance. The Contractor should review the site periodically during warranty period to determine what changes, if any, should be made in the maintenance program. Submit all recommended changes in writing to the Landscape Architect and the Owner.

3.10 ACCEPTANCE

A. Completion of the Work: Upon completion of work, the Contractor shall notify the Landscape Architect and the Owner at least ten (10) days prior to requested date of substantial completion of all or portions of the work. Landscape Architect will review all of the work and prepare a punch list of work not installed or not installed in conformance with the contract documents. All work in the punch list must be completed within five (5) working days from date of issue. Where work does not comply with requirements, replace rejected work and continue specified maintenance until reviewed by Landscape Architect and found to be acceptable.

B. Certificate of Substantial Completion: Certificate of substantial completion will be issued for acceptable work at sole discretion of the Landscape Architect. If punch list items are issued with the certificate, they must be corrected within five (5) working days. If items are not corrected within five (5) working days than the certificate of substantial completion will be revoked and reissued when the punch list items are corrected.Protect all completed work from disturbance from operations of other trades and trespassers. Replace damaged work to specified conditions.

C. Final Acceptance: One (1) year after date of substantial completion the Landscape Architect and the Owner will review the work for final acceptance. Upon satisfactory completion of repairs and / or replacements the Landscape Architect will certify, in writing, final acceptance of the work, which will serve as evidence that Contractor's one (1) year warranty obligations have been met.

3.11 WARRANTY

A. Warrant for a period of one (1) year, following the certificate of substantial completion, all work, against any defects (including death and unsatisfactory growth) as determined by the Landscape Architect. Defects resulting from neglect by the Owner, abuse or damage by others, or unusual phenomena or incidents beyond the Contractor's control are exempt. Should questions arise concerning the responsibility of replacement, the Landscape Architect shall be the sole judge of the need for replacement.

1. Special Warranty: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.
2. Failures include, but are not limited to, the following:
   a. Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by Owner, or incidents that are beyond Contractor's control.
   b. Structural failures including plantings falling or blowing over.
   c. Faulty performance of tree stabilization, edgings, tree grates.
   d. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
3. Plants
   a. Remove and replace all work found to be dead or in unhealthy condition during warranty period as determined by Landscape Architect.
   b. Replacements shall match adjacent specimens of same species. Replacements are subject to all requirements stated in the contract documents and are subject to review by the

Landscape Architect at the project site and should be installed during appropriate planting seasons.

c. Repair grades, paving and any other damage resulting from replacement planting operations, at no additional cost to the Owner.

d. Replacements made during the warranty period or following review for final acceptance will carry an additional one (1) year warranty beginning at the time of replacement.

END OF SECTION

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